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FROM THE ARCHIVE
The agricultural complex—which now comprises Hilgard, Wellman, and Giannini Halls—was a key element in architect John Galen Howard's grand vision of a "City of Learning," which inspired today's UC Berkeley campus. This rendering dates from between 1910 and 1916.

BREAKTHROUGHS

UC BERKELEY COLLEGE OF NATURAL RESOURCES • FALL 2018

Force of Nature

Evolutionary ecologist Erica Bree Rosenblum explores the origins of biodiversity

Magnetic Attraction | A New Dean for CNR

LETTER FROM THE DEAN

In case you don't recognize the photo above this column, let me introduce myself. I joined the College of Natural Resources as its new dean on July 1, coming from the Department of Integrative Biology and the Biological Sciences Dean's Office in the College of Letters & Science. I'm excited to be taking the reins at this particular moment in CNR's history, as we celebrate our 150th year. While the global challenges to environmental health and human well-being are sobering, the opportunities to address them through fundamental research, education, and outreach to society have never been greater.

I want to express my profound appreciation to J. Keith Gilless for his leadership of CNR during a difficult period for Berkeley's administration. Dean Gilless's sustained vision, his careful stewardship of resources, his fundraising achievements, and the attention he has devoted to many recent campus-wide challenges have built a strong foundation for the college's continued growth and success.

This issue of *Breakthroughs* features two CNR faculty who are advancing their respective fields through research—in magnetotactic bacteria and evolutionary ecology—as well as making innovative contributions to teaching by taking a holistic approach with their students. Continuing our 150th-anniversary celebration, we take a retrospective look at the Albright Lecture, honoring one of Berkeley's pioneers in the conservation movement. And we report on the valuable support we receive each year from the donors to our CNR Annual Fund.

I look forward to meeting many of you in the months and years ahead. I'm committed to the success of CNR and to enhancing its role as a leader on campus and beyond by continuing to address challenges in the areas of biodiversity, energy, the environment, food, health, and justice.

I welcome your feedback at dackerly@berkeley.edu.

David Ackerly

David D. Ackerly

DEAN
David D. Ackerly

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FALL 2018

Berkeley UNIVERSITY OF CALIFORNIA College of Natural Resources

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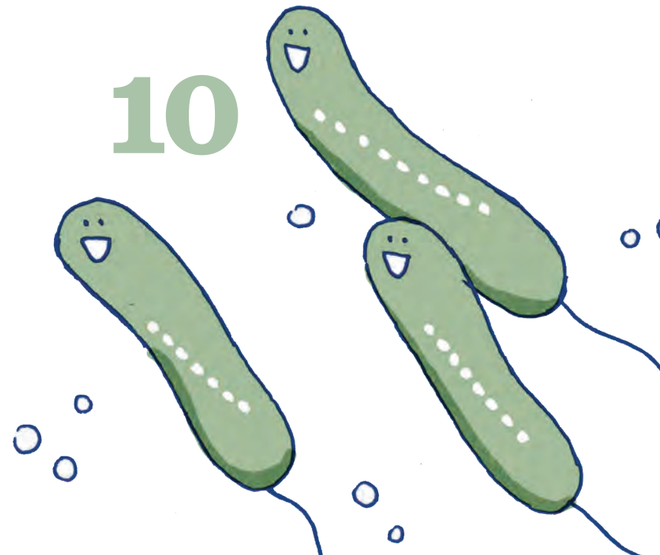


Left: Drying kombu, a type of seaweed
PHOTO: Courtesy of Salt Point Seaweed

COVER: Photo by Elena Zhukova

Hoppy Beer—Minus the Hops

Ask any beer connoisseur what differentiates artisanal brews and traditional light American lagers, and you're likely to hear the word "hoppy." Now a team of biologists, including plant and microbial biology (PMB) PhD candidate **Rachel Li** and PMB adjunct professor **Henrik Scheller,** has come up with a way to develop the unique flavors and aromas associated with hops without actually using any.

The team created strains of brewer's yeast that not only ferment the beer but also produce two of the prominent flavor notes provided by hops. The engineered yeast strains were developed using CRISPR-Cas9, a gene-editing tool co-discovered at UC Berkeley.

