ECOfOCUS
CARY INSTITUTE OF ECOSYSTEM STUDIES
Science for environmental solutions *Spring 2022*

Leng Cheng via Flickr

Through livestock handling, live animal trading, and ecotourism, we are increasing our contact with new animal species and the pathogens they carry.

PREDICTING DISEASE SPILLOVER TO **PREVENT PANDEMICS**

Cary disease ecologist Barbara Han is working to predict zoonotic diseases to preempt future outbreaks. Her recent work is looking at animals that could host and transmit SARS-CoV-2, the virus that causes COVID-19.

Han says, "Zoonotic diseases emerge where people, animals, and pathogens overlap. Through activities like farming, live animal trading, wet markets, and ecotourism, we are increasing our contact with animals and the pathogens they carry. Globally, people are encroaching on wildlife habitat while climate change is forcing species into new places. These changes increase the likelihood that a pathogen will jump to new host species, with potential for mutation."

'Spillback' is when a zoonotic disease spreads from people to animals. 'Secondary spillover' is when a spillback infection is passed back to people.

"Since the COVID-19 pandemic began, we have seen new strains emerge, each with unique symptoms and levels of transmissibility," says Han. "Identifying animals with the potential to become infected and also transmit SARS-CoV-2 is critical to preventing spillback infections and dangerous new variants, which can develop when pathogens move between species."

Han's team is using information on biological traits of animals to predict high-risk species that should be targeted for SARS-CoV-2 testing and surveillance. Their methods combine machine learning, mapping, and molecular modeling approaches in novel ways. Identifying risky species can help wildlife managers and public health officials target areas and animals that should be prioritized for monitoring to prevent spillback and secondary spillover infections.

What makes an animal susceptible to COVID-19? Han explains, "Infection potential partially lies in the ACE2 receptor – a structure on the surface of a host cell that allows the SARS-CoV-2 virus to enter the cell, like a lock and key. Whether an infected host can spread the virus to people or other animals depends partly on the 'binding strength' – that is, how 'tight' the lock and key fit together. If a species has the ACE2 receptor, it could become infected; if binding strength is high, it is likely able to transmit."

Han's team created a model to predict mammals that could contract and spread SARS-CoV-2 based on their biology and information on the ACE2 receptor. A number of species flagged by the model as 'high risk' have since been confirmed for COVID-19 infection; these include white-tailed deer, red fox, snow leopards, and deer mice, among others.

Han says, "Our model found that the riskiest mammals include many that live in disturbed landscapes and in close proximity to people – including pets, livestock, and animals that are traded and hunted. This makes it easy for the virus to infect new species.

We have already seen diminishing vaccine efficacy with new variants. Each time the virus infects a new host, there is a chance that it will mutate and become more dangerous. Targeting high-risk species for lab validation and field surveillance is critical to identifying early interventions needed to prevent spillback infections."

Han concludes, "We should also explore underutilized data sources like natural history collections, to fill data gaps about animal and pathogen traits. More efficient iteration between computational predictions, lab analysis, and animal surveillance will help us better understand what enables spillover, spillback, and secondary transmission – insight that is needed to guide zoonotic pandemic response now and in the future."

ECO*f*OCUS

Ecofocus is published by Cary Institute of Ecosystem Studies, an independent nonprofit center for environmental research. Since 1983, our scientists have been investigating the complex interactions that govern the natural world and the impacts of climate change on these systems. Our findings lead to more effective management and policy actions and increased environmental literacy. Staff are global experts in the ecology of: cities, disease, forests, and freshwater.

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FROM OUR PRESIDENT

Dear Friends:

On April 8th, after a year of planning and 18 months of construction, we formally reopened our headquarters, now named the Tozer Ecosystem Science Building (or TESB to friends). Nearly 300 people toured and celebrated the stunning architectural reinvention. In addition to providing light-filled, quiet space for science, the environmentally-healthy and energy efficient building is fueled by our 4-acre solar field (see *solar.caryinstitute.org* to track our use and production of solar energy). April 8th also concluded the Campaign for Cary, another wild success, raising $7.2 million towards the TESB costs and, despite the pandemic, exceeding our goals.

Staff love the building and it is already proving a strong attractor for new hires and visits from colleagues from around the world. The new space will allow us to do even more 'science for environmental solutions' (our tagline). As this newsletter shows, Cary scientists pursue important questions with significant societal impacts. From research on forecasting zoonotic diseases and managing freshwater resources to siting dams sustainably in the Amazon and deepening our understanding of the ecology of segregation, staff are working locally, and globally, to pursue science that makes the world a better place.

