

TAKING FLIGHT



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VOLUME 5 / ISSUES 1 & 2

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

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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 in Volume 3, Issue 2, and a few more are in Volume 4.1.



“Through my dear friend Joel Friedman, I became aware of iSEE’s dedicated programs,” said Joseph, pictured here with her dog Moonbeam. “The planet and the environment are where all things

future begin. All needs and other great causes depend on where we live and are safe.

“After hearing about iSEE and *Q Magazine*, I felt HOPE, for the first time in many years, that brilliant young people are working on improvements and solutions.”

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

We are grateful!

About Q Magazine

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

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

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

The motto of the CEW is “turning data into narrative” — to absorb the latest environmental research and communicate that research effectively to the public. Certificate courses allow students to engage with the latest on-campus research in sustainability science and identify environmental issues they are passionate about. Whether dropping in to take one of our courses or completing the full three-course sequence, students work with dedicated professors, meet enthusiastic students from disciplines all across campus, and build marketable skills in environmental communication.

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



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**Sydney
Sadler**



**Tyler
Swanson**



**Momo
Wang**



**Rachel
Weingart**

The Writers

Editor's Note:

In Volume 5 of *Q Magazine*, birds take flight and our gaze turns skyward. From hands-on experience with bird banding, to the overlooked threats of noise pollution and glass windows, there's a flock of stories about our feathered friends.

Chartering a different kind of flight, we find ourselves immersed in the Middle Eastern water crisis while, closer to home, we learn the inspiring story of Champaign activists whose decades-long fight saved our beloved Middle Fork.

And don't miss Momo Wang's award-winning memoir of life, death, and bugs. It's a poignant reminder that life crawls as much upon the ground as soars aloft the air.

From the U of I quad to the White House to the Dead Sea, you never know where our dedicated *Q* writers will take you next — and that's exactly the point. Buckle up and enjoy...

Rachel Weingart

Student Editor
and the *Q* Editorial Team

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

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A golden-winged warbler
caught in a mist net.
Credit: David Edlund

BAND AID



By Lauren Brunk

Harsh wind nipped at my bare hand as I carefully unfolded the mist nets at Homer Lake, a forest preserve a dozen miles east of the U of I campus. We unfolded a collection of three nets around bird feeders. Tall trees surrounding us hosted a plethora of birds that watched from afar; what felt like an orchestra of bird calls filled my ears. The discomfort that comes with cold and rainy conditions was not unique to us; as fellow endotherms, conserving energy and internal body temperature for birds is key for survival, and cold temperatures make that difficult. For that reason, there was a larger audience than normal waiting for us to leave the easily accessible snacks of seeds and nuts.

The goal of the mist net was to create a nearly invisible barrier between the highly sought-after bird feeder and the safety of the treeline to capture birds. Mist nets are thin polyester mesh hung between two metal poles, resembling volleyball nets. When the shelves of mesh are connected together, they create pockets, so that when a bird hits the net, it falls into the pocket and entangles itself.

Although the idea may sound strange, mist nets are a very common research technique used by ornithologists, and studies show it is extremely safe for birds. This technique is an incredibly valuable tool for answering questions about bird ecology, such as how long birds live, where they migrate and when, and what areas they inhabit. More importantly, however, this information is used for bird management and conservation, which is becoming increasingly vital as almost 50% of all bird species face drastic declines. These declines are not restricted to rare and threatened species, either: Common and widespread species are also diminishing. A recent comprehensive study estimates North America has lost 3 billion birds in 50 years, an unfathomable number.

Mike Ward is one of many passionate ornithologists seeking to understand these declines and find conservation solutions, particularly for migratory birds. He is a Principal Research Scientist at the Illinois Natural History Survey, the instructor of my Ornithology class at the University of Illinois, and leader of our mist-netting adventure.

Post set-up, Ward, his lab members, and we students filed back into the Educational Center at Homer Lake and shut the glass door behind us. "And now we wait," Ward said with a smile. Gathered together, we watched the nets. For the first five minutes no movement occurred, an eerie stillness. Then, one brave male American goldfinch darted from the trees straight toward the feeders for food. The yellow blur bounced off the net and fell into the pocket, getting tangled. All it took was one — birds of many species now dove toward the feeders in waves. Some bounced off completely like a trampoline and retreated to the treescape, some avoided the nets and successfully reached the feeders, and the rest became stuck in the camouflaged mesh. For 15 minutes or so, we watched the nets until it was time to collect. Because I had the proper permits and experience, I followed Ward outside.

Birds were stuck everywhere in the net, suspended in air. As we approached a bird, the first step was "determining which side the bird had flown into the net" to allow for the easiest extraction. Once Ward determined the entry position, he traveled to that side of the net, wrapped his hand gently around the bird, and slowly slipped the net around its wings and legs. Within a minute the bird was net-free. Ward then handed me a tufted titmouse, an acrobatic gray songbird with a crest. I wrapped my fingers

Author Lauren Brunk holds a tufted titmouse in a bander's grip. Credit: Isabelle Jaquet



around its wings and torso to immobilize it, a technique known as bander's grip. I then placed the titmouse into a breathable cloth bag to reduce its stress. All around me, experienced ornithologists removed birds from the nets with care and placed them in bags. We brought the bags back into the educational center where a station for measurements had been prepared.

Inside, I passed the cloth bag onto Mike Avara, Ward's lab manager, who has years of experience with the science of bird banding. Avara pulled the surprised tufted titmouse from the bag, its showy blue crest flashing, and placed it in a firm bander's grip. The sex and age were taken first, primarily determined using plumage. Avara then used a caliper, a specialized ruler, to measure the wing chord, tail, and tarsus length. The wing chord length represents the distance from the curve of the wing to the longest primary feather, while the tarsus length measures the lower leg of the bird from its "ankle" joint to the end of the leg. Birds have modified bone structures for flight, which causes their anatomy to look different from ours. Although the visible joint immediately below the torso may look like a knee bending backward, their knees are actually farther up their leg hidden in their feathers, while the ankle joint is the one exposed. The length of the wing chord, tail, and tarsus informs researchers about the condition of the birds and how it changes over time, especially given age, habitat changes, and food availability.

Mass was the last measurement needed, and the technique for weighing birds in the field is peculiar and fascinating. Depending on the size of the bird,

ornithologists will use various mundane containers to hold it. For the smaller songbirds we were dealing with, old Walgreen's pill bottles fit perfectly. The pill bottle was first tared, or zeroed out, on the scale. Then, the titmouse was slid gently into the bottle upside down and placed on the scale.

After all measurements were complete, the final step was to attach a small, metal band on the bird's leg: bird banding. This band contained a unique number that connected all the measurements taken to that individual bird. Different birds require different band sizes and types to ensure minimal discomfort for the bird and maximum longevity of the band.

"All of this information we took right now will be uploaded to the BBL (Bird Banding Laboratory) once we're done, and then ornithologists all over the country will have access," Avara said. "That way, when birds migrate north to their breeding grounds or south for wintering, we'll know where they've been and how their physical condition changes."

The BBL is a collaborative scientific organization that supports the collection, curation, and archiving of information from banded birds in North America. When this bird is caught again, researchers will upload the new data to the BBL, and species records can be kept and analyzed across space and time.

With the band attached and all measurements taken, the entire process taking less than five minutes, Avara handed the tufted titmouse back to me. I walked outside, placed the songbird on my palm, and released my grip. With a second to gather its wits, the titmouse flew off my hand and into the nearest tree, with a few angry squawks for good measure. Although a little disgruntled, the tufted titmouse went about its day unscathed. This fast process provides ornithologists with a wealth of information regarding the physiology and behavior of birds.

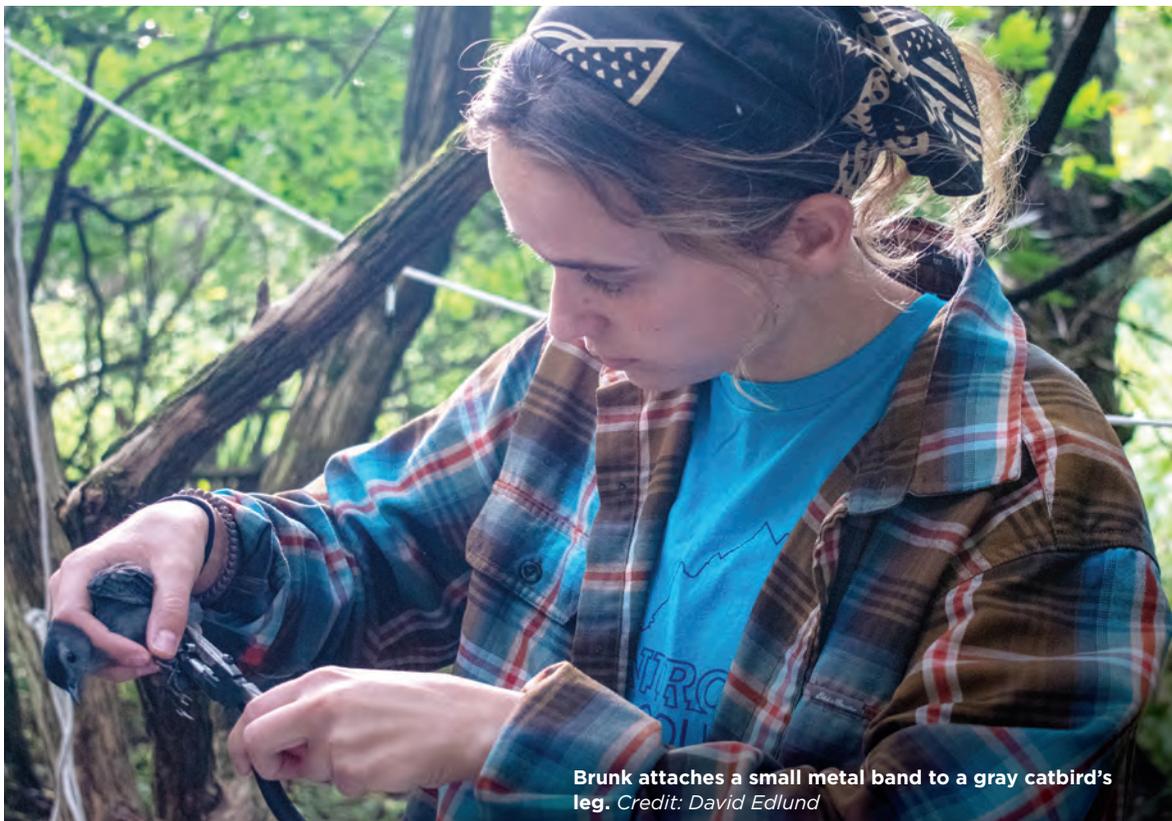
But how did such a peculiar technique come about and become so effective for studying birds?

During the Punic Wars in the third century BCE, Roman

“All of this information we took right now will be uploaded to the BBL (Bird Banding Laboratory) once we're done, and then ornithologists all over the country will have access.” Mike Avara



A researcher measures the tarsus of a black turnstone. Credit: Prince William Sound Science Center



Brunk attaches a small metal band to a gray catbird's leg. Credit: David Edlund

officers tied long, trailing threads on bird legs as messages to their soldiers. The 1600s saw the first recorded instances of bird banding for identification purposes in the practice of falconry. Describing falconry in Asia, Marco Polo wrote, "Each falcon belonging to the sovereign and the barons has a tablet of silver on its feet with its name and that of its owner inscribed so that wherever it is caught it may be returned to him." Early falconers were also known to band herons captured by falcons as a testament to their strength and stamina. By banding and recapturing the herons, bird hobbyists established the lifespans and migratory routes of these birds, helping develop early understandings of bird ecology.

Bird banding in the Western hemisphere was inaugurated by John James Audubon in the early 1800s. Audubon is revered as a significant contributor to the understanding of bird physiology and behavior through his field notes in North America, although he is controversial for his association with academic fraud and racism. Audubon's banding of Eastern phoebes, a small songbird, marked a historical turning point in ornithological research. Near his home in Philadelphia, Audubon wrote that "when (the eastern Phoebes) were about to leave the nest, I fixed a light silver thread to the leg of each, loose enough not to hurt the part, but so fastened that no exertions of theirs could remove it." Audubon was testing whether the same Eastern phoebes were coming back to the same place to nest, otherwise known as site fidelity. The following year he noticed the same banded phoebes did in fact return to the nesting site. This represented the first known understanding of site fidelity in a migrating songbird through bird bands, and reflected basic scientific principles used in bird banding today (for example, being

careful with the attachment of bands).

Today, in the spirit of John James Audubon and others, citizen science is a huge contributor to the successful research system run by the BBL. Scientists rely on contributions from birders and others to track bird movement and answer questions about survival and reproduction.

50-Year Study

Like many other avian ecologists, Henry Pollock, a postdoctoral researcher and instructor at the U of I, has worked on a diversity of projects where mist netting and bird banding were crucial. As an undergraduate he studied abroad in Costa Rica, where he was first introduced to mist netting, and from there developed a strong passion for tropical avian ecology. After his Ph.D. studying bird seed dispersal in Guam, Pollock joined a long-term data collection project on tropical birds alongside his Ph.D. advisor, Natural Resources and Environmental Sciences Professor Jeffrey Brawn.

Started in 1977, this project sought to untangle hypotheses about the life history traits of tropical birds. As Pollock explains, many people assumed "tropical birds were more K-selected and had slower life-history traits, but there were few studies demonstrating this on a long-term scale." In other words, people hypothesized that tropical birds generally lived longer, matured at slower rates, and had lower reproductive output because they lived closer to the equator.

To answer these questions, 20 nets were set up at two

Only with standardized collection protocols over long periods can we understand these important life history traits and the complex relationship of birds to their environment.

sites to capture swaths of different sizes and types of birds in Central Panama. For the most part they caught “small passerines less than 150g, including sparrows, wrens, and manakins,” but birds as small as hummingbirds and as large as toucans and hawks got caught as well. Passerines are small songbirds that make up about 50% of all bird species; Midwestern examples include American robins and Northern cardinals.

Once captured and banded, many different measurements are taken. Pollock takes data “on molting patterns and what time of year they occurred, on body fat condition particularly for migratory birds, and on stress corticosterone levels through blood samples.” Researchers also take morphological data such as “bill dimensions, including bill depth, length, and width, alongside tail and wing length, tarsus, and body mass.” With this information compiled over their 43-year study, they can understand how physical conditions of birds and their populations change over space and time.

Consistent, long-term studies of this kind allow researchers to accurately answer questions on the life history traits of tropical birds while also documenting

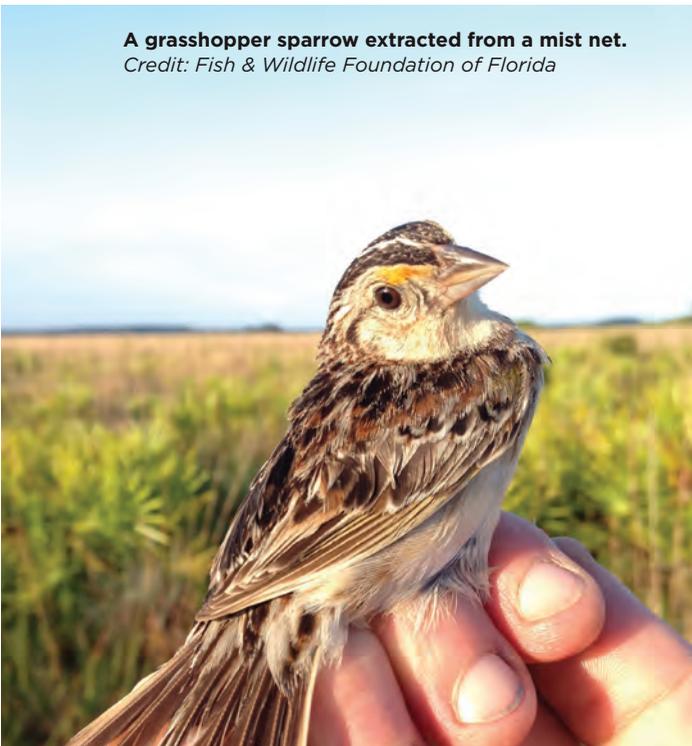
population fluctuations in response to dramatic habitat changes like deforestation for farming and urbanization. Specifically, Pollock has worked with Brawn to document species declines in response to variables related to climate change, such as rainfall. Only with standardized collection protocols over long periods can we understand these important life history traits and the complex relationship of birds to their environment.

Color Coordination

While Pollock’s research contributed to a community-level study of bird species, that is not the case for Sarah Winnicki, a current Ph.D. candidate at Illinois. This project focused on an elusive yet common migratory songbird named the grasshopper sparrow in the Kansas prairie. Grasshopper sparrows are small brown-tan birds with a striped back and orange-yellow strips in front of the eye. Unlike the community-level study from Panama, Alice Boyle of Kansas State University, Winnicki’s advisor, started a long-term study focused on a single, understudied grassland species facing steep declines in 2013. The overall project is focused on capturing male grasshopper sparrows to understand site fidelity. As an undergrad, Winnicki studied where males were relative to each other, and determined if spatial clumping occurred between related or unrelated individuals and why, alongside other questions. To do this, researchers needed to understand which birds were which — and that’s where color bands come in.

As Winnicki explained, “the (U.S. Geological Survey) issues aluminum or steel metal bands, each engraved with individual ID in that band size.” These are the bands used at Homer Lake and throughout the Panama tropical bird study. When these birds are recaptured, the unique number combo is reported to the BBL, which is important for long-term population studies. However, if all birds only have metal bands, from far away “all the sparrows look the same,” and there’s no way to know if related males nest close together through observations. To study these species’ post-banding behavior, researchers also attach “bright colored bands on them, which are colorful loops of plastic in the shape of aluminum band that you can gently squeeze around bird’s leg,” Winnicki said. Each bird is given a unique color combo, and with that information Winnicki and other researchers used spotting scopes and

A grasshopper sparrow extracted from a mist net.
Credit: Fish & Wildlife Foundation of Florida



cameras with high-zoom-capabilities to identify each individual sparrow and its behavior.

Banding would start in early May when the grasshopper sparrows arrived. Winnicki emphasized that “every bander has a different protocol,” but generally setting up mist nets in Kansas prairies requires different steps than in forested habitats. In particular, Winnicki and her fellow researchers “use rocks on the bottom trammel of the net to weigh it down because grasshopper sparrows, like other grassland birds, run along the ground.”

Furthermore, the nets are not always set up in the same place, like the standardized Panama study. Instead, GPS points are taken where males without bands are spotted, and nets are set up there soon after. The study used “targeted mist-netting,” which is a method of luring and capturing a single species. To attract specifically grasshopper sparrows, they use audio lures, which are playback audios of a bird’s calls to target and capture the sparrow. Winnicki said the team would “place a speaker at the base of the net, connect it to an old iPod bought off eBay, and play grasshopper sparrow territorial songs.” The males often react instantly and “freak out” thinking another male is in their territory, then fly straight into the net. If it doesn’t happen instantly, Winnicki watches the nets closely and immediately extracts the bird once caught.

Winnicki said that males were the center of the study “because that was the sex our grant funding was targeting, and because females are especially cryptic and don’t respond to audio lures.” In other words, the males are easier to catch because they are territorial and more vocal relative to females, which is common in birds.

Everything from morphological data (like wing length and weight) to blood samples were collected for hormone and genetic analyses to understand relatedness of individuals. Compiling the data over many study years painted a clearer picture of grasshopper sparrows’ ecology, their site selection and nesting behaviors, and patterns in their population numbers. After testing a variety of hypotheses, Winnicki and her group found that grasshopper sparrows didn’t aggregate their nests near relatives, and there is still uncertainty regarding if and why spatial clumping occurs.

Studying Endangered Species

These same methods used by Winnicki can be translated to studying federally endangered species. Gabby Jukkala, a master’s student at Illinois, does just that; she researches how nest success varies with age in the golden-cheeked warbler, a federally endangered migratory songbird. Golden cheeks, as she refers to them lovingly, are small, round, black and yellow songbirds with a lot of personality.

Jukkala explains how “in a lot of bird species, birds in their first breeding season, referred to as Second Years (SY), have lower reproductive success than older birds, referred to as After Second Years (ASY). This may be due to older birds breeding at a time when conditions are better, being more experienced parents, or just outcompeting younger birds for higher quality territories. My goal was to figure out if age-related differences in nest success occur in Golden-cheeks and, if so, what factors may be driving them.”

Jukkala sought to answer many questions, including if breeding timing, parental behavior, and nesting habitat varied with age, and if differences in these factors influenced nest success. She says that bird banding played an integral role in answering these questions because “capturing birds and looking at their plumage in hand is the only way to accurately age the species.” Once you know the age of a bird and band them with a unique color band combination, “you are able to follow that individual throughout the breeding season to determine their success, as well as identify them if they return in future breeding seasons. Over time this creates a large database of known-age birds and their reproductive success in the study area, which was critical for my study.”

Her research took place in Fort Hood, Texas, an active military installation where a long-term monitoring program has existed for golden-cheeked warblers since 2000. Fort Hood is unique in that “golden-cheeked warblers only breed in central Texas, and Fort Hood has the largest monitored population anywhere in its breeding range. This is because military bases have to comply with the Endangered Species Act, and the base is not subject to urban development pressures like surrounding private lands. This results in large tracts of protected, high-quality

Each bird is given a unique color combo, and with that information Winnicki and other researchers used spotting scopes and cameras with high-zoom capabilities to identify each individual sparrow and its behavior.

“

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Gabby Jukkala



A golden-cheeked warbler.
Credit: Steve Maslowski via Wikimedia Commons

habitat that are actively managed for the warbler and other wildlife.”

To capture the birds on their arrival in March, she used target mist-netting, which required audio lures. Instead of old iPods, Jukkala employed two Bluetooth speakers to attract the warblers. The study used a free sound-mixing app, marketed toward DJs, to choose and mix a variety of golden-cheek audio so that the birds wouldn't get accustomed to any one call. Both territorial songs and female vocalizations were used at different times of the season. Once the birds were released, Jukkala tracked them via color band resightings and took note of their nesting location. Nest success is determined by the number of baby birds that survive and leave the nest. In addition to newly banded birds, she monitored any returning birds in the study area.

Her results showed that younger males experienced higher nest predation because they began breeding later in the season and nested in lower quality habitat than older males, explaining their reduced reproductive success. What she found especially exciting was how her results can be used in statistical modeling of golden-cheeked warblers. By incorporating the reproductive rates of males at different ages, the population models of these endangered species can become more accurate and aid in conservation efforts.

Without the use of mist netting and bird banding, Pollock

and his colleagues wouldn't have been able to track tropical species' life spans and life history traits over time, Winnicki wouldn't know if the same males were nesting closely to each other, and Jukkala wouldn't know for certain if younger male birds had lower reproductive success than older birds and why. Mist netting was essential to analyze morphology, collect demographic data (age and sex), and track behavior in all three studies.