According to the researchers, whose paper appeared in March in the journal *Nature Communications*, excessive amounts of water, fertilizer, and energy are required to grow and transport hops, all of which could be avoided by using yeast to make a hoppy-tasting brew. On average, producing 1 pint of a craft beer takes 50 pints of water merely to grow the hops, which are the dried flowers of the climbing plant *Humulus lupulus*. Another issue is that hops' flavorful essential oils are highly variable from year to year and from plot to plot, whereas using a standardized yeast ensures uniformity of flavor. And hops are expensive.

Li is now the cofounder of a start-up called Berkeley Brewing Science. The company hopes to market hoppy yeasts to brewers and to create other strains that incorporate plant flavors not typical of beer brewed from the canonical ingredients: water, barley, and yeast.

— ADAPTED FROM AN ARTICLE BY ROBERT SANDERS

PHOTO: Jamie Hall

WILDLIFE WORK THE NIGHT SHIFT

Human activity is causing mammals to avoid daylight and seek the protection of darkness, reports a new study led by College of Natural Resources scientists. The study, published in June in *Science* and supported in part by the National Science Foundation, represents the first effort to quantify the global effects of humans on the daily patterns of wildlife. It sheds light on the process by which animals are altering their behaviors in reaction to human disturbance.

"Catastrophic losses in wildlife populations and habitats as a result of human activity are well documented," said environmental science, policy, and management (ESPM) PhD candidate and study lead author **Kaitlyn Gaynor,** "but the subtler ways in which we affect animal behavior are more difficult to detect and quantify."

Gaynor and her co-authors—including ESPM professor **Justin Brashares** and alumna **Cheryl Hojnowski,** PhD '17 ESPM—used data for 62 species across six continents to look for global shifts in the timing of mammals' daily activity in response to humans.

Data collection involved such approaches as remotely triggered cameras, GPS and radio collars, and direct observation. For each species in a study site, the authors quantified the difference in nocturnality under conditions of low and high human disturbance.

"While we expected to find a trend toward increased wildlife nocturnality around people, we were surprised by the consistency of the results around the world," Gaynor said. "Animals responded strongly to all types of human disturbance, regardless of whether people actually posed a direct threat, suggesting that our presence alone is enough to disrupt their natural patterns of behavior."

— MACKENZIE SMITH

Artificially Cooling the Earth Won't Prevent Crop Damage

Recently, scientists have pointed to instances of global cooling caused by gases emitted during massive volcanic eruptions and argued that humans could inject particles into the upper atmosphere to artificially cool the earth, alleviating greenhouse warming caused by increased levels of carbon dioxide. Aerosols—in the case of the eruptions, tiny droplets of sulfuric acid—reflect a small percentage of sunlight back into space, reducing the earth's temperature by a few degrees.

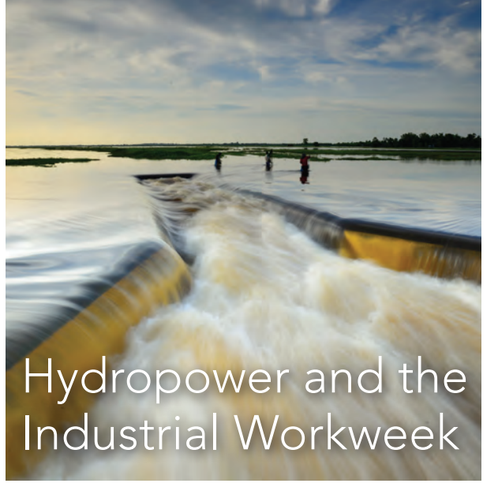
However, a new analysis by UC Berkeley researchers reveals that injecting particles into the atmosphere to counter the warming effects of climate change would do nothing to offset the crop damage from rising global temperatures. After analyzing the past effects of earth-cooling volcanic eruptions and the response of crops to changes in sunlight, the team concluded that any improvements in yield resulting from cooler temperatures would be negated by lower plant productivity due to reduced sunlight.

"Shading the planet keeps things cooler, which helps crops grow better. But plants also need sunlight to grow, so blocking sunlight can affect growth," said study co–lead author **Jonathan Proctor,** a doctoral candidate in the Department of Agricultural and Resource Economics and a doctoral fellow at Berkeley's Global Policy Laboratory (GPL). "For agriculture, the unintended impacts of solar geoengineering are equal in magnitude to the benefits. It's a bit like performing an experimental surgery: The side effects of treatment might be as bad as the illness."