I will end with a bittersweet note. On Christmas day, Cary Institute founding Trustee, Dr. Tom Lovejoy, died. Tom, the dean of Amazon ecology and conservation, was a friend, colleague, and mentor to generations of scientists, and to many Cary staff. We already miss him, and will remember him, and honor him, by naming our auditorium the Thomas E. Lovejoy III Auditorium.

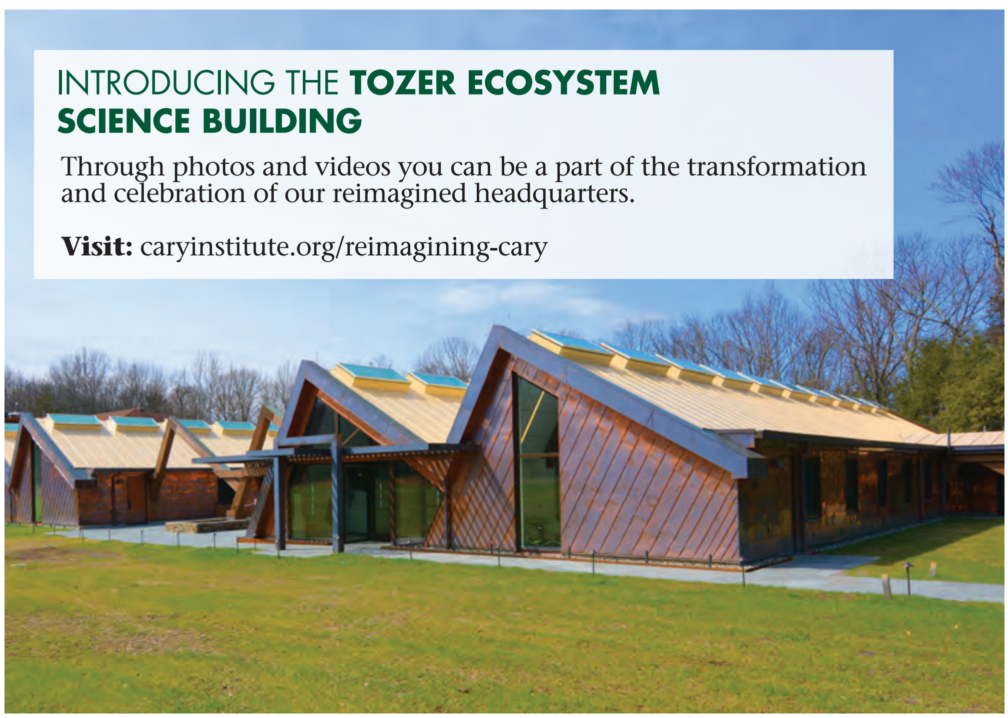
John Halpern

Joshua R. Ginsberg, PhD

INTRODUCING THE **TOZER ECOSYSTEM SCIENCE BUILDING**

Through photos and videos you can be a part of the transformation and celebration of our reimagined headquarters.

Visit: caryinstitute.org/reimagining-cary



David Fischer

LIGHTNING'S LEGACY: **MORE STRIKES, LESS CARBON**

Steve Yanoviak

Evan Gora often climbs more than 100 feet into the forest canopy to study the effects of lightning on trees in Panama.

Climate change is increasing the number and frequency of intense storms in the tropics. This means more lightning strikes, which can be bad for large trees, their neighbors, and ultimately the climate.

Cary Research Fellow and forest ecologist Evan Gora, who holds a dual appointment as an Earl S. Tupper Fellow at the Smithsonian Tropical Research Institute, is studying how climate change, lightning strikes, and tree death shape the composition of tropical forests and their ability to store carbon.

Gora says, "Tropical forests are the most important carbon sink on the planet; their trees hold 40% of the living carbon on Earth's surface. Tree death is the dominant factor limiting carbon storage in these forests. Lightning is a major cause of tree death globally, but we know very little about what this means for tropical forest ecosystems, and how climate change might be intensifying lightning-caused tree mortality."

When trees die and decompose, the carbon they store is released back into the atmosphere. Large trees, the main targets for lightning, emit about 7 tons of CO_2 after an average strike. Plus, neighboring trees are damaged by 'flashover' – when electricity from a struck tree 'jumps' to nearby branches – releasing an additional 5.8 tons of CO_2 per strike. If more trees die due to lightning strikes, tropical forests will store less carbon.