Setting up nets on that cold spring morning at Homer Lake was designed for much more than simply catching birds. It was about collecting data that's added to a larger dataset, the Bird Banding Laboratory, encompassing the North American continent. It was about understanding where birds move and migrate, and how their condition changes. Each bird banded makes our understanding of that bird's lifecycle and ecology more accurate — and increases our chances of conserving these cherished winged creatures for generations to come.



Lauren Brunk is a senior from Grayslake, Ill. majoring in Natural Resources and Environmental Sciences with a concentration in Fish, Wildlife,

and Conservation Biology, minoring in Integrative Biology, and pursuing the Certificate in Environmental Writing. She is doing research with NRES Adjunct Professor Jinelle Sperry, using eDNA and camera traps to study endangered and cryptic species, and NRES Professor Mike Ward, using radio transmitters to study owl migration. She is considering graduate programs in wildlife biology.



SOUNDING OFF

By Faith Maranion

The first time I went climbing outdoors began with a road trip to Wisconsin; it was my first visit to Devil's Lake State Park during autumn. A canopy of leaves hovered above the road leading into the park, while the surrounding trees embraced visitors with blazing oranges, fiery reds, and fading greens. Leaves fell from above, dancing from side to side in rhythm with the autumn breeze. Reaching the ground, they gently settled into inviting piles. Our tires drove over them with a crunch against the gravel. Rolling down my window, the crisp and fresh air filled my senses, but my attention quickly turned to the loud and abrupt bird calls — which I now know came from the great blue heron rookery. I couldn't see these birds, but I heard them. I could hear their deep and rowdy shouts, their long wings beating against the trees, and the falling branches hitting the ground beneath their nests.

The great blue heron. Credit: Devil's Lake State Park Area Visitor Guide



Great blue heron in profile.
Credit: Shutterstock

I was not essential to that ecosystem, but I changed the environment in more ways than I could see. As environmentally conscious travelers in natural areas, we are often careful not to litter or visibly harm the surrounding ecosystem, but we may forget to consider our sheer noisiness. From the buzzing of electronics to the hum of our car engines, we make noise wherever we go. Thinking back on my trip, I can still hear the traffic sounds on the road leading into the park and the music blaring from the car radios. While the noise created by one individual may not have drastic effects, the cumulative and sustained noise produced by entire populations of humans alters the way wild species live, even the lives of the birds who fly above us.

While I didn't get the chance to see a great blue heron that day, I did have a view overlooking the Devil's Lake, still and calm with only one kayak in sight. I wondered what this view looked like before becoming a popular park — before the hikers, climbers, and visitors, before the parking lots, paved roads, and widening trails. I wondered what it sounded like before the presence of humans — before the car engines, traffic sounds, and roaring aircraft. From such a height, I could see the park in its entirety: air,

water, flora, and fauna combining. With 115 bird species year-round and an additional 133 during migratory seasons, Devil's Lake State Park is a reminder that the residents and visitors most essential to this ecosystem are not the 3 million people who visit the park each year, but the non-human species who call this place home.

Birds are unique species that hold essential ecological roles within their natural habitats. No matter which trophic level they belong to, birds are important members of their ecosystem as predators, pollinators, scavengers, seed dispersers, and ecosystem engineers. The health of an ecosystem depends on birds' ability to plant and spread seeds, dispose of decaying waste, control the insect populations, and pollinate plants.

Birds are also of economic value to humans by providing ecosystem services, or "natural processes that benefit humans." These include providing resources like food and feathers, regulation of disease through scavenging, and cultural services such as bird watching and photography. While humans profit off the monetary value that can be generated from these services, birds are worth much more than what they can economically offer humans: their intrinsic value as a species, their essential ecological roles, and how other species depend on birds. When noise pollution interferes with the presence and behavior of bird species, the entire ecosystem feels its effects.

While not as obvious as air or water pollution, noise pollution is defined as any interfering noise that is harmful to humans and non-human species. Our world is filled with sounds, even without the presence of humans, but there is a difference between anthropogenic and natural noise. Sources of loud natural noises include wind, water, and animal sounds, which animals are familiar with and have adapted to: tree branches rattled by the wind, streams rippling over rocks, and the early morning chorus of birds.

However, sources of anthropogenic noises like machinery, aircraft, and traffic can influence an animal's ability to hear and interact with its environment — equipment that pounds and whirs, airplanes taking off for flight, and car engines humming. Animals are facing sound conditions beyond the natural noise they are used to; due to noise pollution, sound levels have doubled in 63% of U.S. protected areas. Protected areas are defined with the goal of ecosystem conservation by minimizing the effect of human activity, but noise pollution isn't often considered in these effects.

Although all species are affected in some way by noise pollution, multiple studies have been conducted to research the effects of noise on bird species. In 2015, a research group from the Department of Biological Sciences at Boise State University published a study investigating the effects of traffic noise on songbird species. This research group created a "phantom road" in south-



Chris McClure,
researcher at Boise
State University, sets up
the speakers to create a
"phantom road."
Credit: The Atlantic

The great tit (*Parus major*).Credit: *Śławek Staszczuk via Wikimedia Commons*

western Idaho by playing traffic sounds at stopover sites, or places where birds stop during their long flights. Using audio files recorded at Glacier National Park, the team created a playback to emulate representative frequency levels of traffic noise near protected areas.

Looking at the behavior of 51 songbird species with a total sample size of 9,924 birds, the study observed that 31% of the songbird population avoided the area affected by the phantom road. Instead of stopping to rest and eat during their migratory journey, many songbirds avoided the site, suggesting that these birds assessed this habitat to be unsuitable. The other 69% of the songbirds did not remain unaffected by the noise, though: Their overall body condition, which correlates to the energy the bird has for migratory flights, and their ability to improve this body condition were reduced compared to the birds in the control conditions without the traffic noise playback. The roads that we build, especially ones in the path of migratory flights, alter the behavior and well-being of bird populations.

In addition to influencing their migratory behavior, noise pollution alters the way in which birds communicate with one another. A joint study by researchers at Leiden University and Groningen University analyzed the acoustic behavior of birds of the great tit species (*Parus major*) in a national park in the Netherlands. For male-female communication, low-frequency songs are more attractive to female birds. In the presence of low-frequency noisy conditions, male birds are faced with two choices: singing at lower frequencies, which may result in not finding a mate because they are not heard, or singing at higher frequencies, at the risk of pairing with a less desirable mate. In environments with low-frequency noise such as those near cities and highways, male birds have been observed to sing at higher frequencies to be heard over this noise.

The presence of anthropogenic noise alters the typical mating behavior and reproductive success of the great tit. This study's findings identified effects of urban noise that extend beyond the great tit species. While male great tits can immediately shift their song frequency, other bird species such as pigeons and cuckoos do not share this ability. Since some bird species cannot adapt to anthropogenic noise, these bird populations could face decreased

breeding success.

Although total elimination of noise pollution is impossible, preventive measures and further regulatory enforcement can mitigate its effects. Since the 1970s, the U.S. Environmental Protection Agency has attempted to place noise limits on industries through the Office of Noise Abatement and Control. The goal of the Noise Control Act of 1972 is to reduce the effects of noise pollution that threaten human well-being by coordinating research, establishing noise standards for commerce, and informing the public. However, these goals have remained unfunded since 1982 because of a desire to transfer greater responsibility to state and local governments. Meanwhile, few states have addressed this issue of noise pollution, and jurisdictional boundaries limit the scope of state involvement.

Most noise pollution regulations were designed to protect the health and safety of humans, so the well-being of non-human species is not the top priority. Nonprofit organizations such as Quiet Use Coalition and Alaska Quiet Rights Coalition have stepped up for non-human species and their ecosystems. These organizations preserve quiet areas and protect public lands and wildlife from noise pollution by working with land agencies, educating the public, and advocating for protective policies. They play a key role in spreading awareness to the public about noise pollution and how it can alter animal behaviors and the health of ecosystems.

As individuals who contribute daily to noise pollution, we should be aware of our noise levels when in protected natural areas while also advocating for policies that can propel systemic change. To substantially mitigate the effects of noise pollution, federal and state noise controls that specifically address the conservation of wildlife must be implemented and properly enforced. While we may not always consider the noise pollution we create as a human population, the birds are listening — to our noise and to our silence.



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graduating, she is interested in working in the field of drinking water treatment.



When I met up with University of Illinois senior Colin Dobson one morning in Fall 2021, he greeted me with a smile, a camera around his neck, and a Target bag full of dead birds.

Let's backtrack.

No, Colin isn't a serial bird killer or obsessive taxidermist — he's a birder conducting research.

Small Birds

BIG IMPACTS

By Eva Bein



An American robin encounters one of the many oddities of the manmade environment: glass windows.

Credit: Wildlife World

Ornithology is the official name for bird science, while “birders” are hobbyists who observe or identify birds in their natural habitat. Ornithologists rely on birders in the field. After spending time with Colin during his bird collection walks, a twice-daily routine where he collects data for a bird strike survey on the University of Illinois campus, I’ve come to know birders as an enthusiastic community with an unparalleled appreciation for the natural world.

As I ventured into the Engineering Quad, the early morning sun was bright against buildings lined with clean, long, reflective windows. The U of I campus offers a perfect example of why cities are major death zones for migrating birds. Birds get confused by the reflective glass and light from windows and accidentally strike them mid-flight, causing over 1 billion bird deaths a year in the U.S and contributing to declining avian populations. The weight of that number of dead birds is comparable to 550 loaded coach buses.

While humans tend to avoid windows better than birds, window strikes aren’t an act of stupidity by birds. In fact, whether birds are migrating 500 miles, like the ruby-throated hummingbird, or more than 25,000, like the arctic tern, birds are quite smart and know exactly where they’re going. They have their own GPS system called “internal magnetic focus.” Their eyes work as the compass as they physically see the direction of the magnetic field on the Earth, while magnetic material in their beak acts as the map that shows the strength of the field, leading them in the right direction. Their eyes can adjust to light twice as fast as a 20-year-old human, and they rapidly adjust the lens to zoom in and out while navigating or searching for prey.

Bird strikes generally stem from two reasons out of birds’ control: glass reflections and light confusion. Windows reflect trees, sky, and other vegetation nearby, making it hard for a bird to distinguish what is real and what is simply a reflection of its surroundings. Clear glass



When people first learn about glass collisions, many assume that brightly lit skyscrapers at night pose a special threat. However, most collisions take place during the day, and almost half occur at home windows; low-rise buildings account for almost all of the rest.



The American Bird Conservancy



The ghostly imprint of a mourning dove on a window after a collision. Credit: Portland Audubon



The Beckman Institute's numerous reflective windows make the campus building a hotspot for bird strikes.
Credit: Eva Bein

also causes collisions if a bird is simply trying to reach the landscape on the other side. When the sun goes down, birds flying at night encounter a different host of problems. Birds navigating in the dark depend on celestial cues, such as stars, along with their internal GPS system. With streetlamps, lit-up buildings, and other light pollution invading their vision, birds end up confusing their cues and colliding with buildings. The American Bird Conservancy shows how common bird strikes are in any area, not just those with tall buildings. According to its website, "when people first learn about glass collisions, many assume that brightly lit skyscrapers at night pose a special threat. However, most collisions take place during the day, and almost half occur at home windows; low-rise buildings account for almost all of the rest."

Of course, bird strikes are not the only cause of the decline in bird populations. Cats remain one of the biggest causes of death, proving the classic cat and bird arch-nemesis theory correct. The U.S. Fish and Wildlife Service notes that habitat loss poses the next biggest threat, while getting hit by cars, running into wind turbines and

electrical wires, and poison from fertilizers and other chemicals likewise contribute to the mortality numbers.

Back on campus, the biggest threat to birds appears to be some of the U of I's newer buildings: the Gies College of Business Instructional Facility and the Beckman Institute, to name two. A common trait of these buildings? Clean, long, reflective windows.

The GEEB Bird Strike Survey that Colin is working on originated in 2019 from Integrative Biology graduate students who were also in ecology and evolutionary biology fields, or GEEB. These students launched their project out of curiosity for which buildings were most harmful to birds and which birds were striking buildings the most. Colin, majoring in Natural Resources and Environmental Sciences, took over a few seasons later. During the Fall 2021 data collection, over 200 birds were found along the main campus routes, creating an average of more than 1,000 noted dead birds over the past five seasons. During fall and spring, when birds are migrating, volunteers conduct counts twice a day across campus to collect data. Results have already shown that fall migration leads to more strikes than the spring and that birds are more likely to strike windows in the direction from which they're migrating.

When I finally connected with Colin — camera, bird bag, and all — we walked the perimeter of each building on the campus route, scanning the ground for any fatalities. To an unsuspecting student strolling through campus, this data collection can be quite a sight. Colin told a story about being seen holding seven Ziplock bags of dead birds. "I was definitely getting looks," he laughed.

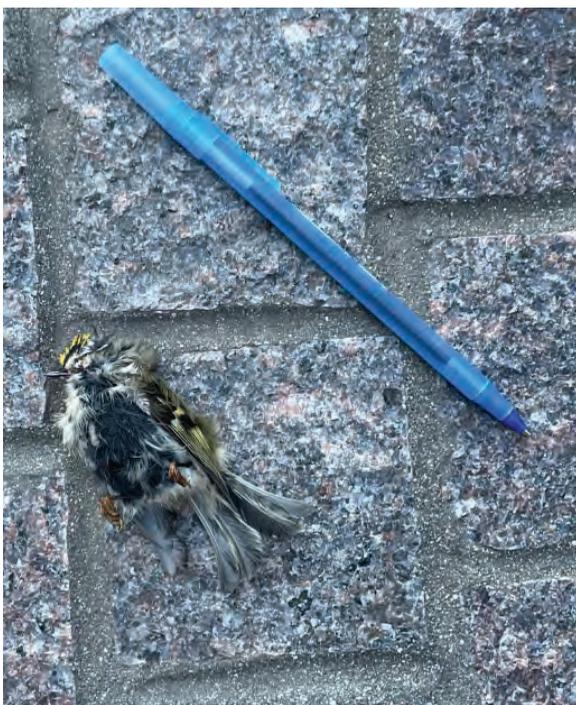
While it sounds odd, bagging dead birds provides valuable data on what local and migrating populations look like during this snapshot of time. This type of information is especially important with our changing climate. With an unpredictable future ahead, this data will prove valuable to scientists looking to make comparisons to the early 21st century.

As we circled Grainger Library, I soon spotted a small blob on the ground followed by an uneasy rush of excitement.

We'd found our first bird.

Colin gently scooped up the northern parula, turning it over to examine its different features, and explained how the blue and yellow coloring clued him in to what species it was. A few feet away lay a yellow feathered golden crowned kinglet that was less than half the length of my ballpoint pen and looked only a few inches wide. For both birds, Colin logged the information: date, route, time of day, building, and direction the window faces. As we went through the routine data collection process, I felt an interesting mix of emotions. It was sad to see the death

A golden crowned kinglet found on the Window Strike Survey. *Credit: Eva Bein*



of such delicate creatures; yet these feelings were mixed with the scientific drive of the data collection. "Yeah," Colin grimaced with a downward glance. "It does get pretty sad. We've collected up to 33 birds in a single day." Whether these birds are traveling from places like Peru, Argentina, or the Caribbean, Champaign is where their migration journey prematurely ends.

We headed toward the south side of campus with the sun above our heads, keeping our eyes glued to the perimeters of buildings along the way. Colin explained how they've logged 52 different species of dead birds just this past season, which sparked a conversation on just how many birds he's actually seen and identified. As the president of the Champaign County's Audubon Society, he's observed birds in all 102 counties in Illinois and has even explored birding internationally. No matter what animal I thought of, from Canada Geese to tropical parrots fit to star in a Disney animation, Colin had a photo or adrenaline-filled bird chasing story to go along with it. He gave me the scoop on how expansive the birding community is, as well as how intense bird watching — and chasing — can truly get.

Colin's passion for birds naturally led him to helping to protect them. The Bird Strike Survey's goal is to raise awareness, collect data, and help with future architectural decisions and solutions when it comes to creating a bird-friendly campus. Colin explained that the survey has finally reached the ears of the Facilities & Services (F&S) administration on campus, who have inquired about the best ways to mitigate the problem. Adding glaze or footing to windows can be a way to add texture and signal

to birds that something is there without the entire cost of replacing the windows. Turning off lights or adding blinds can also prevent unnecessary bird strikes. Colin stressed that, unfortunately, making changes to windows across campus will take large amounts of time, money, and energy, although based on his recent communications with F&S he does have hope that positive changes will take place.

Just before we ended our trek at 9:20 a.m., we catalogued our last fallen bird, a dark-eyed junco. Our route came to an end at the Natural History Building, where we delivered the birds to their freezer storage. I opened the door and came face to face with 300 bagged birds. We couldn't help but dig through the different species as if it were a morbid prize bucket. Fascination trumped fear as I looked at these birds, to be preserved for years to come. While we only stood in the tiled hallway of the Natural History Building for a few minutes, I couldn't help but feel like I was a part of a little piece of ornithological history in the making.

Birds are vital to our planet's ecosystems, and they are icons of freedom and beauty across cultures; yet a birder's appreciation of them goes a step beyond. For Colin, they hold an intrinsic value, worthy of appreciation regardless of their scientific value. That passion makes the unnecessary deaths of birds due to thoughtless building design particularly hard to swallow.

Bags of dead birds should not be the cost of this deep appreciation for ornithology. With some building fixes and progressive design approaches, we'll be able to keep our bird watching up in the sky and the trees rather than directed to the ground. And we'll save millions of birds in the process.



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A Murder of Crows

By Lily Reynolds

Chaos. That is the best word I could use to describe it. Bird feeders filled to the brim with seeds sat in between the nets that we set up to capture and band the migratory birds for research. One after another, a bird, flying toward the feeder in pursuit of food, hit the net. In their struggle, the birds became a flurry of colorful feathers as their delicate limbs became entangled in the fine mesh nets. That is when the clock would start. We only had a short window of time in which the birds could be safely left ensnared in the net. We had to work fast and delicately untangle their wings as they fought and cried out against us. While holding the birds in our hands the pounding of their small hearts was an indicator of their stress levels. Students had handfuls of bagged birds waiting to be weighed, banded, and released. A goldfinch, then a titmouse, even a common redpoll. The birds were endless. It was a race to get them inside, observe the procedure of the wildlife biologists, release them, wash, rinse, and repeat. In the background of all this chaos, we heard them mocking us. "Caw ... Caw ... Caw ..." Crows: The uncatchable bird. Earlier that morning, before the chaos, we had been told it was unlikely we would catch crows.

The morning began in my friend Paola's silver Honda. The smell of cheap coffee and McDonald's hash browns wafted through the car as we rolled up to the nature center at Homer Lake, barely 15 miles from the University of Illinois campus. We needed the coffee, because we were not yet accustomed to the early schedule for viewing and capturing migratory birds. Throwing on our warming layers, we trekked through the nature center until we reached a room crammed with our classmates. Hand paintings of trees and natural scenery covered the walls, and the trickle of water from the filtered turtle tanks filled the silence as we waited for our instructor and teaching assistant to join us. Once everyone had filed into this room, no larger than an average living room, we heard the rundown. We would first set up fine mesh nets called mist nets outside the center by the feeders to capture birds. Once the songbirds became entangled in the net, we would untangle them, bag them, study, band them, and then release them. The whole process, we were told, is quick once you get the hang of it.

As we untangled the mist nets, we saw a giant mass of corvids heading toward us. A voice in the crowd asked, "What would the protocol be if one of those flew into our net?"

The experienced birders chuckled. "It is highly unlikely. They are too smart. But if we do catch one, I'll let one of you deal with that sharp beak."

We laughed, but it struck me. They are too smart? The birds that frequent refuse piles? That farmers put up dummies to scare? That can't be right. I am brought back to the royal garden in Sweden where I had my first up-close experience with crows. My classmates and I observed jackdaws (members of the crow family) battle over a slice of cheesecake at our café table. Sugar coated their beaks in an almost comical fashion. Surely these cannot be related to the geniuses capable of evading our clever traps. But as I would soon come to discover, there is much more to these creatures than I had previously thought. Many of the assumptions that I held were due to myths about crows I had been exposed to.

Throughout history, crows have been given a rotten reputation. Symbolizing death, bad luck, and even being accused of starting the bubonic plague, they have been met with harsh persecution. Crows have had to evade countless extermination attempts worldwide such as bombing, poisoning, and shooting. In Greek mythology the raven was associated with the god Apollo and was cursed with its jet-black feathers due to the raven's inability to successfully watch over Apollo's mistress Coronis. To a superstitious individual, the number of crows holds significance. If five crows are spotted outside of a home, disease will befall the household. Western

literature has further spread crow hatred. The works of Shakespeare and Edgar Allen Poe have managed to give the bird a sinister meaning for their audiences. In Shakespeare's famous play *Macbeth*, crows and ravens are symbols that foreshadow evil afoot, and the eventual death of King Duncan. "The raven himself is hoarse that croaks the fatal entrance of Duncan under my battlements" (Shakespeare, trans. 2021, 1.5.38-40). Shakespeare mentioned corvids so frequently in his writings that author Jemima Blackburn was able to write an entire book in 1899 titled *Crows of Shakespeare*.

Despite this unfortunate negative portrayal of crows throughout history, many species like the American crow have managed to persist regardless of humanity's best efforts to remove them. They have been so successful it can be difficult to imagine a world without them. You can find them nearly anywhere: landfills, cornfields, backyards, stadiums, powerlines, and rooftops. Their characteristic vocalization and sleek glossy black feathers are unmistakable. The reason for their success can be attributed, in part, to their generalist nature along with their impressive intelligence. Capable of thriving in diverse habitats, they inhabit most areas of the continental United States.

Crows do more than survive; they are fiercely intelligent. In one study a crow named Betty was able to select the appropriately sized wire to create tools to reach inaccessible food in a lab. Tool use, a trait often associated with the beginnings of mankind's rise to power, has been widely observed in New Caledonian crows. These geniuses have been observed manufacturing spear-like tools out of pandanus leaves to acquire grubs under leaves.

Crows' intelligence is not exclusively mechanical, but emotional as well. Author Thom Van Dooren noted in his book *Flight Ways* (2016) that crows have been observed to leave offerings on dead crows. Grieving death is a trait, like tool use, that is unjustly associated solely with humans. We like to believe that we are the only beings truly capable of perceiving life and death on this planet,

A crow vocalizing.
Credit: Tim Mossholder
via Pexels





When wearing masks to test crows, researchers also carry signs that explain what they're doing for any curious (or nervous) human bystanders.

Credit: Willamette Biology

Like their New Caledonian relatives, they, too, have been observed to use tools to acquire food. Unlike their relatives, however, they were devastated by the swift colonization of Hawaii in the 19th century. Habitat fragmentation, invasive species, and persecution all led to the downfall of the 'Alalā. This loss, along with the overall loss of 50% of avian biodiversity, may have led to a cascading effect on the forests of Hawaii.