"It's similar to using one credit card to pay off another credit card: At the end of the day, you end up where you started without having solved the problem," said co–lead author, Chancellor's Associate Professor of Public Policy, and GPL director **Solomon Hsiang,** offering another analogy. Proctor and Hsiang reported their findings in August in *Nature*.

The team linked data on maize, soy, rice, and wheat production in 105 countries from 1979 to 2009 to global satellite observations of the aerosols from volcanic eruptions to study their effect on agriculture. Pairing the results with global climate models, the team calculated that the effects of sunlight loss resulting from a sulfate-based geoengineering program would cancel out the intended benefits of protecting crops from damaging extreme heat.

— ROBERT SANDERS



Hydropower and the Industrial Workweek

A study published in *Global Change Biology* in April demonstrates that hydropower—a critical energy source for humans worldwide—introduces artificial flow patterns into rivers, negatively affecting invertebrate biodiversity downstream. The study's lead author, **Albert Ruhi,** joined the Department of Environmental Science, Policy, and Management as an assistant professor in January.

Aquatic invertebrates are very diverse in running waters and perform key roles: Many convert algae or detritus into living animal biomass, funneling energy into and out of river habitats. Each species has a different suite of roles, and maintaining that diversity is key to a river ecosystem's healthy functioning.

Using time-series methods like wavelets, Ruhi and his collaborators found that flow-regime alterations caused by hydropower dams often corresponded to the industrial workweek, resulting in hydropeaking (sudden releases of water to support peak power demand) Monday through Friday. This artificial schedule had varying effects on invertebrates. While 3 groups did well under this regime of periodic pulses, 16 were negatively affected—causing a net decrease in functional diversity.

Ruhi and his colleagues analyzed 11 years' worth of data on invertebrates and combined it with river-discharge data that the U.S. Geological Survey has been recording since 1942. They focused their study on the Chattahoochee River, below Lake Lanier in northern Georgia, then showed that the "workweek effect" is widespread across the American Southeast.

The researchers were further able to project that the risk of observing functional-diversity losses within the next four years would decrease by an average of 17 percent if hydropeaking were lessened.

"We must work to better mitigate the ecological impacts of flow management for hydropower," Ruhi said. "Understanding how freshwater biodiversity responds to different facets of streamflow alteration may be a first step toward operating dams in a greener way."

— KIRSTEN MICKELWAIT

SUBJECT:

Why I Do Science

ENTRY BY: **Danica Chen**

ENTRY #: **017**

Growing up in China after the Cultural Revolution, we were encouraged to excel in science and technology. When I was applying for college, my father recommended that I pursue international accounting at Xiamen University, but the only slot available in that major for my whole province had already been filled. My brother happened to hear that they still had an opening in cell biology. When I was just 19, he set me on my path as a biologist.

After receiving my PhD in HIV transcription, I decided to change my research focus to aging. How we lose the ability to maintain homeostasis and become susceptible to diseases as we age remains an outstanding question in biology. The idea that we might be able to control the aging process was very exciting to me, and this became one cornerstone of my lab.

A related foundational concept is health span: the number of years one can live a healthy life. As aging is arguably the single biggest risk factor for numerous diseases, understanding the cellular pathways that control aging holds the promise of identifying therapeutic targets for not just one ailment but many simultaneously. My research aims to understand the molecular and cellular mechanisms underlying aging-associated conditions and to identify which aspects of these conditions are reversible.

In biology, there are more female than male students from the undergraduate to the postdoc level, but that doesn't seem to be translating into a better gender balance among tenured professors. I'd like to find ways to help women aim high and to create safe and inclusive work environments. Berkeley should aim to be a leader in providing an environment that fosters these values.

Danica Chen is an associate professor of metabolic biology in the Department of Nutritional Sciences and Toxicology, as well as a member of the Berkeley Stem Cell Center and the QB3 Consortium in Lifespan Extension.

Bottled Water Is Not Necessarily Better Water

In a July article published in *Nature Sustainability,* two Energy and Resources Group (ERG) researchers identified the global risks of the planet's increasing reliance on bottled water. The rapid growth of the market for bottled water and its normalization as daily drinking water cannot guarantee universal access, argued **Isha Ray,** an ERG associate professor, and **Alasdair Cohen,** PhD '16 Environmental Science, Policy, and Management (ESPM), a postdoctoral researcher. Instead, the most viable means of achieving universal safe water access continues to be sustained investment in centralized and community utilities.