Using field surveys, drone imagery, and sensors that detect electromagnetic radiation, Gora and his colleagues are studying the effects of lightning strikes on tropical trees in Barro Colorado Island, Panama.

Gora says, "We know that tens of millions of lightning strikes hit tropical forests every year, but finescale monitoring is a challenge. The location of strikes is impossible to predict and they are hard to find after they occur. As a result, we have almost no information about the role of lightning in tropical forests.

We are using a network of sensors and cameras to help us detect strikes and locate struck trees so that we can study both immediate and long-term effects. So far, our findings indicate that lightning is a major driver of tree death and the release of forest carbon."

Gora and his colleagues have located 93 lightning strikes and 2,195 lightning-damaged trees in Panama. They have found that on average, one lightning strike kills 5.3 trees, damages 18.3 trees, and affects an area larger than the size of a basketball court. Large trees are hit most frequently.

Despite clear trends linking lightning and tree death, Gora offers a note of hope: Lightning does not kill every tree it strikes. In cases when lightning is not fatal, the struck tree can actually benefit. This is because lightning kills parasitic plants and neighboring trees, reducing competition while increasing light availability.

Gora is now expanding this monitoring system to other forests and integrating with drones and satellites to study tree mortality holistically.

Gora explains, "More lightning could cause a shift in species composition that favors resistant species. We are working to unravel implications for carbon storage plus what this could mean for the forest ecosystem and organisms that depend on particular tree species to make a living. Understanding how lightning strikes affect tree mortality, tree species composition, and carbon cycling will be critical to predicting tropical forest response to climate change, and consequences for global carbon sequestration."

Evan Gora

When lightning strikes a tree, neighboring trees and parasitic plants like lianas are also affected via 'flashover'.

PROTECTING FISHERIES FROM **SLOW SOCIAL CHANGE**

Spring is here, and for many anglers, that means fishing season is underway. A recent study by Cary aquatic ecologist Chris Solomon and fishery biologist Chelsey Nieman (who led the work as a Cary postdoc) shines light on three slow but steady causes of fishery decline that can drive fish numbers to dangerously low levels.

Acorn Resort via Flickr

Making lakes easier to access via roads and ramps can increase pressure on fish. Balancing access and conservation is a perennial challenge in fishery management.

Nieman explains, “For too long, recreational fisheries were seen as self-regulating. We now know that their sustainability depends on both natural and human features. When these conditions change, it can have big implications for fish populations and the quality of the fishing experience.”

Using a mathematical model of open access recreational fisheries, and data from Wisconsin, the western Pacific, and British Columbia, they considered the impacts of three kinds of social change on fish abundance: the cost of going fishing, the effectiveness of fishing technology, and the importance of catch to angler satisfaction. Their study is one of the first to explore the role that slow social change plays in the resilience of recreational fisheries.

“When change happens over many years or generations, it can be hard for people to perceive it or summon the will to act on it,” Solomon notes. “Yet our work shows that slow social changes that can degrade fisheries may be quite common and widespread.”

Improvements in infrastructure like new roads and boat ramps make it easier for people to go fishing. Advances in technology like fish finders and angling apps make it easier to land fish. As it becomes easier for people to access lakes and harder for fish to hide, these changes increase pressure on fish populations.

“We are also seeing changing attitudes about the importance of catch,” explains Solomon. “Anglers value many aspects of the fishing experience beyond catching fish, such as spending time in nature, socializing, and mastering angling-related challenges. But when people continue to fish even as catch rates decline, fish numbers can fall to dangerously low levels. It’s like the old story about the frog in a pot of boiling water. If you don’t notice a change, you don’t know when to hop out of the water.”

US Army Corps of Engineers

Advances in technology like fish finders and angling apps increase the risk of overfishing. Reducing reliance on technology could help protect fish populations.

The authors emphasize that there are concrete steps that anglers and managers can take to protect lakes in the face of slow social change. Anglers can embrace the challenge of fishing and reduce reliance on technology. Mastering catch and release best practices can improve fish survival. It is also critical for anglers to support and advocate for adequate funding for fisheries monitoring by state management agencies who play an essential role in understanding and conserving fish populations.

One tactic that managers could apply on select lakes is prioritizing higher per-trip catch rates instead of maximizing the number of people who can fish on a given lake. They should also balance conservation and access, and carefully consider long-term effects of improved infrastructure (like roads and ramps) on fisheries.