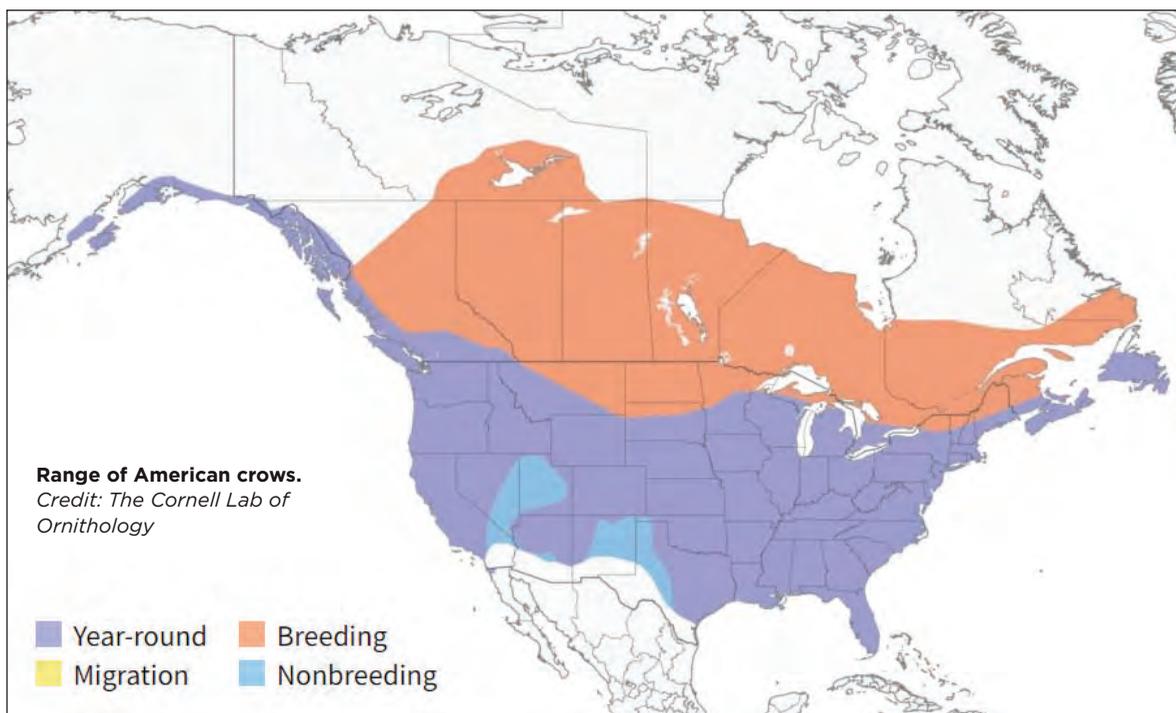
While crows are fascinating in and of themselves, they are essential to ecosystem health. Threats to crows are threats to all, as the Hawaiian examples shows. Susan Culliney and her colleagues examined the role of the 'Alalā in shaping plant communities and developed a study to determine the importance of the reintroduction of the 'Alalā. Birds are often important dispersers of seeds for plants. As they carry seeds away from their parent plants, they decrease the chance of intraspecific competition. Birds gain a meal from the fruit around the seeds, while the seeds hitch a ride to a new location that could increase their ability to thrive. Multiple large-fruited plants in 'Alalā's past range are now rare or endangered. The reintroduction of 'Alalā to these areas could help restore these plants and trees to their natural abundance.

Scientists also developed an experiment on a captive 'Alalā population in which they recorded eating, carrying, and caching behavior (food-storing behavior) along with seed germination success from droppings and pellets. Some plants experienced possible negative effects from crows ingesting their seeds but most noticed little to no effect, while others like the threatened Hō'awa experienced greater success after crow ingestion. This shows that these crows play an essential role in their

but this is a wrongful assumption. Grieving crows would beg to differ.

Another one of the more renowned crow studies was done by researcher John Marzluff, who used troll-like masks on volunteers capturing crows in the wild. This study proved significant in demonstrating that crows can recognize "good" and "bad" people. Crows would attack and taunt volunteers and continued to do so 14 years after the initial study. This ability to recognize individuals is an important trait to have to survive the Anthropocene and years of persecution. An internet trend recently emerged in which people attract and feed crows to gain their trust and receive shiny gifts from the birds. It is important for crows to remember these safe sanctuaries and be able to distinguish friendly backyards from those that deploy netting, spikes, and electrical deterrents to eliminate them.

Some species of crows have not been as lucky as the American Crow. The Hawaiian crow, otherwise known as the 'Alalā, is extinct in the wild. This is not because they lack the intelligence of their American counterparts.



ecosystem's function. Their loss has caused irreparable damage to their native habitat as a direct result of human actions. The scientists' results suggest that restoring the 'Alalā population could save conservationists time and thousands of dollars by allowing the 'Alalā to do the work of reforestation. This plan, however, relies on the survival of 'Alalā in the vastly altered environment of present-day Hawaii. The stretches of forests which they are historically accustomed to have been replaced by invasive species and parking lots. It is imperative that these natural processes be restored because seed dispersal comes effortlessly to these native dispersers. Culliney and her colleagues urge conservationists in Hawaii to consider focusing on strategies such as captive breeding efforts and developing suitable restored sites to allow the 'Alalā to function as productive members of their native habitat.

Persecution, habitat fragmentation, and climate change still impact multitudes of species today — not only our charismatic crow. According to some scientists' predictions, we are undergoing the sixth mass extinction event. The loss of one creature is enough to cause a cascading effect on other organisms along with their habitat. Often, we take for granted the ecosystem services birds provide, like seed dispersal. These services often become overlooked, and the fate of these creatures teetering on the brink of extinction relies on the stories we tell. Through stories, creatures like crows become more than a name, and instead a part of something greater. It is not merely the loss of one species but an unraveling of their way of life that impacts their fellow creatures, plants, and us. Our fates are interwoven with those of crows and all of the creatures in their ecosystems. Stories like the 'Alalā must be shared if they are to have a place with us in the future.

Though the 'Alalā population might still have a chance to recover and be reintroduced to their native range, the same cannot be said for other fruit-eating bird species that once inhabited the Hawaiian island chain. It is up to us now to restore these natural places for future generations of humans, birds, plants, and other lifeforms. This begins with telling their stories. They are not a nuisance to scare away, trap, bomb, poison, and shoot. There is an ecological significance associated with every creature, even us.

This is what I am reflecting on as I continue my avian research in Illinois. These days, I'm waking at 3 a.m. to ensure I get to the field site on time to help a graduate student with her lark research. We pull a long rope with attached soda cans through a field to flush out the eastern meadowlark mothers from their nests. It is grueling work. We walk for miles through lumpy grassland, but I dare not complain. Our aim is to better tell the stories of meadowlarks. We want to capture birds who were once tagged so we can tell the story of where they came from.

An adult Hawaiian crow using a tool.

Credit: Ken Bohn via San Diego Zoo Global



We want to know how many nests they are laying and how many are successful.

Most people that I am close to don't care about crows and have never seen a meadowlark. They have never heard their stories, but now that I am a working bird conservationist, my roommates and my family hear about my work and now share concerns about the declines of these birds. They send me photos of birds and it warms my heart. It is imperative to share these stories with our friends and families, and to continue being curious and seeking them out so we can appreciate our beautifully entangled world and the intricate relationships woven throughout.

When you're next idly watching a crow, be aware the crow is watching you back. They know our patterns and our routines. As our landscape becomes scarred by human hands, they observe these changes. As the prairies and wetlands of Illinois have become obsolete in the age of corn and soy, these birds have had to improvise, adapt, and overcome. As weather patterns become more unpredictable and hazardous, they will need to take shelter somewhere. Watching crows, I wonder if they're thinking, "What kind of creatures are these humans?"



Lily Reynolds is a senior majoring in Natural Resources & Environmental Sciences with a concentration in Fish, Wildlife, and Conservation Biology. She is passionate

about pollinators and birds and hopes to work with them further as a field technician before applying to graduate school programs in wildlife conservation.



By Tori Ruzzier and Sydney Sadler

SUCCESS STORY

As the clock struck 10 a.m. one day in 1969, weathered shoes shuffled across Green Street in front of the Illini Union. With coffee steam billowing out of their styrofoam cups and ties tied tight, aeronautical engineering student Clark Bullard and geography student Bruce Hannon wandered down the street until they ran into another man, machinist and avid fisherman Bob Bales. Though the morning coffee meetings were meant to be between the grad students and their advisors, this day would prove to be much different — so much so that it would change the course of their lives and inaugurate one of the most famous environmental battles in Illinois history. Bullard, Bales, and Hannon didn't know it at the time, but they would soon be leading the fight to protect the Middle Fork Vermilion River.

The Middle Fork is truly an ecological wonder worth protecting. Not only is it the single most biodiverse river in Illinois and the sole certified "National Scenic River" in the state, it's a natural treasure to the people of Danville. It's the place Bullard, Bales, and Hannon raised their children, spent days identifying the many bird species that call the Middle Fork home, and discovered bliss canoeing its rushing waters.

This past March, we had the pleasure of sitting down to talk with Bullard a half century after the battle between environmental advocates and dam-building companies over the Middle Fork first began. Bullard is just about the most right-brained engineer you'll ever meet — though he's incredibly humble about his poetic streak. As he spoke, we realized that his story included lessons that the young environmentalists of 2022 needed to hear.

The First Rumbblings of a Fight

Bullard traced the origins of the dam fight at Middle Fork to a hearing in 1967, where Bales spoke to the environmental organization the Izaak Walton League. Bales informed locals that the Army Corps of Engineers had started creating a reservoir that would cause irrevocable damage to the Middle Fork of the Vermilion River. By the time of the hearing, the Corps had already planned to dam up streams all over Illinois so that “almost every river was slated for a reservoir,” Bullard said.

“The Corps would wait for a drought and go to a community and say, ‘We’re going to cure your drought problems with a reservoir!’ ” Bullard said, chuckling at the hypocrisy. “And they wait for a flood, go to flooded communities, and say ‘A reservoir is the answer!’ ”

Following the Corps’ announcement, politicians joined the Corps in convincing Danville locals that a reservoir would help them. However, their reasoning was based on finding a solution to Danville’s “economic problem,”

as former Danville Mayor Scott Eisenhauer said in a 2011 documentary about the dam fight. He reminisced about how the reservoir plans promised to bring “tourism to Danville” and promote the idea of central Illinois as a place of “recreation.” What was not specified was that the “recreation” the reservoirs promised promoted the use of motorboats. “That’s what this reservoir is all about. It’s really about people who can afford a motorboat,” Bullard said. While canoeing is still a viable option in streams, motorboating requires the killing of the river’s flow so that a boat can better move against the current. When a river’s flow stops, it reduces its inhabitants and makes it nearly impossible to keep clean, subsequently killing its ecosystem.

The Vermilion River’s Ecosystem: A Diamond in the Rough

The Vermilion River is home to 97 species of fish, 46 species of mussels, 16 species of large crustaceans, and 540



Canoeing down the Middle Fork is the best way to understand how important this scenic river really is. *Credit: Kickapoo Adventures*

For each measurement, the streams are graded from A-E, like a report card. The streams with higher grades are deemed “Biologically Significant Streams” (BSS). While most Illinois streams have C-E levels, the Middle Fork is almost entirely made up of Biologically Significant Streams with grades in the A-B range.

species of aquatic macroinvertebrates (VRCOA Action Plan 2011). Some of these are considered “focal species” — the Iowa darter, the smooth softshell turtle, the wavy-rayed lampmussel, and the rainbow mussel. These earn the name of “focal species” because they act like the proverbial canaries in a coal mine. Because indicator species like the wavy-rayed lampmussel are so sensitive to pollution and habitat loss (which dams certainly cause), scientists can monitor the health of these streams by monitoring them.

What’s so important about this research is that it determines which streams need which type of care. According to the Streams Campaign, Illinois streams are measured by their “integrity” (the stream’s capability to support its ecosystem) and their “diversity” (the biodiversity of the stream’s ecosystem). For each measurement, the streams are graded from A-E, like a report card. The streams with higher grades are deemed “Biologically Significant Streams” (BSS). While most Illinois streams have C-E levels, the Middle Fork is almost entirely made up of Biologically Significant Streams with grades in the A-B range.

Interestingly, just because a stream has BSS status does not mean that it stops being monitored and protected by

the IWAP. The Streams Campaign and the Committee on the Middle Fork not only pay attention to Illinois streams when they are dying but try to protect them while they are still strong. Too often, we flock to environmental causes only when we feel guilty or face the imminent loss of a natural treasure. Treating the environment as something to protect and relish regardless of its health demands that we shed our savior complex. This is precisely why it was such a shock when a river as pristine as the Middle Fork came under threat and why it became so important for Bullard, Bales, and Hannon to start a movement.

A Committee is Born

Bales’ outspokenness in 1967 prompted single-issue groups to pop up everywhere to combat the widespread dam propaganda. This included the Committee on Allerton Park, formed to stop a similar dam project on the Sangamon River, which Hannon already headed at the time of the Green Street meeting in 1969. During that meeting, Hannon actually suggested to Bales to give up on the Middle Fork and join the Committee on Allerton Park instead since the single-issue groups had competition for volunteers. It was then that Bales turned to Bullard in the hopes of getting an engineer on the Middle Fork team. Bullard was hesitant at first. At the time, he was a student with no idea how his aeronautical engineering studies could contribute to the environmental movement. However, Bales convinced Bullard that his understanding of fluid mechanics and, therefore, the flow of water, made him the perfect person to debunk the dam-building companies’ engineering reports. After that conversation with Bales, it didn’t take much convincing for the nature-loving engineer to join the cause.

From that moment, Bullard and Bales formed the Committee on the Middle Fork Vermilion River. Eventually, Hannon would also join the committee while simultaneously fighting for Allerton Park. Their first order of business was to draw public attention to the threats made against the river with the reservoir proposal. Bales believed the best way to get the message out was to show the public what was at stake. Hoping to gain public support, Bales, his wife Sandy, Bullard, and his wife Irene would load up a canoe and shuttle down to the river bank with visitors who were willing to explore the natural wonderland in



The Wabash River watershed with the Vermilion River highlighted. Credit: Kmusser via Wikimedia Commons



The smooth softshell turtle is one of many species that call the Vermilion River home.
Credit: Kmusser via Wikimedia Commons

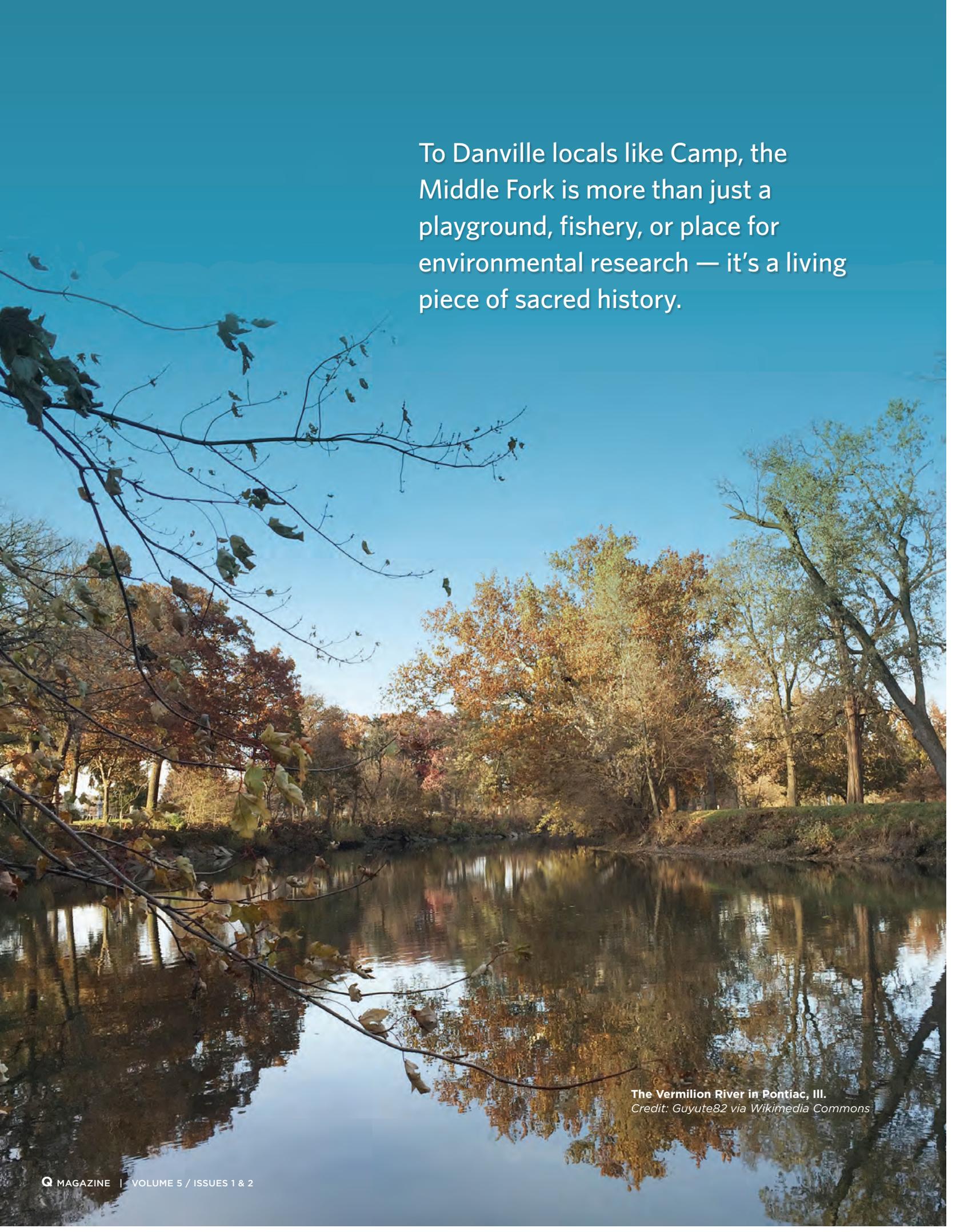
“By 1976, when the big vote came up, we had 10,000 letters on legislators’ desks, handwritten, you know, real letters” that were collected as support for the Middle Fork began to catch the wind in its sail. Covering miles across the plains and prairies of Illinois, the committee spared no effort to rally support for saving Illinois’s most biodiverse river.

their Midwest backyard. Bales was known for saying, “I just let the river sell itself,” and through his journeys he opened the eyes of many supporters. The volunteers of the committee knew that if more people could just see the wonders that this river held, they, too, might just fall in love. Bullard mentioned how he and his wife “would take people down the river from 1970 to ’76, probably 80% of the Saturdays and Sundays from March to September.” While the team continued taking visitors down the rivers in canoes, they also turned their efforts toward a new strategy to gain more attention for their cause.

Before the days of social media and digital circulation, these environmental activists had to physically get out to spread the message as decision time for the reservoir fast approached. Bullard told us that on weekends, he and his fellow volunteers would pack up their cars and fan out across the state with petitions hoping to find anyone who would listen to their urgent message. Sandy Bales was an artist who played an essential role in crafting their message into one that would appeal to potential supporters. After Sandy asked, “What’s going to happen to all that land?” the team came up with the idea of “a river

corridor park,” which would turn the Middle Fork into a more environmentally friendly recreational amenity for the public. The team members then produced a little map hand-drawn of what the park would look like and printed up lots of copies and passed them around everywhere they went in the state. Additionally, Bullard made use of a “35-millimeter slide projector and cassette tape recorder and got them coordinated on a boombox and played them” at each of the stopping points throughout the state. His improvised presentation explained the urgency of the situation — and the danger that the Army Corps plans posed.

At the end of each presentation, the Committee on the Middle Fork Vermilion River would ask for anyone willing to pledge their support through their petitions. Bullard mentioned that “by 1976, when the big vote came up, we had 10,000 letters on legislators’ desks, handwritten, you know, real letters” that were collected as support for the Middle Fork began to catch the wind in its sail. Covering miles across the plains and prairies of Illinois, the committee spared no effort to rally support for saving Illinois’s most biodiverse river.



To Danville locals like Camp, the Middle Fork is more than just a playground, fishery, or place for environmental research — it's a living piece of sacred history.

The Vermilion River in Pontiac, Ill.
Credit: Guyute82 via Wikimedia Commons

Bales and Bullard knew the only way to allow Thompson to fully understand the gravity of the Middle Fork was to return to basics — to go down the river in a canoe.

Statewide Attention

The committee needed a legislative superpower to back its cause, which just happened to align with the agenda of then-gubernatorial candidate James R. Thompson, who would later become Illinois' longest-serving governor. In 1976, while the fight to stop the reservoir was heating up, Bullard and Bales approached Thompson to brief him on the situation. He saw their careful, detailed research and decided to join the fight. Bales and Bullard knew the only way to allow Thompson to fully understand the gravity of the Middle Fork was to return to basics — to go down the river in a canoe.

Days before Thompson was set to journey down the river in a canoe, Sandy went out early the morning before and removed the large rocks from the riverbed that would have stopped the canoe where the river went shallow — a seemingly trivial precaution but essential to enlist a “land-lubber” politician in their grassroots effort. When the day came, Thompson climbed into the canoe and was instantly spellbound by the Middle Fork. There were members of the press present to document this monumental moment. In his interview, Bullard smiled as he recalled that Thompson held the oar upside down, betraying just how out of his element he was in his fight for this beloved river.

Thompson's commitment was significant politically because his declaration to oppose the reservoir meant he was publicly challenging the current governor at the time, Dan Walker, who had declared he was in favor of its construction. It turned out that winning this battle meant multiple successes: Thompson won the election for governor, and the Middle Fork gained another champion.

At the Heart of the Fight

In a 2011 documentary on the Middle Fork campaign, Bullard compared the experience of being immersed in the area to attending church “to reinforce a set of values.”

“To have an attachment to the land, to America, to Illinois, to East Central Illinois, you feel this attachment that is reinforced every time that you visit the place,” he said.

Mike Camp, a resident of the Middle Fork Valley whose farming family has lived in the area for almost 200 years, reinforced the belief in the land as a sanctuary in a newspaper clipping from the time of the dam fight: “I am neither an ecology buff nor a canoe enthusiast, but I know God has given us a natural beauty, and by some stroke of luck, it is one of the clean streams in Illinois.”

To Danville locals like Camp, the Middle Fork is more than just a playground, fishery, or place for environmental research — it's a living piece of sacred history. “I would like to see this natural heritage preserved and passed onto future generations,” he said. When the dam-building companies started pressuring the locals to sell their houses in order to build the reservoir, they were threatening whole family legacies that could never have a price put on them. “They wanted to give us \$11,000 and we said, ‘No way. You'll see us in court first,’ ” resident Peggy Mosher said in the documentary.