While economically developed countries have reached near-universal access to drinking water through publicly owned or regulated water utilities, in most low- and middle-income countries (LMICs), the adoption of safe piped water has been slow. Bottled water is now the fastest-growing form of access to purportedly safe drinking water in LMICs.

Of the top 10 bottled-water-consuming nations over the past decade, 6 have been LMICs (Brazil, China, India, Indonesia, Mexico, and Thailand). The latter countries' consumption of bottled water increased by 174 percent during that period, compared with a 26 percent increase for the high-income countries in the group.

Primarily using bottled water has negative implications across social, economic, health, and environmental lines. "In the short to medium term," the authors note, "LMIC governments should evaluate non-tap options that could expand safe water access."

Community-scale kiosk models, in which disinfected municipal water is delivered at low or no cost in reusable 19-liter bottles, are more sustainable and affordable than commercially sold bottled water.

"If governments and development agencies allow the bottled water sector to continue meeting the rising demand for safe water, then access will continue to grow, but it will likely not be reliably safe or universally affordable," Ray said.

— KIRSTEN MICKELWAIT

CNR Expertise at Work

Meredith Fowlie, an associate professor in the Department of Agricultural and Resource Economics, has been appointed to the Independent Emissions Market Advisory Committee, which serves the California Environmental Protection Agency. The committee is tasked with performing annual reviews of California's cap-and-trade program and other state-mandated environmental initiatives, to evaluate their effectiveness in working toward reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030.

The Intergovernmental Panel on Climate Change (IPCC) has selected **Patrick Gonzalez,** an ESPM adjunct associate professor, as a lead author of a chapter on ecosystems in its next major climate change assessment, *Climate Change 2021: Impacts, Adaptation, and Vulnerability.* The IPCC's reports on human-caused climate change serve as the international standard reference for scientists and policy makers, and the panel was a corecipient of the 2007 Nobel Peace Prize.

FACULTY PHOTOS: Julie Gipple

Five Key Lessons

ESPM 150/290

The UC Water Academy

ESPM Cooperative Extension specialist **Ted Grantham** is one of a trio of scientists leading the UC Water Academy, an experiential course supported by the UC Water Security and Sustainability Research Initiative. Launched in 2017 and co-taught by UC Merced professor Josh Viers and UC Davis hydrologist Sarah Yarnell, the course invites undergraduate and graduate students from all the UC campuses for a semester of readings and online discussions followed by a tour of California's water—from dams to the delta, pipelines to planted fields, irrigation ditches to river rapids. Unfiltered perspectives are shared by farmers, tribal members, governmental scientists, and environmental leaders. Here are five lessons that students have taken away from the course.

1 **Get wet.** Guided engagement in active experiences and direct personal interactions with members of the community promote deeper thinking about the roles and values of water across environments.

2 **Water is a connector, not a sector.** Solutions to California's water challenges lie in connecting traditionally isolated water sectors. Agencies that regulate surface water have historically had limited authority over groundwater, even though water flows between the surface and the ground.

3 **Find the source.** Few Californians are aware of the path that water takes to reach their taps. Many rely on water whose journey begins hundreds of miles away. Others use water sourced from ancient aquifers.

4 **Know where it flows.** Similarly, too few Californians give a second thought to where their water goes after being used. Management of "wastewater" has become a new frontier.

5 **Broaden the boat.** Bringing disadvantaged communities and other previously excluded voices to the conversation is critical for realizing a sustainable and just water future. We're all floating down this river together.

ON THE GROUND

The Albright Lecture

Nearly 60 years of conservation leadership

BY MACKENZIE SMITH

PHOTO: Courtesy of the Bancroft Library

Horace Marden Albright, a 1912 UC Berkeley graduate, was one of America's leading conservationists. After he served as the second director of the National Park Service, he was named the 1952 Alumnus of the Year by the California Alumni Association. An endowment was created seven years later to establish the Horace M. Albright Lecture in Conservation, a lectureship made possible by gifts from alumni and friends. When he delivered the first lecture in the series in 1961, Albright noted key figures in the American conservation movement, including John Muir, Theodore Roosevelt, and Gifford Pinchot. In 1980, he was awarded the Presidential Medal of Freedom, the United States' highest award to a civilian, by President Jimmy Carter.