Nieman concludes, “If anglers and managers can work together to confront the challenges posed by gradual social and environmental change, we can hope to sustain good fishing opportunities and healthy fish populations for many generations to come.”

Learn more: caryinstitute.org/SlowSocialChange

WINTER ROAD **SALT INCREASES ALGAE IN FRESHWATERS**

We rely on rock salt to keep winter roads safe, but it is also polluting freshwaters, with consequences for aquatic life and drinking water.

When deicing salt washes off roadways into lakes and streams, it does not flush out of the ecosystem. Instead, it spreads through the environment and lingers in groundwater and soils, where it accumulates over decades. Since freshwater organisms cannot tolerate high salt levels, salization can cause increases in algae.

Cary Institute postdoc Jennifer Brentrup is part of a team studying the effects of elevated salt levels on microscopic freshwater life. Brentrup explains, "In regions that experience cold, snowy winters, road salt is the primary driver of freshwater salinization. However, it is not the only cause. Climate change, agriculture, mining, and other industrial practices are all contributing to rising salt levels in freshwaters globally."

Alexander Conway

Jennifer Brentrup monitors experimental 'lake' mesocosms at Dartmouth Organic Farm in Hanover, NH.

In a recent study, Brentrup found that salt concentrations well below federally mandated guidelines were still killing zooplankton. She explains, "Less zooplankton means more algae, and this can cause problems for biodiversity and drinking water."

The team leveraged data from 16 study sites located in or near lakes throughout North America and Europe. At each site, research teams created miniature experimental 'lakes', where they tested a range of environmentally relevant salt levels and measured the effects on zooplankton and algae. They found that concentrations well below US and Canadian government thresholds were sufficient to kill zooplankton and cause increases in algae.

Brentrup concludes, "Increasing salt and algae could have reverberating effects on lake food webs. Since zooplankton feed fish, declining zooplankton could reduce fish populations. Lakes could also be facing a higher risk of harmful algal blooms – threatening aquatic life, drinking water, and recreational opportunities. There is a critical and immediate need to set lower salt concentration thresholds for freshwater lakes throughout North America and Europe to protect aquatic life and the many benefits lakes provide."

PLANNING FOR **SUSTAINABLE HYDROPOWER IN THE AMAZON**

Hydroelectric dam expansion is booming globally. Dams provide renewable energy, yet they come with high social and environmental costs. Dams disrupt sediment flows and river levels, with consequences for biodiversity and downstream ecosystems. They also threaten fisheries, floodplain agriculture, and the transportation of people and goods.

The Amazon is Earth's largest and most biodiverse river basin; it's also a hydroelectric hotspot, with 158 existing dams and 351 proposed. Dam projects are typically assessed individually, with little coordinated planning. A recent study provides the first computational approach for evaluating basin-level tradeoffs between hydropower and ecosystem services to guide sustainable dam siting.

Coauthor Stephen Hamilton, an ecosystem ecologist at Cary Institute, explains, "Continued hydropower development in the Amazon is inevitable. So how can that proceed in a way that optimizes energy output at the lowest environmental cost? The answer comes in selecting projects strategically, taking into account multiple environmental criteria that have thus far been too difficult to account for simultaneously in planning large numbers of potential projects."

Hamilton was part of a team led by researchers at Cornell University that developed a novel framework to analyze proposed dam projects collectively – both for their energy generation, as well as their impacts on the environment. Their tool, called Amazon EcoVistas, uses artificial intelligence and high-performance computing to identify hydroelectric dam portfolios that meet energy production goals with the least environmental harm.

For each combination of dams that could be built (~10^{153} total), they analyzed five environmental criteria: river flow, river connectivity, sediment transport, fish biodiversity, and greenhouse gas emissions, as well as energy output. This allowed them to assess tradeoffs among different combinations of projects.

Hamilton says, "Our evaluations demonstrate that whole-basin planning can reduce environmental impacts while optimizing energy production and maintaining crucial ecosystem services. By identifying opportunities for more sustainable hydropower development, Amazon EcoVistas could prove useful to energy planners, decision makers, and researchers working to preserve threatened ecosystems while meeting energy production needs."

Learn more: caryinstitute.org/AmazonHydroPlanning

Bruno Batista

The recently constructed Belo Monte megadam in the Amazon lowlands of Brazil.