At the heart of the reservoir issue was not just the irreversible damage to a biodiverse river but the fact that the promises made to Danville residents about the economic benefits of a dam were hollow. Building a reservoir in the Middle Fork would only reinforce the all-too-narrow definition of “recreation” as something exclusively for the upper class while disturbing the natural flow of the river and destroying its biodiversity.

At the heart of the reservoir issue was not just the irreversible damage to a biodiverse river but the fact that the promises made to Danville residents about the economic benefits of a dam were hollow. Building a reservoir in the Middle Fork would only reinforce the all-too-narrow definition of “recreation” as something exclusively for the upper class while disturbing the natural flow of the river and destroying its biodiversity.

In the end, many people ended up forcibly removed from their homes in the dam fight scuffle before the reservoir funds had dissolved. “They lost everything, and they weren’t going to build the reservoir anyway,” said Camp, expressing the immeasurable loss that locals like him experienced. Though the Middle Fork Valley will “never go back to what it was,” locals find solace in the knowledge that initiatives like the Streams Campaign now protect the valley and that “everybody can enjoy” the park it has become.

History Repeats Itself

Though the battle against the Army Corps of Engineers was won, the war was far from over. After that initial dam project lost funding in 1976, a new threat immediately emerged with the same intentions: to dam up the Middle Fork. “General Motors wanted to build a plant ... they were going to build a brand new car,” Bullard said, and they were going to need a reservoir for that plant. It was incredible how closely history repeated itself. Not only were the same environmental factors put at risk in this

plan, but it turned out to be yet another story of corporate-class CEOs manipulating working-class residents. While the United Auto Workers organized to promote the building of the reservoir in Danville with the promise of creating more jobs, General Motors ended up moving their dam plans to the non-union state of Tennessee instead — specifically to avoid giving jobs to the auto workers of Danville.

After two grueling battles against dam-building companies, the Committee on the Middle Fork Vermilion River decided that it was time to take national legal action and apply for a National Scenic River designation for the Middle Fork. This designation would become the final nail in the coffin for the reservoir project, but it wasn’t granted until more than a decade after the General Motors battle. Until then, the committee worked with every prominent state and national politician — against the headwinds of Ronald Reagan’s anti-environment administration — to finally receive the 1989 designation from the generous hands of Gov. Thompson. “So, that’s how the dam died, finally,” Bullard said.



Iowa darters, which can be found in the Vermilion River. Credit: Jennifer Knutson via Wikimedia Commons

Environmental work takes organizing, volunteering, and many, many generations, but that doesn't mean success is unachievable. The free-flowing Middle Fork of the Vermilion River is living proof of this.

'To thy Happy Children of the Future, Those of the Past Send Greetings'

What's amazing about this fight is that every single threat was defeated. Equally amazing is how unending the fight really is. Though the Middle Fork's National Scenic River designation has kept it protected from any more dam projects, it hasn't been able to protect the river from all environmental threats. In terms of public land per capita, Illinois is ranked 46th out of the 50 states, which makes rivers like the Middle Fork extremely vulnerable. As recently as 2021, the Prairie Rivers Network (which grew out of the Committee on Allerton Park) fought a years-long struggle to stop the energy company Dynegy from dumping coal ash into the Middle Fork and force it to clean up the pollution it had already caused. Unfortunately, building parks and taking legislative action aren't enough to permanently protect the environment.

"The lesson here is simple: Laws and regulation alone do not protect rivers. People do," Bullard wrote in an article for *American Rivers*. Threats of privatization surrounding the river will likely persist, but it is through the work of real, passionate people organizing together, like Bullard's committee and the Prairie Rivers Network, that our natural wonders are preserved.

Today, the conventional wisdom of what environmental activism looks like is: 1. Environmental efforts are secondary and not connected to other social issues; 2. Take shorter showers and everything will be solved; or 3. Environmental issues are caused by corporations and individual people can do nothing about it. Never before were we so moved to think the opposite of all these so-called truisms than when we listened to Bullard's story.

"The lesson here is simple: Laws and regulation alone do not protect rivers. People do," Bullard wrote in an article for *American Rivers*. Threats of privatization surrounding the river will likely persist, but it is through the work of real, passionate people organizing together, like Bullard's committee and the Prairie Rivers Network, that our natural wonders are preserved.

"It's good to have young people involved in the fight. Because it's going to be a long one," he said. Environmental work takes organizing, volunteering, and many, many generations, but that doesn't mean success is unachievable. The free-flowing Middle Fork of the Vermilion River is living proof of this.

If you ever visit the Middle Fork, remember that it would be nothing more than a large, stagnant pond if it weren't for the Committee on the Middle Fork Vermilion River. Its sparkling waters testify to the decades-long commitment of a small group of Champaign activists to protect this unique waterway. One of the state's proudest rivers still runs free because of these true believers who never gave up the fight for its preservation.



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TRAIL OF DESTRUCTION

By Zoe Huspen

Outdoor enthusiasts have enjoyed the Kickapoo State Recreation Area in Vermilion County, Illinois, for decades. It provides an opportunity to experience the scenic landscape that Illinois has to offer, with forest-covered hills, picturesque waterways, and miles of biking and hiking trails. Visitors hike, swim, kayak, and mountain bike through Kickapoo nearly year-round, from the breezy spring through the hot summer to the crisp autumn months.

Kickapoo is not solely enjoyed by humans, though. This area is also inhabited by bird species, plants, and soil in dire need of conservation. The popularity of Kickapoo's biking trails represents a new struggle over the delicate balance of conservation and tourism revenue. Human overuse of natural areas such as Kickapoo threatens biodiversity because species may be pushed out of their typical habitats, a phenomenon of our increasingly urbanized world. The issue at stake, at Kickapoo and other popular natural sites around the globe, is how healthy recreation and nature conservation can coexist.



Kickapoo State Park's Trail Six.
Credit: Nicolas Mann

Mountain bikers currently enjoy 25 miles of trails in Kickapoo, which attract a wide range of cyclists throughout the Midwest. The state plans to expand these routes with another 15 miles, for a total of 40 miles by 2023, at the urging of the Kickapoo Mountain Bike Club. In 2021, the Illinois Department of Natural Resources (DNR) approved construction of 10 miles of trails along the Middle Fork River as the initial stage of this larger plan. The Kickapoo Mountain Bike Club has pushed for the expansion due to the trails' recreational appeal and ability to draw in tourism revenue.

But this new construction has triggered an environmental battle. Environmentalists are worried that the new trails will contribute to the existing erosion problem at Kickapoo State Recreation Area and could prompt a loss of biodiversity in pristine forested areas of the park, specifically for endangered species.

Mountain biking was notably not included in the initial list of recreational areas in the Kickapoo Master Management Plan when it was approved nearly 40 years ago, most likely due to a lack of interest at the time. The plan identifies the recreational, agricultural, and residential uses of the Kickapoo area and how the land can be maintained for future generations. In 1982, the available outdoor recreation programs in Kickapoo and Middle Fork outlined in the plan were day-use, camping, fishing, canoeing, hiking, hunting, winter sports, scuba diving, administrative facilities, and horseback riding — but no mountain biking. Local environmentalists believe that the construction of bike trails contradicts the goals of the Kickapoo Park Master Management program, which monitors land use and development in this area. The plan includes descriptions of the natural resources found there and the properties they contain.

Soil makes up a significant portion of the topography, and the plan acknowledges the limits that places on recreational use: "At Kickapoo and Middle Fork, limiting factors of steep slopes, erosion hazard, seasonal wetness, and flooding are likely to affect recreational program selection and location, increase design and construction costs, and increase the level of facility management." The plan has not been updated in the 40-plus years since its creation.

As the topography of the area faces new development demands and environmental degradation, environmentalists argue that it is necessary to consider how these changes over time could affect the Kickapoo Park Master Management plan currently in place.

The first bike trails were created in the 1990s, after the formation of the Kickapoo Mountain Bike Club in 1993. Ten trails currently run through Kickapoo State Recreation Area, varying in difficulty and terrain. Since 1993, volunteers have built bike trails on about 1,000 acres of land throughout the recreation area, and motorized vehicles are not allowed. The club's volunteers are responsible for maintaining the trails for local mountain bikers. The

Kickapoo Mountain Bike Club claims on its website that it "works closely with the Illinois Department of Natural Resources, as well as the Kickapoo State Park Superintendent, to ensure that there is as little impact on the environment as possible." But the construction of 3 more miles of bike trails in Spring 2019 raised questions about the club's commitment to minimize the environmental impact.

Environmental activists from the Prairie Rivers Network found that the methods used to construct those trails are not up to

expected environmental standards. Moreover, one of the new trails approved in 2021 is being built on the previous location of Dynege Energy Co. The tract housed a coal mine for decades before Dynege shut it down, leaving behind economic and environmental destruction. The area is already prone to leakages and contaminated by improper closure of the site, when surface ponds built to hold coal ash leaked toxic byproducts into the soil. Activists fear that the bike trails will worsen these environmental hazards.

DNR approved the construction of the trail with a permit specifically stating that "This proposed 5-mile extension would be constructed similar to the other 17 miles of single-track trails in the park using hand tools to clear vegetation and grade a 2-foot-wide earth surface trail." Despite these parameters, heavy machinery — not hand tools — are being used to build the mountain bike trail, clearly violating the standards of the permit. The

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Kickapoo Mountain Bike Club lacks the necessary compliance to construct these trails — and the machinery may cause unnecessary damage to the natural landscape.

Prairie Rivers Network activists worry that the design of the new mountain bike trails will affect the durability of the natural ecosystem. The construction of the trails will eventually lead to erosion caused by bikes packing down the soil, making it extra slippery and possibly causing habitat displacement for species living there. If water is no longer able to pass through the trails, it will flow downstream and cause erosion over decades of weathering. This issue can affect soil quality and create permanent damage to the ecosystem.

In June 2021, a group of botanists from the University of Illinois submitted a report to DNR that raised alarms about one of the new bike trails. “A Report of the Botanical Resources and Species of Conservation Concern Associated with a Proposed Mountain Bike Path in the Kickapoo State Park Dynegy Tract, Vermilion County” outlined how the trail — an addition connecting the existing mountain bike trails to Kennekuk County Park — will

affect the current vegetation of Kickapoo. They conducted a vegetation survey by noting any species living within 10 feet of either side of the proposed addition, known as mountain bike trail 11. Their results showed that at least nine species already demand conservation efforts on the proposed trail: the broad-winged hawk, eastern whip-poor-will, yellow-billed cuckoo, Acadian flycatcher, wood thrush, Kentucky warbler, yellow-breasted chat, field sparrow, and eastern towhee. The authors said constructing mountain bike trail 11 will result in forest fragmentation that will disrupt the current habitats of these birds and threaten their ability to increase population size to preserve the species. They concluded that mountain bike trail 11 as currently proposed “... cannot be constructed without resulting in extensive damage to the site’s biodiversity, ecological integrity, and sustainability.”

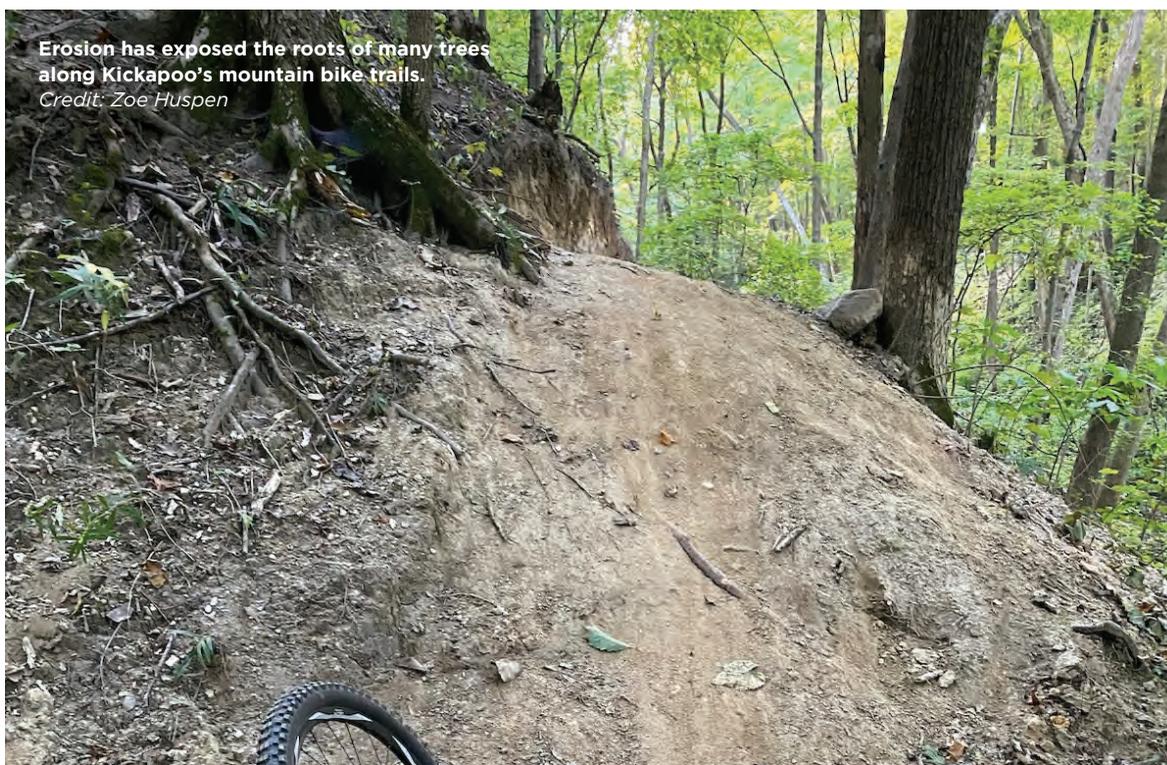
Prairie Rivers Network found violations affecting the surrounding plants and soil in Kickapoo. Generally mountain bikers are encouraged not to ride the trails when they are too slick, and no trees less than three inches in diameter are to be cut down for the construction of new trails. Despite these regulations, tire tracks are evident on muddy trails, and trees have been cut that are smaller in diameter than what is listed. The lack of accountability for compliance violations is worrisome to environmental organizations working to minimize damage to the park’s natural resources. The lasting impacts of this harm fall on both the environment and taxpayers. The mountain bike club likely will not have to pay for the costs of these future damages; there is no binding contract that would require it to. As a result, local taxpayers would have to bear the additional costs of attempting to restore the area.

The use of the Kickapoo State Recreation Area for mountain biking also may conflict with the needs of current recreational users. Approximately 100 mountain bikers pass through Kickapoo State Recreation Area every day, generating noise that can disrupt the serene environment that hikers seek to enjoy. The noise can threaten the biodiversity of the wildlife surrounding the trails and the habitats that they call home by scaring them off. The expansion of mountain bike trails also brings additional wear and tear, requiring volunteer work to minimize erosion. That in turn can restrict recreational use if sections of the trails are temporarily closed to avoid overuse or to repair damage to hiking trails. Hunting season already conflicts with mountain biking, as the trails are closed for one month during prime deer-hunting season. The construction of new mountain bike trails could also strain the existing relationship with hunters to balance recreational land use.

Conservation and tourism are competing concepts in our profit-driven society. The larger question at play here is



Mountain Bike Trails Map. Credit: Kickapoo Mountain Bike Club



how governments attempt to preserve parks while simultaneously drawing in as much tourism revenue as they can. The difficulty is that each person views the best way to strike this balance differently.

Prairie Rivers Network and other environmentalists would like to see three main requests implemented by DNR: Update the 40-year-old Kickapoo Master Management Plan; implement the park's 30-year-old Corridor Management Plan; and analyze alternative siting for trails to minimize environmental damage. Updating the master plan would allow for a nuanced understanding of the topography of the state park. Uses of the park have changed over time as the natural environment shifted due to factors such as erosion and climate change. Environmentalists believe it is necessary for the park plans to reflect these changes and maintain current species biodiversity. Implementing the 30-year-old Corridor Management Plan would improve on the existing regulatory measures in Kickapoo State Recreation Area. It calls for a feasibility study for the park's hiking trails, which has never been

conducted. The plan also would help ensure that any future projects similar to the installation of new mountain bike trails follow the necessary steps to maintain the biodiversity of the ecosystem as much as possible in the construction process.

The ability of tourists to appreciate nature through various recreational hobbies is the hope of both the mountain bikers and environmentalists. If DNR were to analyze alternative siting, it would provide an opportunity to reap the benefits of increased tourism revenue without as much long-term environmental degradation. Specifically, environmental activists are advocating for no construction of new mountain bike trails in the Dynegy tract. Instead, they suggest that alternatives such as former strip-mined lands be seriously considered for new biking trails.

Local environmentalists believe that the construction of bike trails contradicts the goals of the Kickapoo Park Master Management program, which monitors land use and development in this area.

Environmental organizations and government officials have communicated their concerns about the proper

maintenance of Kickapoo State Recreation Area to DNR. The late state Sen. Scott Bennett, who represented Illinois' 52nd District, reached out to the department in March 2020 requesting that the Citizens Advisory Committee included in the original master plan for Kickapoo be reinstated. The original plan was approved in 1992, and he argued that the Advisory Committee needs to become operational. The current condition of the river bank near the Dynegy coal ash impoundments is already fragile given the improper closure of the site decades ago, and the Advisory Committee would ensure a better future for the area.

Prairie Rivers Network also has taken steps to express its opposition to additional mountain bike trails. The organization requested on May 13, 2021, that DNR immediately cease construction of the approved 10 miles of new bike trails on land along the Middle Fork River next to Kickapoo State Recreation Area. The letter states that the plan for that segment would cause permanent damage to the ecosystem and deny access to other recreational users who enjoy the space. Prairie Rivers believes that public input is necessary before construction continues, to ensure that Kickapoo State Recreation Area can meet the needs of current generations while maintaining biodiversity and enjoyment for generations to come.

The letter goes on to acknowledge the work that DNR has done for the Middle Fork, Illinois' only officially designated National Scenic River, and recognizes how funding limitations have prevented full implementation of the Corridor Management Plan (CMP). The letter describes specific concerns, such as difficulty in accessing information about the project, inadequate protection from the Comprehensive Environmental Review Process (CERP), significant erosion on existing bike trails, piecemeal planning, insufficient consideration of alternatives, and a lack of accountability and enforcement. These efforts from environmental activists acknowledge the recreational and economic benefits of the mountain bike trails while still prioritizing compliance with the Kickapoo Master Management Plan and conservation of the ecosystem.

Conservation and tourism are competing concepts in our profit-driven society. The larger question at play here is how governments attempt to preserve parks while simultaneously drawing in as much tourism revenue as they can.

Similarly, the Sierra Club has expressed concerns that the project does not sufficiently consider the ecological worth of the area. In an April 2021 letter, the organization asked that construction cease until those concerns are addressed. The organization has four main concerns: finding alternate locations for additional bike trails; providing adequate resources to monitor the new trails; maintaining the Upland Forest area for non-intensive uses; and protecting the ecological integrity of areas that are currently undisturbed natural habitats.

Why should the average person care about what is happening to the Kickapoo

State Recreation Area? Even if you have no connections to this particular location, the larger picture is extremely relevant. As long as humans continue to breathe in air and spend time outdoors, these developments affect everyone. Mountain biking and other forms of ecotourism are sure to grow, but as our climate changes and natural spaces come under increasing pressure it is important to figure out how to balance the recreational use of these spaces with the very real need for conservation and biodiversity. As important as it is to preserve access for the current generation to the wilds of Kickapoo, it is imperative we preserve that same privilege for future generations and species.



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By Tyler Swanson

The Rise of AGRIVOLTAICS

Agriculture is a staple of American life. While metropolitan regions exist throughout the nation, it rarely takes more than an hour of driving to find yourself on a road surrounded by fields of grain, livestock, or other commodities that feed and clothe the world. Yet, increasingly, you may find yourself on a similar road surrounded by a field harvesting a far different product: solar energy. At first glance, an environmentally minded traveler may view solar fields as an encouraging sign of a brighter future independent of fossil fuels; however, this perception misses a critical insight into the tensions and conflicts that went into the conversion of that field from agricultural land to a solar site.



These sheep live at the La Ola Solar Farm on Lanai Hawaii. They keep the weeds and grass trimmed in the hard-to-reach places between and under the solar panels.
Credit: Merrill Smith via Wikimedia Commons

Today, farmers across the United States are faced with a critical choice as globalization and trade disputes cause agricultural commodity prices to fluctuate. Farmers may continue to farm their land as they have for years, possibly generations, in hopes that better days will come. Or instead, they could turn that land over to a solar developer and attain financial security, receiving steady payments for several decades. On the flip side, solar developers are rapidly running out of land to build solar farms and are increasingly turning to farmers for land to rent. Sometimes, the price a solar developer will pay for a farmer's land is too high to refuse. For example, one North Carolina farmer claims to receive between \$700 and \$1,100 per acre annually from a developer for the right to construct a solar array on the farmer's land. (For comparison, a farmer can generally expect to make \$320 an acre planting corn or soybeans.)

The growing demand for solar energy is spurring the conversion of agricultural land usage as state and national policies simultaneously promote renewable energy development to combat climate change. The American Farmland Trust, an organization focused on the conservation of agriculture, estimates that building out the nation's solar energy supply will result in the conversion of nearly 2.1 million acres from agricultural use to utility-scale solar generation in the contiguous United States by 2040. Two million is only a sliver of the nation's nearly 900 million acres of agricultural land, but the conversion of farmland to solar facilities has a significant impact at the local level, where residents hesitate to trade rolling fields and pasture for uniform lines of glaring glass. In some cases, the rapid buildout of solar farms has led to intense public opposition. In 2017, Currituck County, North Carolina, banned solar array construction after growing local opposition to the visual appearance of solar panels; and in 2019, Oregon prohibited solar development on prime farmland in an effort to protect land for agricultural use.

I spoke with Alexis Pascaris, Director of AgriSolar Consulting, about the issue of solar-agricultural land use tensions. Her work is dedicated to creating synergy between solar energy generation and agriculture. Pascaris explains the plight of rural communities undergoing a transition from agricultural to solar land use:

"(A) lot of my neighbors are grazing cattle, and I love the aesthetic. I think, 'Would I want to see solar panels over the heads of these cows?' ... (but) I can only imagine what folks feel who grew up in rural communities whose fathers farmed on this land forever, think about that agricultural heritage. ... And then think about telling folks we're gonna transform it, and we're gonna put energy infrastructure on it."

Fortunately, creative scientists have formulated a compromise that may help solve the land-use debate: agrivoltaics.