Here, *Breakthroughs* highlights the notable and quotable from decades past and present of the Albright Lecture.

1963

"In terms of conservation and resources, we are in the process of conquering 'outer' space but we are neglecting 'inner' space, the space that is our home."
— **Stewart Udall,** 37th secretary of the interior and a three-term Arizona congressman

1970

"Man always adds something to nature, and thereby transforms it, but his interventions are successful only to the extent that he respects the genius of the place."
— Pulitzer Prize–winning microbiologist **René Jules Dubos**

1975

"The artist and the photographer, especially among the young people of our time, seek the mysteries and the adventures of experience in nature."
— **Ansel Adams,** photographer

1980

"The conservation challenge of the '80s is reshaping our attitudes and values and our practical approaches in such a way that we can live in an era of scarcity without ruining the life systems on which we depend."
— public servant **Robert Cahn,** a founding member of the Council on Environmental Quality

1991

"The most compelling reason for preserving natural ecosystems and the organisms that comprise them is also the least understood by the public: They provide a series of indispensable free services to civilization."
— **Anne H. Ehrlich** and **Paul R. Ehrlich,** conservation biologists and co-authors, most recently of *The Dominant Animal: Human Evolution and the Environment*

2000

"The challenge of environmental protection in the new millennium is no longer scientific, or economic, or even political—it is moral."
— **Carl Pope,** former executive director of the Sierra Club

2009

"If you are only focused on business and capitalism in its traditional sense and you're not looking at your broader impact on the world, you might wake up to discover that your business is gone."
— **Sally Jewell,** 51st secretary of the interior and former CEO of REI

2011

"Climate change is no longer an abstract thing at all; it is very real and very powerful."
— journalist and environmental activist **Bill McKibben**

2013

"Creating an enduring place within the natural systems that keep us alive—that's the biggest challenge of our time."
— marine biologist and *National Geographic* explorer-in-residence **Sylvia Earle**

2016

"The earth's waters are not owned by the polluters or the government—they're owned by the people."
— **Robert F. Kennedy Jr.,** environmental attorney and board president of Waterkeeper Alliance

2017

"Nature doesn't need people, but people really need nature."
— Conservation International CEO **M. Sanjayan**

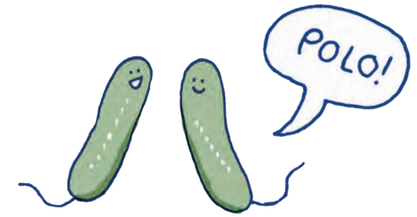
Watch a video of CNN political commentator and Dream Corps founder Van Jones delivering the fall 2018 Albright Lecture at nature.berkeley.edu/albright.

PHOTO: Courtesy of Van Jones

Magnetic Attraction

Arash Komeili charts the course of magnetotactic bacteria

By Zac Unger
Photo by Elena Zhukova
Illustrations by Wren McDonald



In a laboratory at Koshland Hall, a bobblehead doll of the X-Men character Magneto sits on a shelf near a few dozen tubes and jars of murky pond water. When a visitor stops by, plant and microbial biology professor **Arash Komeili** grabs a bottle from a countertop and pours a few milliliters of the cloudy water into a test tube. "This is from a stream near my house," he says, "or maybe Strawberry Creek. It probably contains tens of millions of bacteria."

He holds a common refrigerator magnet to the tube, and suddenly sludge drifts upward along the side of the glass. Unsatisfied with the display, he quickly prepares a slide with a water droplet and places it under a microscope. On an attached video screen, the bacteria appear as a scattered constellation of black dots. When Komeili holds the magnet up to the slide, the bacteria rush to gather at the edge of the droplet. Like a line of dancers, they follow the magnet, then fall back into disarray when it's removed from the glass.

If you didn't know that bacteria could be magnetic, you're not alone. In fact, Komeili's work is bringing attention to a once obscure corner of the biological world, and even causing scientists to reevaluate basic facts about the structures of single-celled organisms. Think back to your introductory high school biology class: Bacteria were probably presented to you as one of the earth's simplest life-forms, lacking nuclei and defined organelles. Look a little deeper than Bio 101, however, and you'll find that these organisms aren't really so simple after all.