SUPPORTERS' CORNER

In gratitude for your generous support, please join us for the

Ned Ames Honorary Lecture

Saltwater Intrusion and Sea Level Rise:

The leading edge of climate change across North America's Coastal Plain

presented by
Dr. Emily S. Bernhardt

Nicholas School of the Environment at Duke University

Friday, June 3, 2022
reception 6:00 pm // lecture 7:00 pm

Join us for a short film, *The Seeds of Ghost Forests*, and conversation featuring Drs. Emily S. Bernhardt and Joshua R. Ginsberg.

Please note: The in-person event is reserved for members of the Aldo Leopold Society. Please RSVP to Vicki Doyle at doylev@caryinstitute.org. A virtual option is open to all; to register, please visit: caryinstitute.org/events.

This event is sponsored by the generous, continuing support of an anonymous donor and

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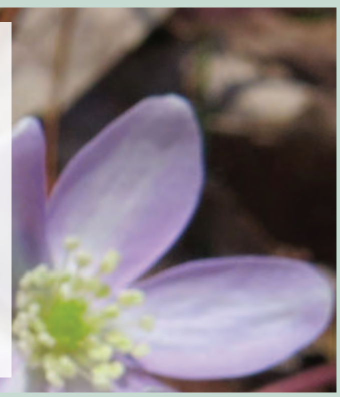
REMEMBERING **CHRISTINA LANG ASSAEL**

Christina Lang Assael was a longtime friend of Cary Institute who was passionate about protecting the environment. Her investments in the Lang Assael Family Science Innovation Fund and the Campaign for Cary have been vital to the Institute. The Innovation Fund provides seed money to Cary scientists working at the frontiers of ecological science.

The Christina Lang Courtyard, adjacent to the science wing and lunchroom, will serve as a hub for Cary staff and visitors to think deeply, gather, and collaborate for decades to come.



Barry Haydasz

IN CASE YOU MISSED IT

Videos of our virtual events can be viewed online at caryinstitute.org/lecture-videos

Oh Deer! How Deer Shape Forests in the Catskills & Beyond
Panel discussion featuring Cary's Charles Canham, Vassar's Lynn Christenson, and Brendan Quirion of the New York State Department of Environmental Conservation.

The Ecology of Segregation
Cary Science Conversation with Cary's Steward Pickett, MIT's Anne Whiston Spirn, and University of Maryland's Marccus Hendricks.

Tree ID Workshop
Learn how to ID trees in the early spring with Cary's Mike Fargione and Julie Hart and Brian Straniti of the Dutchess Land Conservancy.

The Tick Project in Focus
Learn about findings of The Tick Project, a 6-year study investigating two tick control methods in Dutchess County, NY, featuring Felicia Keesing of Bard College and Cary's Rick Ostfeld.

Barry Haydasz

SUPPORT SCIENCE

Leslie Tumblety

One of the greatest threats to US trees are invasive insect pests and pathogens that are accidentally imported into the country in wood shipping materials and/or on live plants bound for the nursery trade. Cary's Tree-SMART Trade initiative offers recommendations for improving shipping practices and tightening regulations to protect trees in our forests and communities. Learn more about the Asian longhorned beetle in a new blog post by Cary forest ecologist Gary Lovett: **caryinstitute.org/ALB**.

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URBAN **GREEN INFRASTRUCTURE EQUITY**

Many cities have embraced green roofs, bioswales, tree plantings, parks, and other forms of green infrastructure to manage urban hazards and build resilience. But too often, equity is absent from planning efforts, and projects fail to involve, or consider impacts on, marginalized communities.

Researchers from Cary Institute and The New School recently completed a multi-year study exploring urban green infrastructure equity across the US. They undertook two projects – a nationwide analysis of 122 green infrastructure plans in 20 US cities, and the development of a green infrastructure governance toolkit. Both seek to improve the equity of green infrastructure in planning, policy, and practice.

Explore study findings from the 20-city analysis and recommendations for cities at **GIequity.org**. You can also view a webinar led by Cary researchers: 'Building Equity into US Urban Green Infrastructure Planning' (**caryinstitute.org/GIEquityWebinar**).

To help stakeholders examine social processes that shape decision making for environmental projects in cities, Cary's Amanda Phillips de Lucas developed an experiential toolkit called *Governing Green*. Drawing from interviews with city officials, nonprofits, and community leaders from six US cities, the toolkit allows users to explore green infrastructure projects from the standpoint of different stakeholders.

Access *Governing Green*, accompanying resources, and a recording of a virtual workshop at: **caryinstitute.org/GovGreenResources**.

Funding for GIequity.org and Governing Green was made possible by the grant 'Making Green Infrastructure Equitable' from The JPB Foundation.

Timon McPhearson