Defined as the co-location of agricultural production and solar energy generation on the same plot of land, agrivoltaics presents a means to soothe the concerns of rural residents fearful of losing their agricultural heritage while addressing the nation's need for clean energy. This land-use technique has exploded in popularity in recent years as researchers across the country test the technological feasibility of co-locating crop and solar production. The University of Illinois has recently become a leader in agrivoltaics research with the development of the SCAPES (Sustainably Colocating Agricultural and Photovoltaic Electricity Systems) project, an interdisciplinary effort to research agrivoltaics, develop educational materials, and conduct outreach via extension services. Meanwhile, an entire industry has rapidly grown around the principle of grazing livestock on solar sites as a means of vegetation control, a practice aptly named "solar grazing" that ensures the grass and weeds on solar farms do not grow high enough to cast shade on the solar panels.

In an effort to learn more about this budding industry surrounding grazing sheep on solar farms, I scoured the internet for news on the practice, eventually landing upon an article about sheep being contracted to graze the new solar site at Susquehanna University in Pennsylvania. Caroline Owens is one of the hundreds of farmers across the United States engaged in the practice of solar grazing. During a phone interview with Owens, I learned that her experience began in 2019 when Susquehanna University reached out to her with a request to lease her flock of sheep to fill the role of vegetation management for the university's new 14-acre solar site. "The minute I heard

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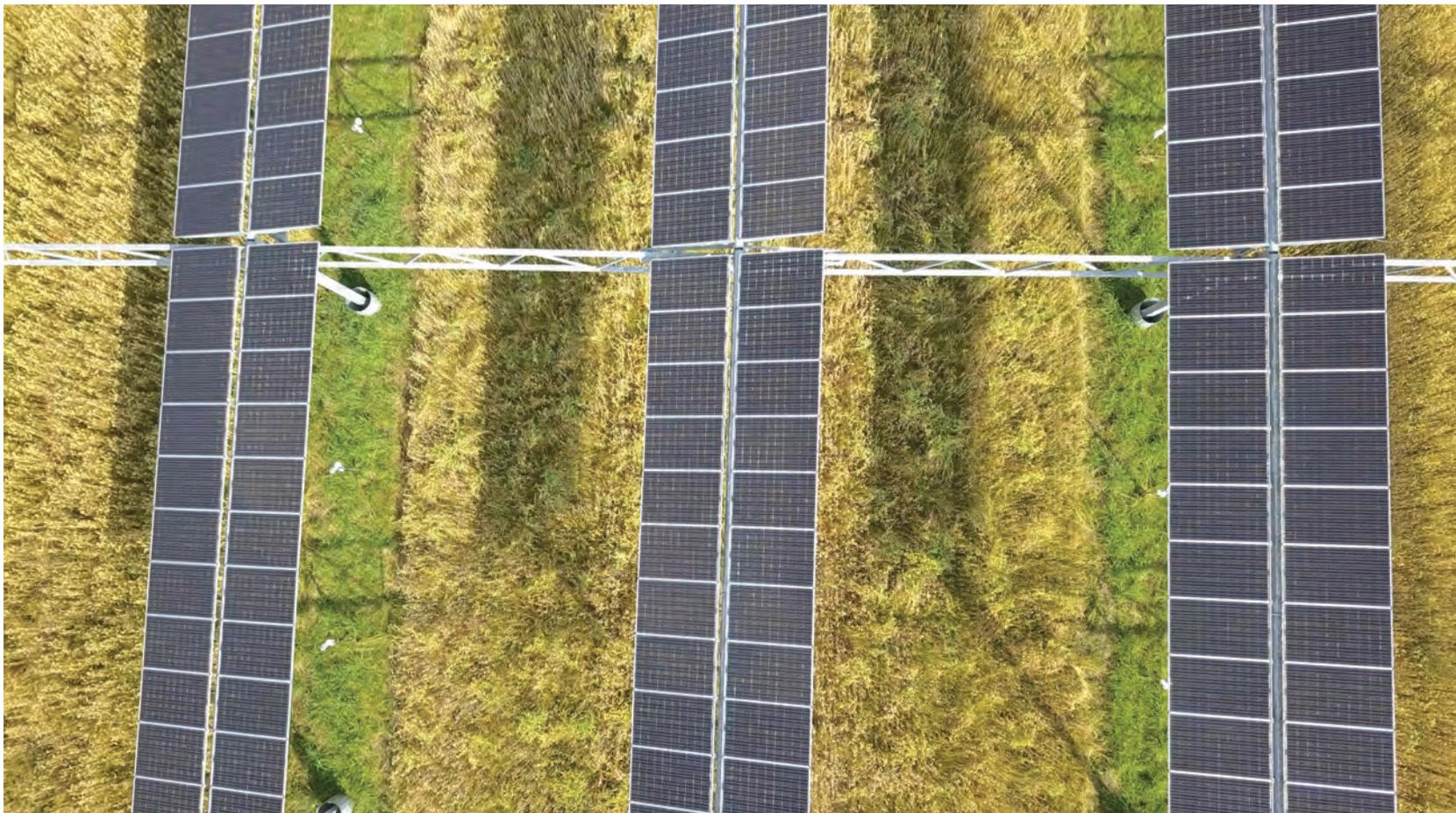
about it, I knew it was a good thing ... it was a perfect fit," she said. Owens attributes Susquehanna's decision to lease her sheep for the solar farm to her farm's visibility in the community, jokingly referring to herself as "the sheep lady." While humorous, it is also an accurate title. Owens Farm offers farm tours to interested community members and university classes, as well as selling meat and livestock raised on the farm.

Three years after Owens began grazing her sheep on the Susquehanna University solar site, it is evident that the decision has paid off. She collects payments from the university for the vegetation management services the sheep provide and is in talks to expand her solar grazing service to other solar farms, providing Owens Farm with an additional revenue stream. Solar grazing has led Owens to a seat on the Board of Directors of the American Solar Grazing Association, an industry trade organization that serves as a hub for solar grazing education and for connecting farmers and solar developers who want to use solar grazing on their property.

In addition to providing a financial boon for farmers, scholars note the potential solar grazing holds for the broader rural economy. Professors Nikola Kochendoerfer and Michael L. Thonney of Cornell University project that solar grazing could spark a 14% increase in sheep farms and a 65% increase in the New York sheep flock, generating \$5 million to \$8 million in tax revenue and increasing lamb sales by \$12 million per year. Owens is equally optimistic about the economic benefits of solar grazing. She spoke of the "huge trickle-down effects. People are going to need more of everything, more hay, more feed, more buildings, more border collies, more handling systems. ... It's just a huge opportunity for everything down the line."

As the solar grazing industry has grown and its economic benefits continue to materialize, a critical question about agrivoltaics remains: Will it resolve the land-use dilemma? The answer may change depending on who you ask. Owens says that the community surrounding the Susquehanna University solar site has come to love the sheep that graze the field. "It really softens the whole

The agrivoltaics pilot plant by Fraunhofer Institute for Solar Energy Systems at the Heggelbach farming community in the south of Germany. Solar modules are mounted 5 to 8 meters above ground with supports spaced in ways that allow the operation of normal farm machines. Credit: Tobi Kellner via Wikimedia Commons



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industrial look. Having field fencing instead of chain link fencing is one very simple thing. ... If it looks like woven wire, it's the thing they've always looked at in rural communities." She is also confident about the direction of the solar grazing industry and expects to see more and more solar farms with grazing sheep. "I think these conversations are taking place all over the country. And I think it's going to ramp up quickly."

The concept of agrivoltaics has also gained support among policymakers in recent years. In Massachusetts, the State Department of Energy runs a program that provides monetary compensation for solar developers who build agrivoltaics. Additionally, the U.S. Department of Agriculture awarded a \$10 million grant to SCAPES, the U of I-led project that seeks to optimize the design of agrivoltaic systems. The growth of agrivoltaics-related industries and policymaker support is critical to bringing about a solution to the land-use dilemma, but this does not mean agrivoltaics is a panacea that will end all of the contentions around solar siting. Pascaris stresses its situational potential: "I don't think all ag land is going to be agrivoltaics ... I think marginal agricultural land can be agrivoltaics, and in places where agriculture is dying and struggling, we can revitalize it with agrivoltaics. I see it in niche applications that create these awesome benefits. ... We've got to look to the built environment first: rooftops, car ports, super fund sites, and all that degraded land."

Whether or not agrivoltaics will solve the agricultural-solar land use debate, the concept's growth is undeniable. For example, BlueWave Solar, a Massachusetts-based solar energy development company, has positioned itself as a leader in this space, developing agrivoltaic farms in New Jersey, Maine, and Massachusetts. In Colorado, farmer Bryon Kominek has expanded his family farm into Jack's Solar Garden, home of the Colorado Agrivoltaic Learning Center. The center offers public tours to curious residents and partners with governments and universities to further research the potential of agrivoltaic systems. On the west coast, Solar Oregon, a solar energy advocacy group, organizes public tours of Oregon wineries that feature solar panels in their vineyards, presenting agrivoltaics not just as a novel land-use technique but also as a tourist attraction.

Transitioning from a fossil-fueled to an electrified world

presents many novel challenges to society. Chief among these is the question of where to build solar sites and how to develop them in a way that is not destructive to practices as culturally and economically significant as agriculture. Agrivoltaics has presented itself as a partial solution rapidly gaining traction among stakeholders, and the approach provides a lesson to scientists and policymakers pushing the energy transition forward. Achieving a clean energy grid is possible, but it requires that the energy infrastructure be collaborative and not competitive. In its current form, solar energy appears to be the latter, fomenting public opposition as communities fear the loss of their cultural identity. Alternatively, agrivoltaics advocates see the practice as collaborative, an opportunity to advance toward a clean energy grid in a manner that is conscious of the rural identity. Either way, the question of how to sustainably build out a clean energy grid must be solved as the energy transition persists. Agrivoltaics is quickly establishing itself as one partial solution to the problem.



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DEATH KNELL FOR THE DEAD SEA?

By Laila Ismail

Located between Jordan, Palestine, and Israel, the tiffany blue water of the Dead Sea glimmers beneath the beaming sun, illuminating the white salt formations rising along the shore. The shimmering salt overtakes the beaches and reaches the smooth brown rocks surrounding them. Red and sunburned bodies pepper the beach, littered with cabanas, tents, showers, and other evidence of human invasion. The air is thick and salty and stings the throats and eyes of anyone close enough to the water's edge.

View of the Dead Sea shoreline.
Credit: Shutterstock

The Dead Sea.

Credit: Kavram via Shutterstock



The Dead Sea is the saltiest and most mineral-rich body of water in the world, and the only life it supports are microorganisms that reside at the top of the sea's freshwater plumes. Though it is technically considered a lake, the Dead Sea is at least six times saltier than most bodies of water on Earth. Precisely because of its striking geological features and unusual composition, the area bustles with activity every day. More than 800,000 people visit the region each year. As my Palestinian father grew up in Jordan, his school would frequent the Dead Sea on field trips to learn about its history and to enjoy its famous buoyancy. Many tourists seek rejuvenation from conditions such as dry skin and eczema, while others may visit to snap a few photographs of themselves floating effortlessly atop the Dead Sea, reading a newspaper.

Despite the "deadness" of the sea itself, it is part of an ecosystem that supports a wide range of life. The freshwater springs and aquifers that surround the sea are home to countless indigenous plants, fish, and mammals. Twice a year, more than 300 species of birds call the Dead Sea home during their migration from Africa to Europe and back. The surrounding areas are cultivated with subtropical vegetation such as bananas, dates, and grapes.

But all of this is threatened as the waters of the sea and the region are drying up. Dead Sea water levels have been dropping since 1960. Currently, the waters recede about

a meter per year, with about a third of its surface area evaporating into the air. The recession is evident in aerial photos of the lake, which demonstrate how significant the water loss is and will continue to be. Resorts that were once positioned next to the lake's shores are now kilometers away and must use tractors and shuttles to transport guests to the water's edge. The ramifications of a shrinking Dead Sea are enormous.

Shrinking & Sinkholes

In November 2018, adjacent to the Dead Sea, the ground shook and swallowed several cars on Israel's Route 90 without warning. No one was severely injured, but there was costly damage. As the saline waters continue to recede from the shore, so do the freshwater aquifers that surround the lake; as these aquifers drain their water, piles of salt remain. During the winter floods, freshwater trickles down from the mountains into the thick underground buildups of salt. The freshwater dissolves the salt, leaving the chamber empty and fragile. As a result, major sinkholes have formed in the area along the Dead Sea, threatening anyone who dares to tread across its surface.

Prior to sinkholes forming around the Dead Sea, little was known about their formation. As a result of this unique

opportunity, geologists such as Gidon Baer and Ittai Gavierieli have been able to study changes in the water and monitor exactly how sinkholes are formed. Scientists use time-lapse cameras above-ground to detect where the water goes in and comes out. By studying the Dead Sea sinkholes, they have realized that they are not isolated cases but part of larger and interconnected underground drainage systems called karsts. These karsts carry water between each sinkhole. With current technology, scientists can now predict when a sinkhole will form and can implement safety measures. However, to theoretically stop sinkholes in the region, 1 billion cubic meters of water would need to be added to the Dead Sea every year. Consequently, there is no feasible way to completely stop them from forming.

Mineral Beach, a tourist resort in the northern Dead Sea, was closed in 2015 because of these sinkholes. The management of Mineral Beach could not ensure the safety of guests following a sinkhole that swallowed many parts of the resort. Many other populated areas such as highways, bridges, roads, and beaches have similarly been shut down.

Causes of the Crisis

Many factors contribute to the disappearance of the Dead Sea. Firstly, areas surrounding the Dead Sea are already in or approaching a water crisis. And the situation is poised to worsen dramatically. Jordan's yearly decrease in rainfall could reach 30 percent by the year 2100 due to climate change. The Jordan River, the main source of water for the Dead Sea, currently supports a lush region of farmlands and vegetation. At first glance, the river is abundant and can support its surrounding ecosystems. However, the area must be irrigated to sustain life in the arid climate and requires millions of cubic meters of water from the Sea of Galilee. In the 1950s, Israel diverted the Jordan River into the National Water Carrier project. This project simultaneously brought water to major cities, while also helping to legitimize Israel as a nation after its occupation of Palestine. Notably, Palestinians lack access to this water and depend on expensive rations of water supplied by the government. Other countries such as Syria and Jordan take water from the area under peace treaties with Israel. Additionally, these countries have a history of overuse and faulty water infrastructure, which has increased since



Sinkholes have destroyed many roads near the Dead Sea.

Credit: Nir Alon via Alamy Stock Photo

“ We are not talking about saving the Dead Sea because it’s nice or not nice. We think that the Dead Sea is a symptom of sickness in the management of water resources. The saving of the Dead Sea will be a good indication that we moved away from sickness to a healthy environment. ”

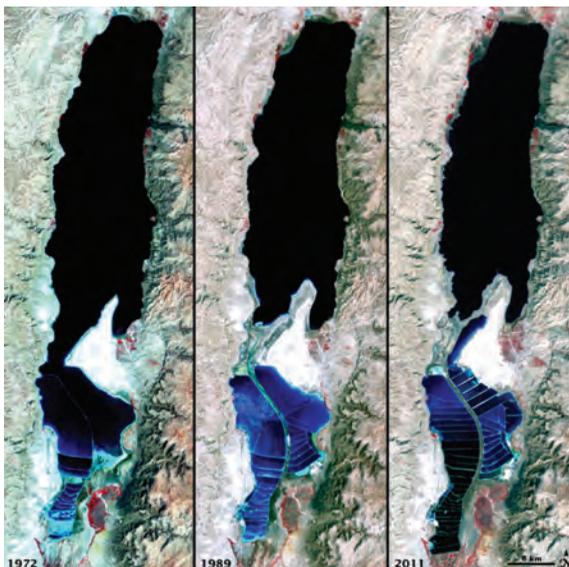
Salem Abdel Rahman, Ecopeace Middle East

the start of the Covid-19 pandemic. As the temperature continues to increase in the region, water use is also expected to follow the same trend. The Max Planck Institute for Chemistry projects an average temperature exceeding 116 degrees Fahrenheit during the day and almost 90 degrees at night. As a result of the diverted water for human uses, the Jordan River’s flow weakens, unable to fulfill its contribution to the Dead Sea.

The second factor in the disappearance of the Dead Sea is the extractive industries it supports. It is rich with minerals such as potash, magnesium, salt, and bromine, which companies such as Dead Sea Works exploit. In the southern shallow basin of the sea, water from the sea is pumped into shallow evaporation ponds. The basin’s harsh sun quickly evaporates the water, leaving only valuable minerals. The minerals are used for medicine, fertilizer, chemical feedstock, and even as a substitute for food salt. With these methods, the company can produce 3.3 million tons of potash from one source. The company’s Dead Sea units have assets worth \$6 billion, according to an independent study by Silver Coast Research. The Israeli Water Authority has continually worked with Dead Sea

Works, despite concerns of over-extraction and overuse by the company. In 2021, the Water Authority granted the company an annual license that allowed it to extract more water than the previous year. Dead Sea Works extracts two-thirds of the water for demineralization and claims that its methods only account for 9 percent of the sea’s water loss. However, environmental groups estimate that the loss is closer to 30 percent. Dead Sea Works claims to also return half of the water it pumps after use; this figure is also highly contested by environmental groups.

During an interview with *Smithsonian Magazine*, environmental activist Gidon Bromberg said that irrigation “is one of the main reasons that the Dead Sea is dying.” According to environmentalists and government officials, Israel, Jordan, and Syria have put in place a water policy that encourages “unrestricted agricultural use.” Israel’s farmers receive large government water subsidies, using half of the country’s freshwater supply. Similarly, “Jordan uses about 71 billion gallons of water a year from the Yarmouk River and channels it into the King Abdullah Canal” for irrigation. As a result, there is almost a complete depletion of lower Jordan’s water supply.



The shrinking Dead Sea. Credit: NASA

In looking at water consumption as a cause of the Jordan River and Dead Sea’s recession, it is also important to note the inequities in that consumption, which are tied to the ongoing Israeli occupation of Palestine. In June 1967, the Israeli military gained complete power over all water resources and infrastructure in the Occupied Palestinian Territories. As a result, about 180 rural Palestinian communities lack access to running water in Israel. On average, Palestinians in the region consume an average of 73 liters of water a day, while an average Israeli citizen consumes about 300 liters of water a day. Furthermore, Palestinians are unable to drill new wells or deepen existing ones and install water pumps, which puts Palestinian lives in the hands of a government that has repeatedly stolen their resources and infringed on their human rights. Palestinians also lack access to the Jordan River and freshwater springs, so as the Dead Sea loses essential water flows that maintain its water level, Palestinians lose access to water needed to survive.

Thinking about Solutions

Salem Abdel Rahman, a Jordanian activist from Ecopeace Middle East, explains the need to save the Dead Sea: “We are not talking about saving the Dead Sea because it’s nice or not nice. We think that the Dead Sea is a symptom of sickness in the management of water resources. The saving of the Dead Sea will be a good indication that we moved away from sickness to a healthy environment.” Backed by the World Bank, Jordanian and Israeli leaders proposed the Red Sea-Dead Sea Conveyance Project (RSDSC) in 2006. The project planned to maintain the historic landscape of the Dead Sea by bringing water from the Red Sea in a 110-mile-long pipeline. In addition, desalinated water from the Red Sea would be supplied to cities in Israel and Jordan for drinking water. There have been multiple studies done on the feasibility and effectiveness of the project. In an article published by Palestine Academy Press, the potential positive outcomes of the project were discussed, such as water being transferred to the Dead Sea, economic revival, and the increased use of hydroelectricity. However, the negative potential of the project also raised many concerns. Issues with the RSDSC Project include damage to groundwater and Red Sea coral reefs, mixing of Dead Sea and Red Sea waters, and threats to archaeological sites. Environmentalists from Friends of the Earth Middle East have also claimed that the project was a stopgap solution and would not address the reasons for the disappearance of the Dead Sea in the first place. The project stalled for more than 10 years as the sea continued to shrink. In 2021, the Jordanian government canceled the project since there was “no real Israeli desire” for the plan to come to fruition. The project was also halted by growing political tensions between Jordan and Israel.



The Red Sea-Dead Sea Conveyance. Credit: Synergia Foundation

Other alternatives for the future of the Dead Sea have been proposed by locals and scientists in the region. A popular option is a plan of inaction that would simply allow the lake to retreat. Supporters of this scenario explain that the Dead Sea is not expected to fully dry out, but will reach an equilibrium and cease to shrink. Gavrieli supports the no-action plan and wants to see the receding shoreline turned into “sinkhole parks” where people can see the new sinkholes and learn about their formations. Other plans deal with the sustainable use of the Jordan River. The Jordan River can be used sustainably by finding alternatives for drinking water such as desalination and wastewater treatment. Further, the initiative involves the use of low water-consuming crops and encourages realistic water prices.

When asked about the future of the Dead Sea, hydro-geologist Carmit Ish-Shalom stated: “If our children say they want to save it, they can’t even do it because it’s too late. Everything that’s happening here, it’s because of us.” Despite the state of the Dead Sea, there has been little intervention to preserve its future. Similarly, Palestinian communities within Israel are forced to leave their home country as water becomes scarcer and more restricted. As the Jordan River’s powerful flows weaken to a trickle due to overuse, water that is used for drinking is still diverted away from the Palestinian communities. The two futures intertwine, and one issue cannot be solved without the other. If the Dead Sea is to be saved, the Israeli government must first pass laws and repair infrastructure to use the Jordan River more sustainably and distribute it to Palestinian communities equitably. Further, the exploitation of the Dead Sea’s minerals must end, as it is a large source of water loss. These measures can slow the shrinking of the Dead Sea while governments and scientists figure out a way to restore it. In political terms, the restoration of water access across the region is critical to Palestinian communities’ survival, and in their larger fight for human rights, reparations, and statehood.



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CLIMATE GIANT By Gabe Lareau



Donald Wuebbles delivers a climate presentation.
All photos courtesy of Donald Wuebbles

You'd be hard pressed to find any international climate treaties, agreements, or legislation not influenced by the work of University of Illinois Professor Emeritus Donald J. Wuebbles — the result of an entire career dedicated to climate science and advocacy.

A 1970 U of I graduate in Electrical Engineering, Wuebbles first discovered his passion for atmospheric sciences in his postgraduate work and earned his Ph.D. in the field in 1983 from the University of California Davis. After he returned to his alma mater in 1994 as a professor, Wuebbles played an integral part in establishing the School of Earth, Society, and Environment in 2006 and served as its first director. The school, and both its interdisciplinary Sustainability major and Atmospheric Sciences major (which Wuebbles also helped develop), have become nationally renowned.

“It’s all about the science. It’s not about politics. What we do about it as solutions is where the politics comes in.”

Wuebbles’ influence, however, expands far beyond Illinois. From early 2015 until January 2017, he served as Assistant Director with the Office of Science and Technology Policy (OSTP) in the Obama administration. On the international circuit, Wuebbles has co-authored numerous assessments for the United Nations Intergovernmental Panel on Climate Change (IPCC), his leadership helping IPCC garner the Nobel Peace Prize in 2007.

Additionally, as a Board member for the National Oceanic and Atmospheric Administration (NOAA) and author of more than 500 peer-reviewed science articles and reports, Wuebbles has firmly established himself as a force in modern climate research and communication.

Q Magazine sat down with Wuebbles in November 2022 to discuss his work, the changing climate, and how we are to tackle what he describes as humanity’s greatest challenge.

From 2015 to 2017, you were the White House expert on climate change; you know your way around Washington. Given the results of the 2022 midterms and the make-up of this new Congress, where do we stand on tackling climate change in the short term?

That’s a complicated question. The fifth National Climate Assessment is going on right now. Those are reports required by Congress following from the Global Change Act of 1990, signed in 1992 by the first President Bush. That law requires us to assess our understanding of what’s going on with climate change and its impacts on the American people. I was a leader in the second, third, and fourth ones, not as much in the new one.

Congress this last year passed the Inflation Reduction Act, which is really in large part about climate change. I don’t see, at least with this administration, there being any further changes because of the Republican majority in the House. But there is a lot in the IRA ready to get us going, particularly in terms of incentives toward reducing our emissions of the greenhouse gases resulting from fossil fuel use. We’ve started already to make the transition away from fossil fuels. And we are already seeing a lot more use of solar and wind energy, more battery-powered vehicles and things like that. I think what the Inflation Reduction Act will do is really highly move us in that

direction. Once we have the momentum going, I don’t see that being reversed.

When I give presentations to Congress, what I discover in private is that essentially all the Republican members of Congress know that the climate is really an important issue. It seems to be something within their party that they have to deny it as part of their platform. But the reality is they know it’s important and they know the science is real.

It’s all about the science. It’s not about politics. What we do about it as solutions is where the politics comes in.

As you mentioned, President Biden signed the Inflation Reduction Act into law. From a global standpoint, will this legislation have any meaningful effects on the global community now that the U.S. has finally done something substantial? Will other nations start to follow?

I think once we really show that happening, that, yes, it acts as a kind of a model for other nations. And I think it will have an impact, but it’s not going to be immediate. But over the next decade, I think that can be really important. I’m very hopeful that because of these incentives getting that transition started, the momentum will be so strong that it will make the transition complete over the next 20 to 30 years. We really need to get to what is called net-zero emissions by 2050, if possible, but certainly by 2060 at the latest.

As a recipient of the Nobel Peace Prize for your service on the IPCC, what’s been your main takeaway from working with such a diverse group with one set goal?

Our primary goal is always to put out the best science. We’re scientists, not politicians. And the science tells us there is a very serious problem. The chief scientist for the United Kingdom a few years ago said this is not only one of the most important problems, it may be *the* most important problem of all time for humanity. We need to take it seriously. The international assessments have really demonstrated that fact with the reports we’ve done.

“ People always ask me, how can I be so optimistic? I’m optimistic because we can deal with this. It doesn’t do us any good to be just distressed or depressed about it. If you have a can-do attitude, we can take care of this and we can make it better for the next generation. ”

The Intergovernmental Panel on Climate Change was started by the U.N. in 1989 with the idea that it would bring together scientists to assess the state of the understanding of climate change, much like the U.S. Global Change Act, which was passed by Congress the following year. I was a coordinating lead author for a chapter in the very first assessment and continued in that role for four or five different IPCC assessments. They’ve continued to just build a stronger case throughout time. What we knew 32 years ago when we did the first assessment still holds true and has only been strengthened by further evidence: more observations from satellites, and more observations of all types indicating just how serious this issue is.

We’ve found a lot of new things — such as the concerns about extreme weather and its increasing intensity that we did not know about back then — that make this even more serious and require major attention. Those assessments were very useful, and I think will continue to be useful. There’s been an argument going on: “Should we really need these things?” Well, I think we do because I think we need to just keep updating our understanding. Also, I think the reports themselves are useful and provide information to policymakers that is needed for them to make the right decisions.

We’ve all heard about rising global temperatures, how the Arctic is thawing, and catastrophic weather — which has been especially prevalent recently. But what is an effect of the climate crisis that you would like to see get more attention?

The media like to call this “global warming,” and that was a term that was kind of developed about 15 or 20 years ago. It’s misleading to most of us as scientists because it suggests just a little bit of warming, but that’s not really what it’s about. This is really about the increasing intensity in extreme weather, which includes heat waves. About 20,000 people died in Europe this past summer due to their heat wave. That’s not insignificant. We have seen similar heat waves throughout the world.

Coming soon are heavier-duty droughts. We now think the drought in the Southwest is likely going to be further strengthened over many decades, centuries potentially. There may be parts of the Southwest that essentially become unviable for humans. It’s a very serious issue and we need to be probably more concerned about that than we have been. The water in the West, I think, is a major issue that doesn’t get enough attention in the rest of our country. However, this isn’t just about heatwaves and droughts, it’s also about more precipitation coming as larger events. For example, more extreme precipitation in the Midwest and the Northeast is leading to more incidences of flooding. Stronger hurricanes are also affecting our coastal regions.

Sea level rise is the other really major issue. Over the next 10 to 30 years, we expect an extra foot of sea level rise. Some people may say, “Well, that doesn’t sound like much.” But one foot has a huge impact on coastal areas, and it will make some areas essentially unlivable. Then, when you have a storm surge or you have a high tide, it’s going to make things even worse.

It’s also a question of tipping points. We don’t fully know the ramifications of the melting sea ice in the Arctic. Probably over the next 30 years we’ll no longer have sea



Wuebbles with John Holdren, Director of the White House Office of Science and Technology Policy during the Obama presidency.

ice in the Arctic in the summer. Melting permafrost in the Arctic could also increase atmospheric concentrations of several important greenhouse gases. Could these kind of responses to the changing climate result in further permanent changes to our climate? We need to understand such potential tipping points.

Another thing that probably doesn't get enough attention is ocean acidification. As we put more carbon dioxide into the atmosphere, a high fraction of that carbon ends up in the ocean where it turns into carbonic acid, making the ocean less basic. The potential impact of that on ocean life is still not clear, but it could be quite important. I worry about that as being the thing we haven't paid enough attention to at all.

How do we balance adapting to present catastrophic weather crises while also trying to prevent future ones?

We basically have three choices: mitigation, reducing those emissions; adaptation, responding to the changes we can't stop; and suffering. Right now, we're doing some of all three.

In the future, we're going to need to adapt. But are we going to adapt by thinking ahead or are we just going to respond to disasters as they occur? Well, we know that responding to disasters as they occur is much, much more expensive than planning for the future. So, we need to get into the other mode.

It's hard for us as a capitalist society to really deal with that, but we need to be in that mindset. Otherwise, a whole lot more lives and impacts on the economy are on the line. I have no question in my mind that we need to learn not just how to adapt, but adapt proactively.

On a global scale, one's individual carbon output isn't even measurable. But collectively, we've caused immense environmental harm. What individual action can we take, if anything, that might have a non-zero effect on mitigating climate change?

Communication is probably the single most important thing we can do. Telling those who represent us that this is really important, that we need to take it seriously, and that they need to then enact policy that will deal with mitigation and adaptation. That's where it starts. And that includes how you vote, too.

There are things we can do ourselves, reducing our own emissions. This usually means trying to be more efficient in our use of energy. It also saves money. It's a very useful aspect to think ahead and plan your trips more efficiently and effectively. In the end, it's a win-win because you're saving lives, you're saving resources, and you're saving your own cash.

"Climate doomism" is an attitude that any more effective action to be taken in fighting climate change is beyond our capacity. So how do we fight this way of thinking?

Yeah, I find that distressing. People always ask me, how can I be so optimistic? I'm optimistic because we can deal with this. It doesn't do us any good to be just distressed or depressed about it. If you have a can-do attitude, we can take care of this and we can make it better for the next generation.

I think being proactive in thinking about how effective we can be to really deal with this is important, and being optimistic is part of that picture.

Recently, David Wallace-Wells published a story with *The New York Times Magazine* saying we've avoided the climate apocalypse. Is this just a nice catchphrase, or does the science actually support that?

I saw that article, and I don't agree with it. I don't think we know that we've avoided the worst possible impacts of climate change. I mentioned tipping points earlier. We don't know how some of these feedbacks in the system are really going to affect us in the future. One I really worry about is the increasing number of wildfires. Millions of fewer trees are holding carbon and wildfires are putting carbon back into the atmosphere.

Perhaps even more important is melting permafrost. This could also put a lot more carbon back into the atmosphere. These kind of things, these tipping points, we don't understand them well enough yet, but they could make this even more serious than we realize.

While I like to think we avoided the worst of the changes by beginning to reduce emissions, I still worry about potential feedbacks within the climate system that could totally change that picture. It's important that we try to continue to improve our understanding of those feedbacks and how they might affect the system. So, no, I don't agree with that viewpoint.

“ Yes, we have a lot of more immediate concerns about the economy, terrorism, and whatnot. But we need to be thinking about these longer-term issues as well. They’re going to have such a huge impact on us, but also especially on our children and grandchildren. And I think it’s important we think about them as well. ”

It’s the general consensus that the world is falling behind on meeting the goals set by the Paris Climate Agreement. Is limiting warming by only 2.5 degrees by the end of the century goal still feasible? Are the goals set in that agreement still feasible or were they ever?

The Paris Agreement really is a recommendation of trying to keep changes below 2 degrees centigrade. Anything above that is going to bring really major change. There’s nothing magic about that number, but it’s a good goal.

We’re at 1.1 degrees centigrade right now. The Paris Agreement tried to say not only keep it below 2 degrees, but to keep it at or below 1.5 degrees centigrade. My analyses indicate that it’s almost impossible for us to keep it at those levels. We are not likely going to stop emissions by 2050, which is what that would entail. Can we keep it at 2 degrees centigrade? Yes, but it’s going to be very hard. What we do in the next decade, how well our society is going to transition its energy and transportation systems, will really determine whether we can keep it at 2 degrees. I remain optimistic about us being able to do that. But realistically, I doubt we will.

I suspect that we’re going to end up being more in the 2.5- to 3-degree temperature change. That’s going to be very devastating to our society because by the end of this century, it probably means 2 to 3 feet and possibly more of sea level rise. Plus, further intensity of severe weather. I find that very worrisome.

The worst-case estimates for temperature rise at 2100 have recently been reduced from 5 to 3 degrees, mostly due to projected abatement of coal production and the advancement of renewable energy. Do you see this as a cause for optimism?

As I said before, I think that’s somewhat unrealistic at this point. If you forget about the feedbacks I mentioned with permafrost and wildfires, then yes, we’re reducing fossil

fuel emissions enough that we won’t be at the 5-degree centigrade level, probably more like 3.5 degrees or lower. And that is good. But I worry about those feedbacks; they’re the unknown that could really change that picture.

COP27 recently took place in Egypt. Do these types of conferences serve as a net positive for the climate? It’s easy to make a pledge to reduce emissions, or in this case to give reparations. But what’s needed for countries to turn that into action?

Some of my work was key to the Montréal Protocol to protect the ozone layer. They have meetings similar to the COP meetings every year, but they don’t get as much notice as they used to. Those meetings have been effective because it went from countries being asked to offer changes to being *required* to make changes. I think we’re going to have to do the same thing with climate change. It has to go from a voluntary effort to something which mandates that key requirements be met in order to greatly reduce emissions over the over the coming decades.

I don’t think that’s going to happen in the next year or two, but I think it will happen, perhaps in the next five years when we really make that transition in those international meetings. It has to happen.

In the United States, we get about 20% of our energy from renewable sources. How do you think that number will change in five, 10 years? Has that 20% had a measurable effect on our carbon output?

First of all, it makes sense economically. We know that coal is a more costly form of producing energy than natural gas. And even now solar and wind are already actually cheaper than *that*. Also, I just completed a paper showing that our use of fossil fuel emissions has caused most of the world’s air pollution problems. Their elimination by 2050 actually would mean saving 8 to 9 million lives per year.

So given the economics, given things like air pollution, it just makes sense that we make that transition. We need to move it ahead because of climate change and make it as rapidly as possible. I'm confident it's going to happen, but how quickly is what I'm worried about. It has to happen soon.

How has your interdisciplinary education served to your benefit?

Oh, it's been huge. I actually discovered the atmosphere as a graduate student here. I would consider myself kind of multidisciplinary in my thinking anyway, and I wanted to do something that was systems thinking, broader thinking. I needed a job after I got my bachelor's degree, so for the summer I started working with Sidney Bowhill, a Professor in the Electrical Engineering Department.

Professor Bowhill was also doing studies of the upper atmosphere, so I spent the summer helping him with his private company he ran on the side. That made me realize, "Hey, this atmospheric science thing is pretty fun. This is what I want to do." I totally changed my career and finished my master's degree doing an atmospheric model. I then went to NOAA, then to Lawrence Livermore National Lab, and finally got my Ph.D. at UC Davis.

Throughout all that studying about the atmosphere, the ozone layer, air quality, and climate change, I began to realize we really need to understand societal relationships as well. So, I began to embrace more multidisciplinary work. When I came back to the U of I in 1994 to be department head, I brought that with me. I really wanted to see the university be more multidisciplinary. Gradually, the university has changed in that direction, and it's going to have to continue. If we're going to study all these major issues connected with the environment, we need to be looking at those from a variety of angles.

Compared to 10-15 years ago, are you more or less hopeful about the state of the climate than you were back then?

Unfortunately, the more I learn, the less hopeful I become. I mean, I'm optimistic, as I mentioned earlier, because I think we have a choice, first of all. But I also know more now about extreme weather, sea level rise, and other related issues like ocean acidification than I did when I first started working on this over 30 years ago for those very first climate assessments. Even 15 years ago, going back to the second or third national climate assessments as

well as the IPCC, what we know now about those issues is so much different. In a sense, they look so much worse for humanity than they did back then. So, I think that I am more pessimistic probably than I used to be.

But at the same time, I get excited when I see what can be done. I used to think, for example, that climate change is going to cause such a reduction in food production that the Midwest wouldn't be able to feed the world like it once thought it could, that climate change would drastically reduce yields. But now, I think of some of the newest science saying that we can adapt plants to deal with water in different ways and other technology developments. Then, I'm much more optimistic about our ability to continue to reduce starvation around the world. I think it's especially important for the Midwest to continue to be a key player in that, so other areas of the world can enhance their abilities as well.

What is something that you think everybody needs to hear about the current fight against climate change?

First of all, this is all science. Secondly, this is one of the most important issues humanity is facing, period. Yes, we have a lot of more immediate concerns about the economy, terrorism, and whatnot. But we need to be thinking about these longer-term issues as well. They're going to have such a huge impact on us, but also especially on our children and grandchildren. And I think it's important we think about them as well.



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Environmental Writing. Additionally, Gabe works as a Communications Intern for iSEE. Gabe has blogged for *Let's Move Quad Cities* and was their "Bike-to-Work Week" writer in 2021. He also successfully advocated for World Bicycle Relief in "The Project for Awesome," winning WBR a \$30,000 grant.



On a balmy summer day in New Mexico, a small pond shrinks under the sun's intense rays. Schools of spadefoot tadpoles swim about, indistinguishable from the shades of brown that make up their watery nursery. At first glance there seem to be two distinct species of spadefoots in the pond. The smaller tadpoles appear more streamlined with oblong bodies that flow into a thin tail. The larger ones are almost triple in size with more spherical bodies. Make no mistake, though: These tadpoles are all the same species. Nearly invisible to the untrained eye, these tiny creatures belong in fact to a vast tangled network of species, with which humanity is intertwined. Stressed spadefoots can be indicative of larger ecological distress.

The Frogs Are NOT OK

By Rachel Weingart



Spadefoots are a species of frog that inhabit a variety of regions in the United States. Although called “spadefoot toads,” these creatures are technically frogs, not *Bufo*idae but *Scaphiopodidae*.

While frogs and toads are not always charismatic, they play a vital role as indicator species. Because frogs are specialists that can thrive only under very specific environmental conditions, their ecological well-being is indicative of the health of the ecosystems they call home. Like a canary in a coal mine, they can warn us of ecological dangers.

Many species adopt seemingly bizarre behaviors to survive existential threats. For the spadefoots, a major survival mechanism is cannibalism. Although scientists originally believed that it was a rare behavior only exhibited by animals under extreme human-caused stress, cannibalism is actually a natural part of the life cycle for creatures like spadefoots. This misunderstood practice is an example of environmental adaptation that, while harmful to some individuals, benefits the species as a whole.

David Pfennig, a researcher at the University of North Carolina at Chapel Hill, studies the toads to learn more about their unique relationship with members of their own species during the tadpole stage of development. He explains that some spadefoot tadpoles primarily consume decaying plant matter and other small organisms like fairy shrimp. These omnivorous tadpoles are the smaller ones

— their diet is low in calories and nutrients. In contrast, some natal ponds are so rich in spadefoots that some of the tadpoles develop into the “carnivore morph, which exhibits enlarged jaw muscles and mouthparts.”

While varying dramatically in size, these tadpoles are still all the same species. This phenomenon is called phenotypic plasticity, or a physical change exhibited by an organism as a response to environmental factors. According to Pfennig, this plasticity “allows them to thrive in environments (such as deserts) where rainfall is highly variable. Specifically, in response to changing water levels in their pond, spadefoot tadpoles can either speed up or slow down their development.” Since their natal ponds are transient, spadefoot tadpoles are in a race against both time and each other to develop into toadlets. The more they eat, the faster they’ll grow. But there’s only so much food, so cannibalizing their smaller brethren is sometimes the best option to ensure survival. Evolution favors traits that benefit the survival of species, not individuals, and in this case survival means growing and developing faster than the pond can dry up. Cannibalism offers a unique way for spadefoot tadpoles to grow into froglets with lungs faster due to the nutritional benefits provided by members of their own species.

Kin recognition, the ability of an organism to distinguish between genetic relatives and non-relatives, also plays an important role in the spadefoot lifecycle. In an article published in *Scientific American*, Pfennig and Paul Sherman



explain that spadefoots choose to associate based on morph: "If the tadpole remains an omnivore, it tends to congregate in schools that consist primarily of siblings. Its cannibalistic brothers and sisters, however, most often associate with and eat nonsiblings." There is a delicate balance struck between practicing cannibalism and promoting the survival of their genetic relatives, and kin recognition defines this boundary line. Carnivore morph spadefoots will nibble on other spadefoots and "either eat [them] if they are not related or release them unharmed if they are siblings." However, the survival of the individual comes first, especially if a carnivore morph spadefoot hasn't had a good meal in some time. "The tadpoles stop discriminating against kin when their own survival is threatened — after all, a carnivorous tadpole is always more closely related to itself than to its sibling."

In a meeting with *Discover Magazine's* Bill Schutt, Pfennig explains that spadefoot tadpoles use tactile cues to determine the relative population density of their natal, transient pond. When there are too many spadefoots and too few resources available, some of the spadefoot tadpoles develop overnight into the carnivore morph and begin cannibalizing the omnivore morph tadpoles. The high population density compounds the already existing selection pressure caused by the threat of their natal pond evaporating in the desert environment.

But there's more to this survival story. Riparian ecosystems are home to more forms of life than just spadefoot

toads, and the compounding effects of climate change will continue to weigh heavily on all riparian species. The extinction of one species can create a cascading effect, rippling throughout the food web and causing the extinction of other species that depend on each other for survival. This phenomenon is known as a trophic cascade. These major ecological upheavals result in the loss of biodiversity, which is our last, best barrier against the climate crisis. With the rate of extinction skyrocketing, each passing season leaves us less and less time to understand the complex inner workings of the natural world and take action to preserve vulnerable species.

Losing frogs would mean losing vital indicator species, as well as diminishing the rich biodiversity in riparian areas that are already continuously threatened by anthropocentric factors. What can be done? University of Illinois researcher Valerie Buxton and her colleagues are exploring means of encouraging spadefoots to reproduce. Frogs and many other animals tend to live among members of their own species, a phenomenon known as conspecific attraction. This poses a challenge to repopulation efforts, however. If a habitat is devoid of frogs, reproductive frogs from nearby habitats will typically refrain from using the area as a breeding ground.

Buxton's team, however, has shown that the New Mexico spadefoot can successfully spawn in unoccupied, artificial breeding ponds amidst a chorus of recorded spadefoot calls. Overall, "spadefoots colonized playback ponds faster



Spadefoot carnivore-morph tadpoles are highly cannibalistic. Here, a carnivore New Mexico spadefoot eats an omnivore. Credit: David Pfennig

A spadefoot breeding pond in southeastern Arizona. Spadefoots emerge from their underground burrows for only a few weeks each year to feed and breed in these temporary, rain-filled ponds.

Credit: David Pfennig



and more often than control ponds,” meaning that there is a potentially viable method of human-guided conservation, should the need arise to artificially increase spadefoot populations to maintain biodiversity in riparian areas.

The complex relationships between species make up the backbone of the biotic world. In his book, *Flight Ways: Life and Loss at the Edge of Extinction*, Thom Van Dooren explores the idea of multispecies entanglements. All forms of life on this planet are connected, and therefore humans are entangled in the ways of life practiced by other species, both thriving and disappearing. Escaping from an anthropocentric framework and looking back at it with a critical eye allows us to face hard truths. In Van Dooren’s mind, the most important step we as human beings can take is to acknowledge that the animals we share our planet with “inhabit richly storied worlds” just as we do. Van Dooren blurs the line between that which is human and that which is alive, creating a sense of oneness with all that lives on our planet. But he also acknowledges the inherent brokenness of our connections to other species.

Nature is not gentle or benevolent, and the pressure of anthropogenic extinction is immense. While humans try to care for species whose members are few in number, this

human care for near-extinct animals can end up becoming a form of violence in itself. In the words of Van Dooren, “the care that is practiced at the dull edge of extinction is often intimately and inextricably entangled with various forms of violence.” There is an experience of violent care that occurs when human beings make judgments about the value of cannibalism in enabling spadefoot populations to survive and ensure that the species as a whole is not pushed into extinction. In a world where the days grow hotter and the ponds dry up faster, the phenotypic plasticity and subsequent cannibalism among spadefoot tadpoles will only grow more common.

Unlike spadefoots, humans cannot simply develop overnight into a new, cannibalistic morph to survive modern anthropogenic pressures. From climate change to environmental degradation and habitat destruction, humanity doesn’t have a great track record. The behavioral and physiological adaptation of spadefoots should thus be taken as a cautionary tale. Survival demands adaptation in one way or another, through either a physiological or societal change. But as spadefoots have shown us, adaptation may not always align with our social norms.

Today, people seem more willing than ever to grapple with the challenge of making our world a better place for all species. Climate change is not going away, and neither will our entangled relationships with the natural world. We can work together to create a world in which these impacts are mitigated, and biodiversity is preserved. Maintaining riparian habitats, removing invasive species, eliminating toxic pollutants and runoff, and conducting more ecological research should be top priorities.

Perhaps the most powerful tool at the average person’s disposal is the ability to raise awareness for other species who cannot speak for themselves. We must teach others where the riparian places in our world are and work to encourage appreciation of the incredible creatures that call them home. Love the wild places in our world — and teach others how to love them, too. It is hard to know where to start when faced with so much brokenness, but why not begin with the humble frog?



Survival demands adaptation in one way or another, through either a physiological or societal change. But as spadefoots have shown us, adaptation may not always align with our social norms.



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A Bug's Life

By Momo Wang

When I was a teenager, maybe 15 or 16 years old, I was sitting on the couch in the living room when I saw a ladybug run across the corner of a table. The sight filled me with a sudden and strong sense of horror. The ladybug was tottering madly about, its body halfway squashed, its dotted orange shell cracked like a pistachio, revealing an almost completely flattened abdomen. It stumbled forward in a sort of crazed and horrible dance, running at an alarming speed, given the extent of its injuries. I couldn't look away from it.

It's just a ladybug, I know. It's just a beetle with barely any brains. But you would have understood if you'd seen it, too — the way it walked, the way it dragged its twisted wings, and the horrible way its legs moved, like a broken mechanical puppet.

I remember this ladybug, may it rest in peace. I remember the spider my karate teacher smashed on the mats with his bare foot in 2016 and the fat, buzzing beetle that struggled for days in the bathroom, hanging by one leg from a spiderweb. I remember the upside-down cicada I put back in a tree. The friendly cricket in the basement to whom I fed a piece of pumpkin. And that enormous fly from years ago, about the size of a thumb, that rode into the house on my dad's back, sending me and my siblings running and screaming from the kitchen. The fly was biting him, but no one would help because we were all terrified out of our minds.

When my siblings and I were younger, we used to play with the ants that lived on the patio in our backyard. Every few months, my dad would make a bonfire, and we'd pick through the ashes for pieces of charcoal. We drew extravagant mansions for our ants, complete with restaurants and classrooms and state-of-the-art movie theaters. It was a grand time. We smashed grapes and berries where we wanted them to go, then watched with absorption as more and more of them trickled into our rooms, outlining our offerings with their dark bodies. Black, red, brown, shiny, fuzzy, smooth, fat, slender, winged, big, medium, tiny — all came to feast in the great, glittering city.

I've always been more fond of the smaller ants. The big black ants that seem to grow fuzz on their bodies and become hairier and hairier the older they get disgust me a little. I'm not sure why. I suppose I don't like it that they're large. I don't like it that they look almost blue in the sunlight. I don't like their skittery, skittery legs and the fact that you can feel the weight of them as they run up your arm.

One sunny day, I'd turned on the tap to wash the dishes when I saw, too late, six or seven of these guys struggling at the bottom of the sink. Most were clear of the water, but one was right in the middle of a puddle, wandering around in circles. Moving with practiced efficiency,

**Don't worry,
spiders,
I keep house
casually.**

— Kobayashi Issa

A ladybug. Credit: Thomas Kirchner via Wikimedia Commons



I tore off a corner of a paper towel and turned back to the sink to fish it out. But when I returned, I found it curled up. Its body, so active a few seconds ago, was lifeless and unmoving. I prodded it. I scooped it up. I stood there with the paper, unable to believe it. A life gone, just like that? A few seconds had made all the difference? I remember feeling disappointment and a little guilt. If I had moved faster, if I had grabbed the whole paper towel instead of stingily tearing off a corner, if I had stuck my hand in to rescue it instead of looking for something else ...

I'm afraid I'm revealing myself as somewhat of a sentimental idiot. Who cares so much about an ant drowning? Or a ladybug? There are people starving in the world. There are people at war and children fishing through garbage dumps to find scraps to sell for their families. What is a bug to that? Why even bother? It seems so stupid when I write it out.

Perhaps a bug is nothing. I remember the waxworms I used to fish. I remember the wriggling earthworm that I cut into pieces as a child to feed to a baby bird we'd found in the grass. The bird died. I remember when I was maybe seven or eight, searching for acorns at the park while my dad fished in the pond. Some of the acorns had holes in them, and inside would be an interesting treasure — a small white worm, surrounded by the mush it had made out of the acorn meat. For hours, I diligently cracked

nuts, looking for worms. I put them in a plastic bug-viewer which I took home

In this world
we walk on the roof of hell,
gazing at flowers.

— Kobayashi Issa

How much are you enjoying yourself, tiger moth?

— Kobayashi Issa

and filled with various plants. Then, that night, I found an even greater treasure — a little frog.

Out I went and dumped my worms onto the dirt to make room for my new pet.

I remember a spider I accidentally tangled in its web one day while I was sweeping. Sorry and determined to offer a quick end, I stepped on it. I remember my family's Great Ladybug Extermination, that time we used the vacuum cleaner to suck up the hundreds of ladybugs perched on the walls or running across the tables or flipped over and kicking on our windowsills. I remember a big brown beetle, one of those lumbering and slow-looking fellows that bump against the window screens in summer. It'd gotten stuck in a spiderweb in the corner of the bathroom mirror. By this time, I'd developed my own principles for dealing with bugs stuck in spiderwebs. If I saw no spider, I took it down. If there was a spider, I left it in. A very small spider occupied this web. I couldn't imagine how it could possibly consume such a large beetle. But for two days, the beetle dangled there by one leg, buzzing. Sometimes, it looked as if it were almost about to get free. Finally, I couldn't let it be anymore. I took the beetle down from the web, hoping it was not too late. It had earned its life with its endurance.

I remember my freshman year of college, when I found a green worm in my salad. I brought it to my dorm and snuck lettuce out of the dining hall for a month for it to munch. And munch it did. It grew fatter and lumpier, until one day it stopped moving and became a cocoon. I removed it from its cup and placed it on the shelf above my desk. Occasionally, I'd check in to see if anything had changed. One day, I returned to find the cocoon empty. The moth or butterfly — I never found out which — had emerged while I was away. I wonder what happened to it. Maybe it starved to death somewhere in my dorm hall. Maybe it found its way outdoors?

I remember the attempted rescue of another worm, this one from just a couple years ago. Visiting my mom in Kansas, I found an earthworm blistering on the sidewalk, a victim of a rain spout that had come and gone before the worm had completed its journey across the cement. It was shriveling in the sun, attacked by ants. I picked it up and carried it back to the house, using my hands to shade it. Learning from the times when I did harm through good intention, I searched the internet for expert advice on dried earthworm rescue but didn't find any answers. Doing my own amateur best, I made a moist bowl of dirt, placed the worm on top, and then a wet paper towel over the bowl. In a couple of hours, it was moving a bit more,

An extreme macro photo of an ant.
Credit: Retro Lenses via Wikimedia Commons



A catfish. Credit: Harmil via Wikimedia Commons

A huge frog and I, staring at each other, neither of us moves.

— Kobayashi Issa

unnatural, and by the next morning, it was dead.

In the same house, during that same summer, my dad brought home some catfish in a tub. They were alive and still struggling. I hated to see them moving their gills, trying to breathe the dry air. I had the urge to grab the tub and run back to the pond where they'd come from and dump them in the water. If they'd been my fish, I would have. But what would my dad say? Wouldn't that hurt my dad, who had worked so hard to fish them? I thought about taking a knife or a big stick and ending their struggle quickly. But wouldn't that make me more responsible for their pain than if I had just left them alone? For a long time, I couldn't decide. I stayed in the kitchen, watching them, and crying. In the end, I did decide to leave them alone. I craved clarity, a simple world where I could avoid culpability by just refusing to take part. Perhaps if I never caused pain with my own hands, that would be enough. But the next time, when my dad brought home a large bass, I took the back of a cleaver and tried to kill it with one blow, the way I'd seen in Asian supermarkets. I'm too small and weak, though, and it didn't work. I hit it several more times to put it out of its misery, and by the end, there were thin lines of blood on its scales.

its skin moistening up. But it looked pale and swollen and

I have tears in my eyes as I type this. I feel so small and confused, like a ridiculous clown. Regret for the bird. Regret for the fish. Regret for the bugs I chose to kill and the ones I didn't. A hypocrite for the pain I caused on purpose and for the pain I caused from neglect. For the pain I'm still causing. You can be forgiven for your thoughts. You can be forgiven for the pain you cause yourself. But the pain you cause to others is the one thing you can truly never take back. It is always there, unerasable. Some days I think I care too much. Some days I think I don't care enough. Maybe I should have never brought home the bird. Maybe I should have left the worm on the sidewalk. Maybe I should have smashed the struggling ladybug, which I sat and watched crawl on its miserable way until it disappeared from my sight.



Momo Wang graduated from U of I in May 2022 with a B.S. in Earth, Society, and Environmental Sustainability. She lives in California,

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At Illinois

T a k i n g
t h e
T e m p e r a t u r e
o f C l i m a t e
C h a n g e

By Julia Marsaglia

As a child, Sonia Lasher-Trapp had an intense fear of storms. She can still remember sitting through them alone in her basement in the middle of the night, sheltered from the bright lightning and pounding rain. Eventually, her dad began watching the storms with her, turning her fear into awe. “My parents had really good advice: What you’re afraid of, it’s often because you don’t understand it,” she recounts. This transformed her perspective, and Lasher-Trapp went on to study the phenomena that she once hid from. Today she’s a Professor of Atmospheric Sciences at the University of Illinois Urbana-Champaign researching the impacts of climate change on precipitation. “I know now when to be scared,” she said.

Similar to that change of heart, over the course of her career Lasher-Trapp has witnessed a transformation in society’s attitude toward climate change. For years, a strong, well-funded lobby questioned whether it was even real, with efforts by corporations to silence scientists on the facts of climate change. “That was really hard to take as a scientist because we’re looking at the data and we’re saying, ‘It’s a graph! It goes up! What are you debating?’” But now, inspired by the work of emerging young environmentalists, scientists are feeling much more hopeful.

Lasher-Trapp and other climate researchers at Illinois have seen firsthand the changing attitudes toward their field and the energy of student activists. While the University of Illinois is still far from being free from fossil

fuels, it has been recognized for its work in sustainability in large part because of student efforts. Through two student-initiated fees — the Cleaner Energy Technologies Fee and the Sustainable Campus Environment Fee — the Student Sustainability Committee allocates one of the nation’s largest green funds toward environmental stewardship on campus. Since 2008, this committee has dedicated more than \$15.5 million to projects that promote sustainability, including support of two solar farms, the addition of native and pollinator plants, and geothermal energy system installations across campus.

On a broader level, students play a major role in drafting the Illinois Climate Action Plan (iCAP) — the university’s road map for reaching carbon neutrality by 2050 or sooner. Although the plan has been met with some criticism, it lays the groundwork for necessary change. One initiative that came out of the iCAP is a new sustainability-focused general education requirement that would require students to take a three-hour elective course exploring sustainability challenges and solutions.

“The U of I really prides itself in being a leader in sustainability,” says Creen Ahmad, a 2021 graduate who advocated for the sustainability gen-ed requirement in her role with Illinois Student Government. “It’s written in the iCAP ... and the chancellor has signed off on the iCAP. It’s now a matter of technicality of how every college is going to do this.”



U of I students held a climate strike on Earth Day 2021. Credit: Julia Marsaglia



Madhu Khanna

Madhu Khanna, Director of the U of I Institute for Sustainability, Energy, and Environment (iSEE) and a leading scholar in agricultural and environmental economics, has observed this evolution of the climate movement throughout her

lifetime. She describes the phenomenon's transformation from "something that people thought wasn't going to affect us ... something that's going to happen in the future and (was) the responsibility of governments," to an issue that cannot be left for future generations to solve. Nowadays, many people feel an urgent need to actively push governments toward sustainability. Millions of young activists around the world have taken to the streets for climate marches, demanding that governments eliminate the use of fossil fuels and reduce harmful greenhouse gas emissions. The #FridaysForFuture effort that grew out of Greta Thunberg's 2018 protests in Sweden has engaged more than 14 million people around the world, with climate strikes, policy advocacy, and other actions.

Overall, the movement is "going in a positive direction," says U of I student Hailie Collins, President of Illinois Solar

Decathlon, a student organization that builds sustainable, solar-powered homes. But she doesn't foresee huge shifts until her generation becomes a majority of the workforce "because a lot of sustainability initiatives do come from policy." Although college students aren't yet the dominant force in decision making — and may feel their youth makes it difficult to enact change — speaking up and being informed is still crucial.

Having witnessed students voice their concerns about climate change, "it's very energizing to have younger people taking the reins of this movement," says Wendy Yang, Associate Professor of Plant Biology and Geology at Illinois, who studies ecosystem ecology and greenhouse gas dynamics.

The question is not whether we move forward in combating climate change, but how to do it. "There are a number of great solutions that we already know can mitigate climate change," notes Khanna, and what we need to do now is "create the institutions and the policies that can ensure that we act upon those solutions." Young people are "placing a lot of expectations — as they should — on the leaders and administrators who are actually the ones who can enact that change" at the institutional and policy level, says iSEE Sustainability Programs Coordinator Meredith Moore. Using their voting power is one of the most impactful ways that individuals can influence change close to home.

As a Teaching Assistant Professor of Atmospheric Sciences, Alicia Klees teaches her students "not to trivialize the power of having a mayor or governor who's really on board with green energy." She does this by encouraging her students to vote for eco-friendly candidates, not just at the national level but also at the local level. Urbana Mayor Diane Marlin, for example, has committed to bettering her Illinois community's environment by supporting programs like the Mahomet Aquifer Protection Task Force, which can identify existing and potential water contaminants.

We are no longer waiting around for change. When it comes to global warming, many young people realize that we can't afford to wait — it's time to act. It's "probably the most important thing that's happening in our lifetime," says M.J. Oviatt, a 2018 graduate and former co-president of Students for Environmental Concerns. Because younger generations have learned about and experienced the consequences of climate change that come from inaction, an increasing number are getting involved.

A 2019 article published by the Pew Research Center found that in the United States, 71% of those aged 18 to 29 say climate change is a threat, compared with just half of Americans 50 and older. "Young people are gaining more of a voice, whereas before they were dismissed or



Green Ahmad at U of I's annual Green Quad Day. Credit: Julia Marsaglia

shut down,” says 2020 U of I graduate and environmental activist Abigale Pstzroch.

While many are accused of being too radical, Ahmad disagrees. “We’re not radical,” she argues. “You have to care more.”

Today, not only are most people able to recognize climate change as a reality, but many also understand that “the climate change movement is also an environmental justice and social justice movement,” as Yang notes. Better yet, people are talking about it as an environmental justice issue.

“It doesn’t seem like people are as cautious about having difficult conversations” about climate change as they were a handful of years ago, Moore says.

So, let’s talk about it. In her environmental advocacy efforts, 2021 Illinois graduate and former iSEE intern Julija Sakutyte says her voice is prominent because of her privilege as a white cisgender woman. Given that privilege, “one of my priorities has been to uplift the voices of Black, Indigenous, and People of Color because those are the people who are impacted by climate change the most.”

Ahmad expresses a similar sentiment: “It’s very obvious now that certain parts of the world, and even in America certain communities ... will face the brunt of environmental catastrophes.”

In Champaign-Urbana, the Fifth and Hill community’s residents, who are predominantly Black and low income, face environmental injustices at home. An old Ameren manufactured gas plant that closed in 1953 left coal tar and other wastes behind, turning the area into a toxic site. Benzene and other harmful compounds have contaminated the surrounding neighborhood’s soil and groundwater, and the site was never properly cleaned. Pstzroch, who is involved in the Fifth and Hill Community Rights Campaign, remarks how “there’s a lot of turnover in the community ... so a lot of the people who move in don’t know that they’re living next to a toxic site.” The fact that people have had to live among hazardous chemicals for almost 70 years since the plant closed shows how crucial



it is for all of us to be strong advocates for environmental justice.

Perhaps the most important thing about environmental justice is that it interconnects with other forms of justice. For Ahmad, coming to the University of Illinois allowed her to become an advocate for Palestine, and she realized that she “was always making this connection between being Palestinian and caring for our land, caring for the environment.” This has allowed her to understand the importance of centering Native and Indigenous communities in environmentalism and making sure environmentalism is rooted in anti-colonialism. Today, “different NGOs take land away from Native people to preserve it. That’s just a new form of colonization,” Oviatt says. The success of the environmental movement is inseparable from social justice, and that’s something that the new wave of environmental activists not only understand but emphasize.

These activists are also focused more on meaningful outcomes than anything else. “Young people in particular are so motivated to not even place the blame on other people, but act to do something about it,” Moore says.

As younger people grow and begin to understand the implications of climate change, they “are getting involved and saying, ‘It’s our future and we need to make sure we take action now to protect it.’ And that is very powerful,”

Since 2008, this committee (Student Sustainability Committee) has dedicated more than \$15.5 million to projects that promote sustainability, including support of two solar farms, the addition of native and pollinator plants, and geothermal energy system installations across campus. On a broader level, students play a major role in drafting the Illinois Climate Action Plan (iCAP) — the university’s road map for reaching carbon neutrality by 2050 or sooner.



Members of the University of Illinois Students for Environmental Concerns (SECS) march on campus.
Credit: Abbi Pstrzoch

Khanna says. "I'm hopeful again that we might actually see some action in the next decades."

At this stage a certain amount of suffering from climate change is inevitable, and that can be a heavy burden for those who are most vulnerable. "It's hard not to be pessimistic about the environmental movement because of the state of things at this moment," Pstrzoch acknowledges, but the demand for change is so great that the severity of those impacts can be minimized. Nevertheless, the emotional toll of fighting for your planet's future is exhausting.

Sakutyte advocates for "more self-care and more acknowledgement of the burnout and the stress that is very real when you're involved in something as heavy as climate change and environmental activism."

Oviatt was one of those who suffered from burnout as a result of promoting environmental awareness on campus. "We failed so many times," she recalls. "These campaigns take so long, and ... you're fighting against the status quo and that's really hard to do." But when she returned to campus in 2019, seeing "people who were still in it and wanting to be part of the movement and seeing people join even after I'd left ... it was so worth it." Oviatt gained a newfound sense of dedication to the climate movement and plans to stick with it this time. Her impact on campus continues to grow; more students have taken up the fight since she graduated, continuing to hold climate strikes similar to the one she once organized that brought out a large crowd of students and speakers to hold the University of Illinois accountable for its fossil fuel investments.

"The university tells you about the 'Power of I,'" says Karla Sanabria-Véaz of the Graduate Employees' Organization, who spoke at the 2021 Earth Day climate strike about the need to unite against environmental racism. "I believe in the power of us."

The University of Illinois is a microcosm of the global environmental movement. Year after year, young visionaries learn from high-achieving, experienced professionals, and the values they impart matter. The worldwide reach of universities like the U of I makes it especially crucial for them to be leaders in groundbreaking, innovative change, despite challenging obstacles. Let's make sure the push to mitigate climate change is something that current students will be able to reflect on decades from now with pride and enduring optimism.



Julia Marsaglia graduated in 2022 with a degree in Earth, Society, and Environmental Sustainability and minors in English and Chemistry. She's

originally from Normal, Ill. but has moved to Arizona to be a Watershed Technician for the Coconino National Forest through the ACE EPIC program.



HIDDEN *wonder*

By Abby Culloton

Hidden among the cornfields of central Illinois, at a location so unknown you need a set of coordinates to find it, lies an ecological paradise. Point Pleasant wetland in Penfield is a rich, diverse ecosystem teeming with wildlife and a hotspot for birdwatching in Illinois.

I walked along the grassy path on a crisp spring morning, listening to the vibrant hum of life all around and breathing in the smoky smell of a freshly burned prairie. Joining me was Aerin Tedesco of Champaign, who holds the records for most birds spotted by a female birder in Illinois, and my friend Lily Reynolds, a student in Natural Resources & Environmental Sciences at the University of Illinois and aspiring ornithologist. I felt like a bit of an imposter walking between the two of them as they enthusiastically pointed their binoculars at a bird and immediately called out its name, while I was simply in awe of how many species lived here that I never knew existed.

Before it was an ecological haven, however, Point Pleasant was an environmental battleground between forces of degradation and restoration.

Vanishing Wetlands

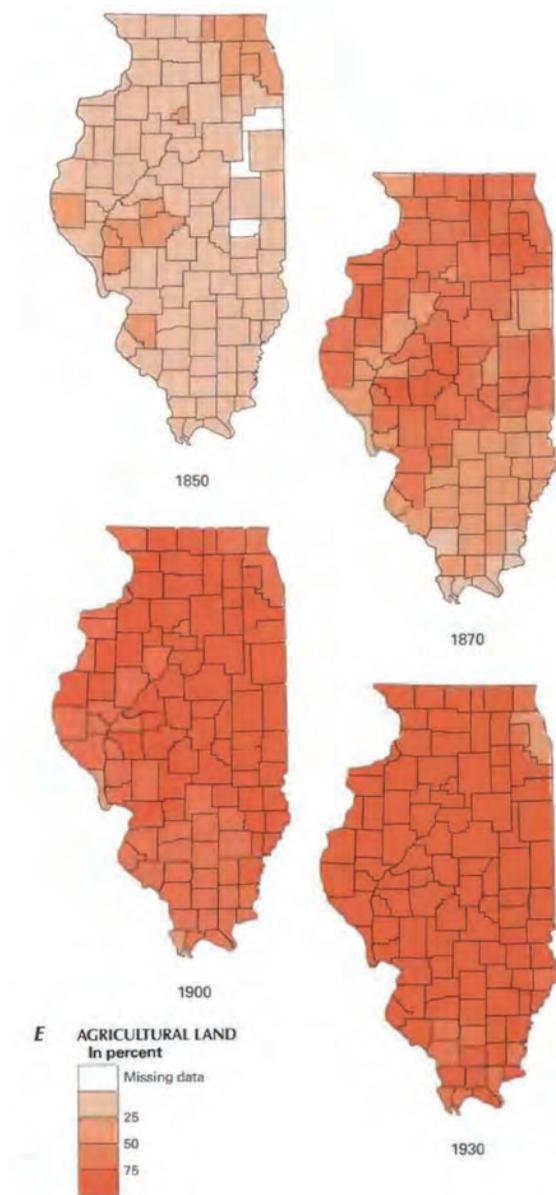
Wetlands like Point Pleasant provide food for wildlife, maintain water quality, and moderate climate conditions. There are four main types of wetlands — marshes, swamps, bogs, and fens — though they all look a bit different. In fact, they can be found on every continent except Antarctica. Certain marshes and swamps are present year-round, while others, such as vernal pools, appear only during certain seasons. Point Pleasant is a marsh, a rolling prairie with no trees but plentiful

grasses and wide pools of water. It's the perfect place for biodiversity to thrive year-round.

Regardless of size, type, or location, wetlands all provide crucial base functions for ecosystems. They are incredibly vibrant habitats, housing a variety of plants, birds, insects, mammals, fish, amphibians, reptiles, and microbes. Wetlands are sometimes referred to as “biological supermarkets” because they contain a wide range of foods that attract all kinds of organisms. This was evident at Point Pleasant as we observed the lively buzz of cardinals, cranes, and hundreds of other species stopping in for a morning meal. Wetlands are important habitats for breeding and provide a safe resting place for birds and mammals during migration. Hiking through Point Pleasant, it was obvious why wetlands are valued among the most productive ecosystems on the planet,



Vernal pools are seasonal wetlands that appear after large precipitation events in the spring, and they provide an important breeding ground for amphibians such as salamanders and frogs. Credit: Adirondack Council



Growth of agricultural land in Illinois from 1850 to 1930. Credit: U.S. Geological Survey

Wetlands are being threatened nationwide and worldwide, and in Illinois, more than **85% of wetlands have been lost** since the time of European settlement. The primary culprit of wetland loss in Illinois is artificial drainage — the technique used to make land suitable for crop production. From agriculture alone, **5 million acres of wetland have been drained in Illinois.**

comparable to coral reefs and rainforests. Unfortunately, they are also among the most endangered.

Wetlands are being threatened nationwide and worldwide, and in Illinois, more than 85% of wetlands have been lost since the time of European settlement. The primary culprit of wetland loss in Illinois is artificial drainage — the technique used to make land suitable for crop production. From agriculture alone, 5 million acres of wetland have been drained in Illinois. That is enough to fill almost 2.5 million Olympic swimming pools. Wetlands are also drained to make room for other developments, such as housing, transportation, and landfills. Those that remain are threatened by degradation due to polluted runoff from agricultural and urban areas.

Point Pleasant's Road to Restoration

The history of Point Pleasant illustrates the threats posed to wetlands by agricultural development. According to historian Elizabeth Hansen, there was a post office on the property from 1853 to 1862 (the Point Pleasant Post Office, after which the restoration team would come to name the wetland 150 years later). During the same period, there was a wagon way station on the property and a ford across the Middle Fork River, indicating that this was an important crossing point during the westward expansion period. By the early 1900s, the property was converted almost entirely into agricultural land and a channel was dug through the middle of the wetland to drain the area. Throughout the century, this channel would carry harmful nutrients from the farm fields straight into the Middle Fork River, as well as stripping away a key habitat for hundreds of native species.

In addition to being a rich ecosystem before agriculture took over the area, Point Pleasant is unique for a few other reasons. First, it is incredibly ecologically diverse. The area is not only home to wetlands and the Middle Fork River, but acres of rolling tallgrass prairie and wooded groves as well. It is also topographically interesting, containing historic mounds and basins known as kames and kettles. A kettle is formed by a large chunk of glacial ice that slowly melts over time to leave a depression in the soil, while kames are high elevation points formed by the sediments that washed away from the depression.

Additionally, scientists discovered a 25-foot-thick layer of peat under the kettle basin in 1997. The peat formed in wetlands worldwide comprises the largest terrestrial carbon sink and sequesters more carbon than all other vegetation types in the world combined. This means that the peatlands at Point Pleasant are an incredibly important carbon sink, and if they were to be disturbed for anthropogenic use, they would release even more CO₂ into the atmosphere. For all these reasons, Point Pleasant

was a clear target for restoration. The Champaign County Forest Preserve District (CCFPD) has worked to obtain the land in bits and pieces since the 1970s, and finally purchased the full property after receiving an Illinois Department of Natural Resources grant in 2010.

The restoration process began with lots and lots of seeds. According to Peter Goodspeed, Director of Natural Resources at the CCFPD, teams planted 80-100 species in each segment of the property. These were a mix of naturally collected seeds from the area and from local plant nurseries. The team also engaged in what is known as “broadcast frost seeding,” where seeds are spread on top of snow so that as it melts, the seeds have a better chance of getting into the soil and successfully germinating. Of course, the early stages of the project also required lots of manpower, from mowing to spot-treating areas to removing invasive species.

Another large problem the team faced was how to tackle the altered hydrology in the area. Because of the man-made channel running through the property and the number of agricultural tile drains in the area, it was next to impossible to restore the water levels to their natural state. So, the CCFPD engaged in some creative engineering. In 2020, it received funding from the Illinois Clean Energy Community Foundation to install an artificial water control structure. This consisted of a weir, which is a type of low dam used to regulate water levels; a riprap, which is a layer of stones along the edge of the wetland to prevent erosion; and a riser pipe that can be used to manually control water levels as needed. These elements function much like a beaver dam by allowing water levels in the wetland to remain stable, while also giving forest officials more control to drain water for restoration work or flood prevention. With the help of the U.S. Fish and Wildlife Service, the team was also able to retrofit the existing tile drains to make them non-perforated, meaning that the adjacent agricultural land can still be drained without also draining the wetland.

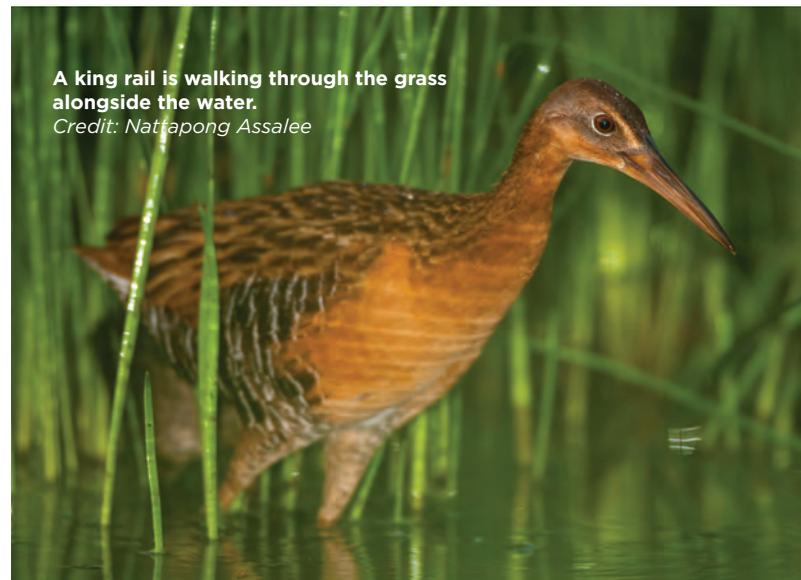
Reaping the Benefits

All these restoration efforts in recent years have resulted in clear environmental benefits. The wetland serves as a filter to keep harmful sediments and nutrients out of the Middle Fork River, and also helps to prevent flooding in the agricultural land nearby. Since the soil below the wetland stays saturated year-round, it also prevents the peat from decomposing and releasing excess CO₂ into the atmosphere. Point Pleasant has also become a recreation hotspot.

As Goodspeed spoke about the area at a webinar for the

Champaign County Audubon Society, his face lit up when he described the “explosion of color” and the “seemingly endless” views of the horizon. “Point Pleasant is one of those places where you can look off into the distance and get these sweeping vistas of the prairie,” he said. Thanks to Goodspeed and his team at the CCFPD, these beautiful views are preserved for everyone to enjoy. Hundreds of plant and animal species enjoy this area as well, with more than 28 dragonfly species alone recorded in the area. CCFPD staff have also sighted more than 80 birds in the area, with some of the most notable being sandhill cranes, great egrets, great blue herons, blue-winged teals, sora rails, and maybe even a king rail, though only a few lucky birders have ever spotted one.

Tedesco was one who reported hearing the king rail at Point Pleasant. In fact, she has seen 120 bird species there, which is the second most of any birder at this location. In 2020, she embarked on her first of two “big years,” which are year-long birdwatching challenges



A king rail is walking through the grass alongside the water.

Credit: Nattapong Assalee

where birders try to record as many species as they can by sight or sound during the year. In 2021, she broke the Champaign County big year record, recording a total of 248 species.

Point Pleasant was a crucial location for Tedesco’s big year. Out of the 248 bird species she recorded in the county, more than 100 of them were at Point Pleasant. The wetland also holds a special significance to her because it is where she tied the record with the sighting of the yellow-breasted chat. Describing the moment when she heard the bird, Tedesco remarked, “We jumped around and high-fived and made a quick recording! Then



A wetland at Point Pleasant.
Credit: Champaign County Forest Preserve District

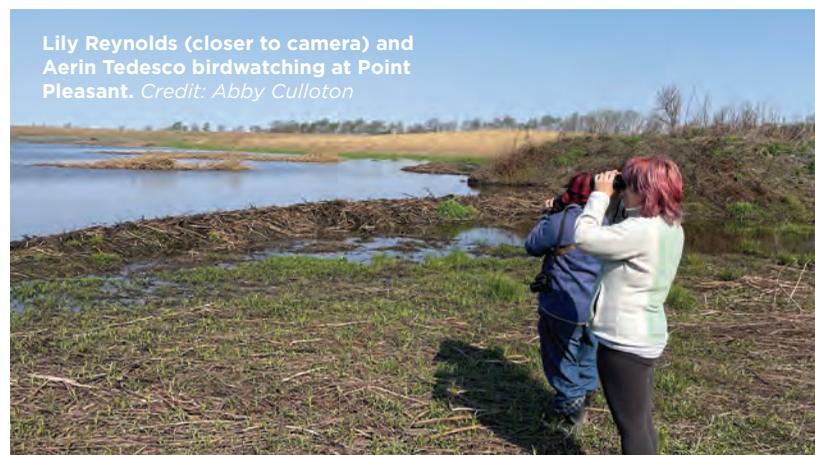
we headed toward the bird. He was easy to spot, high up in a clump of trees, singing like he owned the place.”

The Future of Our Wetlands

On my trip out to Point Pleasant with Tedesco and Reynolds, I saw firsthand the sheer number of species that thrive on this land. I saw the way people could thrive, too — Tedesco would excitedly point out a bird and help us recognize it, while Reynolds and I would listen intently, learning from the best. Along the hiking trail, we saw a variety of birds deep in the woods, along the riverbanks, and high up in the trees. As we reached the main wetland, we gazed out at the vast open space, frantically taking note of every bird we saw swooping above the water or resting on the banks.

Suddenly, from a patch of trees just behind us, I saw something slowly walking toward the water. With my mediocre bird knowledge, I asked, “Is that a ... heron?” Tedesco immediately turned around and exclaimed, “That’s a sandhill crane!” Soon after, it called out and made a low rattling sound, almost as if announcing its presence. Seeing a sandhill crane in Champaign is a rare enough feat, as they tend to only migrate through the area for a brief period in the spring; but after we began taking

photos and videos of the crane, we soon noticed a small, fuzzy, yellow creature bobbing behind it — a sandhill crane colt! As we would learn after consulting natural history specialist Geoff Williamson, this was the first time anyone has seen a sandhill crane breeding in Champaign in at least a decade, but possibly much longer. As I saw this historic little creature trailing behind its parent, I felt a sense of hope that if this place that was once damaged can become an ecological haven once more, we can restore other spaces as well.



Lily Reynolds (closer to camera) and Aerin Tedesco birdwatching at Point Pleasant. *Credit: Abby Culloton*

While the restoration work at Point Pleasant is far from over, this sighting was a true testament to the success of the work that has been done so far. So how does this provide a model for other locations looking to restore wetlands? First, by combining ecological principles, sustainable engineering methods, and local context, the CCFPD team was able to restore the site in a holistic sense that benefitted the natural environment, surrounding communities, and users of the site. Additionally, though this isn't one of the largest or most well-known ecological restoration projects to take place in recent years, it is very indicative of the impacts of small-scale work. Local agencies and communities can identify areas in need and set out to create their own restoration projects; these are the efforts that are going to matter most in the coming years.

When I asked what restored natural spaces meant to her, Tedesco replied simply: "They're everything." Throughout my time at Point Pleasant, it became clear to me how one small place can make a world of difference. While this may just be one small wetland restoration project, it has succeeded in bringing key species back to the area and

serves as a living advertisement for the benefits of local activism. Ecological restoration is an important weapon in our fight against environmental decline; local, on-the-ground efforts like those that restored the natural beauties of Point Pleasant are small but important victories.



Abby Culloton is a senior from Bartlett, Ill. studying Civil and Environmental Engineering and a recipient of the Certificate in Environmental Writing. She is passionate about both engineering and environmental sciences

and hopes to bridge these two fields to work in habitat restoration and stream ecology. Outside of classes, she is the secretary of the Society of Women Engineers on campus and interns with Illinois-Indiana Sea Grant.



A mother sandhill crane and her colts.
Credit: Dina Johnson

“ ... this was the first time anyone has seen a sandhill crane breeding in Champaign in at least a decade, but possibly much longer. As I saw this historic little creature trailing behind its parent, **I felt a sense of hope that if this place that was once damaged can become an ecological haven once more, we can restore other spaces as well.** ”



HERBAL *Remedy*

By Olivia
Grubisich

Silent and tragic, opioid addiction festers in the American soil. It devastates consistently, but dips in and out of national attention. Most recently, the Hulu original series "Dopesick" described with fresh nuance how the deceptive marketing of OxyContin by Purdue Pharma catalyzed the torrent of prescription drug abuse.



When the U.S. Department of Public Health and Human Services declared the opioid epidemic a public health crisis in 2017, the medicine that began with promise for pain relief revealed its double edge. The relief opioids bring to people living in pain cannot be overstated, but the social and ecological consequences of addiction have run rampant.

The pain of opioid addiction stings perhaps nowhere more than in the rural U.S. Native to Greenbrier County, West Virginia, Allie Rambo recounts in a *New York Times* feature her first encounters with opioids. "By seventh grade my friend and I were stealing her mom's OxyContin and Xanax. Everyone I know had a prescription for something." Chilling photographs document moments in Allie's life and capture the lived reality of opioid addiction. The photographer is a friend of Allie's, and he witnesses her darkest moments as an addict, from the death of friends

and strain on family to the haunting feeling of living on borrowed time.

People like Allie deserve to stay at the center of the opioid story, but ramifications of the opioid epidemic also echo far beyond individuals, because the life cycle of these drugs does not end with ingestion. As they metabolize through human systems and are disposed of, opioids trickle — quite literally — into surrounding ecosystems. Improper disposal of opioids and the natural process by which they leave the human body lead to environmental consequences that often get overlooked in the face of the human devastation addiction causes. That toxic runoff from human-made chemicals enters the environment seems obvious, but little documentation of opioid contamination levels actually exists. Wastewater treatment plants are not required by law to test or report levels of opioid traces, leaving scientists in the dark.



Drugs like OxyContin affect not just people, but entire ecosystems.
Credit: Toby Talbot via AP



Zebrafish can develop opioid dependence just as people do.
 Credit: NERYXCOM via shutterstock

At the University of Utah, researchers began addressing the effects of contaminated runoff — by accident. Professor Randall Peterson’s lab studies zebrafish and their biological similarities to humans, similarities that make them excellent candidates for studying drug addiction. What started as an investigation into

Their research shows that zebrafish can develop opioid dependence the same as people do, and as a result, opioid residue making its way into aquatic ecosystems presents real danger to the creatures living there. Changed behavior of any species on a large scale disrupts the natural flow of ecosystems, leaving all species vulnerable to a cascade of changes.

zebrafish’s potential turned into the chilling realization that addiction could affect fish the same way it does people. To see how the zebrafish would react to opioid ingestion, Peterson’s lab constructed a large tank fitted with two motion-sensitive platforms. Motion over one end released the common opioid hydrocodone, while motion over the other induced no change. Over the course of five days, the number of motion detections between the two platforms was compared. At first, the ratio of trigger events was equal, but as time went on the number of

hydrocodone triggers increased dramatically. By the end of the five-day trial, the fish activated the hydrocodone platform 2,000 times a day, while completely ignoring the other side. Their draw to hydrocodone indicates the fish developed a desire to continue ingesting the opioids.

Their research shows that zebrafish can develop opioid dependence the same as people do, and as a result, opioid residue making its way into aquatic ecosystems presents real danger to the creatures living there. Changed behavior of any species on a large scale disrupts the natural flow of ecosystems, leaving all species vulnerable to a cascade of changes. After the Peterson lab published its conclusion that the fish went through the same cycle of tolerance, dependence, and withdrawal in the constructed lab setting, environmental scientists realized the same thing could happen in nature. This means that if aquatic life populations encounter pockets of drug-saturated water, they will return to these specific sites, making themselves vulnerable to potentially unfavorable conditions like shallow water, overcrowding, and increased predation.

The natural world is not only a site of damage in the opioid epidemic; it is also a site of potential respite and cure. Documentation of the medicinal use of natural products traces back at least to 2600 BC, when cuneiform tablets from Mesopotamia documented oils of *Cupressus sempervirens* and *Commiphora*, better known as Cypress and myrrh, as treatments for cough and inflammation. In the mountains of northern China’s Zhejiang province, vibrant purple flowers decorate the tapestry of flora spreading across the forest floor. The purple gems, called yan hu suo, rank as one of these storied treatments



Yan hu suo (*Corydalis yanhusuo*) has a storied history as a natural remedy, and perhaps a bright future as well.
Credit: Nature Library

as well, making appearances in early texts of Chinese medicine such as the Shennong Herbal and Lei Pao Zhi as a remedy for ailments including poor circulation, depression, and most notably, pain relief.

This pain-relieving ability is what brings yan hu suo to the opioid epidemic's landscape, where it is currently being studied as an anti-addictive additive to prescription opioids. Despite the documented success of natural products and herbal remedies, so-called western science often dismisses the validity of traditional medicine in favor of its own advancements. Yet between 1980 and 2010, 34% of drugs approved by the FDA were natural products or direct derivatives of natural products, proving a fact that should not be forgotten: Medicine's own roots grow from traditional practices.

Olivier Civelli finds inspiration in medicine's ties to the natural world. A Professor of Pharmaceutical Sciences and Cellular Biology at the University of California-Irvine, he works to close the gap between the organic history and future of medicine. A video interview accompanying his 2014 publication details how he turned his lab's focus toward study of traditional Chinese medicine in an effort to develop new methods of pain management. In conjunction with research groups in China, Civelli worked to document the properties of plants used in traditional Chinese medicine and, in his 2014 article, published his initial findings on the analgesic properties of yan hu suo.

"In the pharmaceutical industry, drugs are always aiming at one target," Civelli says. "Ultimately, if you want drugs to treat these kinds of (complex) disorders, you need drugs that work at more than one target." Natural products and their derivatives, yan hu suo included, often fit the polypharmacological profile he seeks.

Civelli's lab isolated as many compounds from yan hu suo as they could, looking for proof of what traditional methods told them to be true: yan hu suo stops pain. Through different experiments, yan hu suo's secrets slowly made themselves known, the most remarkable being its interactions with different receptors in the body. Receptors act like loading docks, where they receive signals from ingested substances, like medication, that induce changes in the body. The primary interaction they found was with morphine receptors, which, as their name suggests, are the same receptors that act in the pain-relieving mechanism of morphine and other opioids. But the further they dug into yan hu suo's abilities, they found that its journey through the body differs from opioids in a big way.

"(Yan hu suo) does not work on the morphine receptor efficiently enough to relieve pain," Civelli says in the same interview. "We found out that this compound is able to inhibit the dopamine receptor." In opioids, the release of dopamine from these receptors triggers the "high" feeling that entices prescription users to exceed safe dosages,

“ In the pharmaceutical industry, drugs are always aiming at one target. Ultimately, if you want drugs to treat these kinds of (complex) disorders, you need drugs that work at more than one target. ”

leading to tolerance and eventually dependence. If yan hu suo can inhibit this process, as Civelli's initial findings indicate, then it could deter the development of addiction from opioids altogether.

In 2021, Civelli's lab published a study further investigating these receptor interactions through exploring the administration of yan hu suo and morphine together. The first part of the experiment showed yan hu suo and morphine provided the same level of pain relief as morphine by itself, meaning the addition of yan hu suo didn't hinder morphine's efficiency. But unlike morphine alone, the co-administration maintained its efficiency throughout the entire trial. When opioid tolerance develops, the drugs become ineffective unless its dose is increased, leading to redosing at shorter intervals than what is considered safe to find both pain relief and dopamine release. The co-medication's prolonged success suggests that yan hu suo could work as an addiction deterring additive to opioid prescriptions. The immediate impact of these results is the possibility of increasing dosage intervals, leading to less overall opioid ingestion in patients. The risk of addiction decreases without compromising pain relief.

The second assessment further investigates tolerance development of the morphine and yan hu suo co-administration. In the simulated models, morphine lost its pain-relieving properties after only seven days, indicating that complete biological tolerance had developed. When co-administered with yan hu suo, morphine showed no signs of losing efficacy over the course of the experiment. In other words, something about yan hu suo changed the way morphine works in the body, while deterring all tolerance build-up usually associated with morphine use. This reinforces what Civelli and his lab found in the first part of their experiment: When used together, yan hu suo and morphine seem to eliminate pain without causing addiction.

The third and final piece of the study tapped deep into yan hu suo's healing wisdom. Not only did yan hu suo show the possibility of blocking morphine's tolerance mechanism, its administration seemed to reverse addiction after it had already developed. These possibilities and the results from all three layers of

Civelli's study show promise, yet only begin to probe the surface of yan hu suo's potential in relation to the way opioids like morphine are prescribed and dosed.

Yan hu suo's capability to change the pain-relieving landscape of the medical field could be the first step to decrease both opioid levels in water runoff and the number of people held in the clutch of prescription drug addiction. If what Civelli's research has found hidden deep in the Chinese countryside holds true, then its application as a way to curtail the number of opioids prescribed becomes all the more hopeful. But the process by which yan hu suo could go from its quaint home on the forest floor to the mainstream market is a long journey, and one that won't occur overnight. Confirmation of yan hu suo's abilities, as well as extensive trials detailing both its interactions with morphine and potential to work with other opioids, is imperative before any grand claims should be made. Even with the promising nature of Civelli's research and the well-documented success of yan hu suo, skepticism surrounding the "anti-addictive" mechanism remains necessary.

After all, it wouldn't be the first time pharmaceutical companies sold lies about their products to turn a profit. With no clinical evidence, Purdue Pharma received FDA permission to market OxyContin's long-lasting formula as "less prone to abuse" and went so far as to train sales representatives to tell doctors it was less addictive than other opioids on the market. The American market became saturated with these dangerous pills as a direct result.

Somewhere in the Zhejiang province, purple blossoms glisten in the rolling streams of sunlight flickering through trees. It seems criminal to think of implicating something so beautiful in the insatiable profit-thirst of Big Pharma, but if yan hu suo were to be commodified by the pharmaceutical industry, a healthy skepticism must be our first response. That said, there's reason for optimism. Chinese tradition entrusted yan hu suo with the well-being of all its people, fostering relationships of mutual care that lasted successfully for centuries. With yan hu suo's combination of humble origins, ancient wisdom, and medical possibilities, she's pretty easy to root for.



Olivia Grubisich is a graduate from New Lenox, Ill. She completed her Bachelor of Science in Chemistry in May 2022 and is currently enrolled in the U of I's M.S. Journalism

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