Specifically, Komeili studies magnetosomes, microscopic structures within bacteria that contain magnetic particles, such as iron, allowing the bacteria to navigate in relation to the earth's poles, just like Viking mariners using lodestones. "For the bacterial cells, it's a valuable product because they use it to align in the earth's magnetic field," he says, "and then they can navigate the environment along a restricted space."

Magnetic Marco Polo

Unlike Vikings, bacteria aren't looking for new lands to conquer, but magnetism does help them find resources and hospitable environments. Take a typical lake, for example, in which oxygen levels are highest near the surface. Magnetotactic bacteria prefer areas with a lower oxygen content, Komeili explains, "so they swim up and down along the magnetic field lines, and then they decide where to stop." Like playing Marco Polo in a swimming pool, they're continually sampling their environment to move in more promising directions.

The magnetosome isn't a true compass, and it can't tell bacteria exactly where to go—it's more like the earth's magnetic field is a train track, and the magnetosome is the train's wheels. "Then you have an engine and a conductor," Komeili says, "but you can't escape those tracks."

While this navigation technique is exciting in and of itself, Komeili is even more interested in what the presence of magnetosomes reveals about basic cell biology. To begin with, there's that traditional understanding of bacteria—that they don't have organelles, the specific functional subunits associated with complex organisms such as plants and animals. "When I was getting my PhD in cell biology," Komeili says, "that was certainly what I had heard and believed."

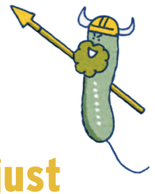
The presence of what is essentially a "magnet factory" within some of these cells doesn't square with the sort of basic biology that high school students have been taught for generations. The magnetosomes don't spring up magically, Komeili says. Rather, "the bacteria are making this compartment, and then within that compartment they're making the magnetic particle." And that level of complex organization just isn't something that organisms this simple were thought to be capable of. Until, that is, Komeili and his colleagues began their groundbreaking research.

A blueprint for magnetosomes

Establishing the basic science that undergirds the magnet factory has been the thrust of Komeili's inquiry. This has been painstaking, multifaceted work that required figuring out the genetics that control the magnetosome formation process. With those basic tools in place, the researchers then began changing one factor at a time in their bacterial "lab rat," to reverse engineer how the magnetosome is created.

"Over time, we assembled a little blueprint of how magnetosomes are made and how the magnetic particles are made," Komeili explains. "And the

Komeili studies magnetosomes, structures that allow bacteria to navigate in relation to the earth's poles, just like Viking mariners using lodestones.



blueprint says, 'To make the compartment, you need these genes, then to bring in the iron, you need these other genes. And to turn the iron into something solid like a mineral, you need these other genes, and then to put them together in a line, you need *these* genes.'"

The study of magnetic bacteria is still in its relative infancy. Komeili did a search of PubMed, the scientific database, and between 1975 and the early 2000s only one or two papers per year matched the term "magnetotactic bacteria." "In the last five or six years, though," he says, "you have 50 to 75 papers a year with that search term." And many of those build on the foundational work being done in the Komeili lab.

There is already great promise for practical applications of magnetotactic bacteria. In the field of environmental remediation, they can be used to bind toxic heavy metals such as chromium, neutralizing them and speeding cleanup. Geologists and paleontologists are also eager to do more work with them: The orientation of fossilized magnetic bacteria provides valuable information about continental plates and the history of the earth's magnetic poles. But perhaps the most exciting potential is in the field of cancer detection and treatment. One of Komeili's colleagues at Berkeley is **Steven Conolly**, a professor in the Department of Electrical Engineering and Computer Sciences who is working on a new technology called magnetic particle imaging.

One long-term goal is to use magnetic bacteria DNA to label mammalian cancer cells—essentially creating a living magnetic biomarker of cancer. Researchers already rely on a similar optical genetic reporter, fluorescent proteins. But, as Conolly notes, "tracking cancer with magnetic reporters has great potential because you can see magnetic signals deep inside an animal without worrying about the attenuation of light through layers of tissue."

Conolly envisions a research measurement device the size of a toaster—simply pop a mouse inside the machine and you could measure tumor volume very quickly, without even making an image. Additionally, magnetic labels could help physicians track the success of immunotherapy treatments, which are often frustratingly invisible once inside a patient. "If we put magnetic reporters on them," Conolly says, "then we can see them anywhere. It's like looking for stars at night instead of looking for stars during the day."

Fun with serious science

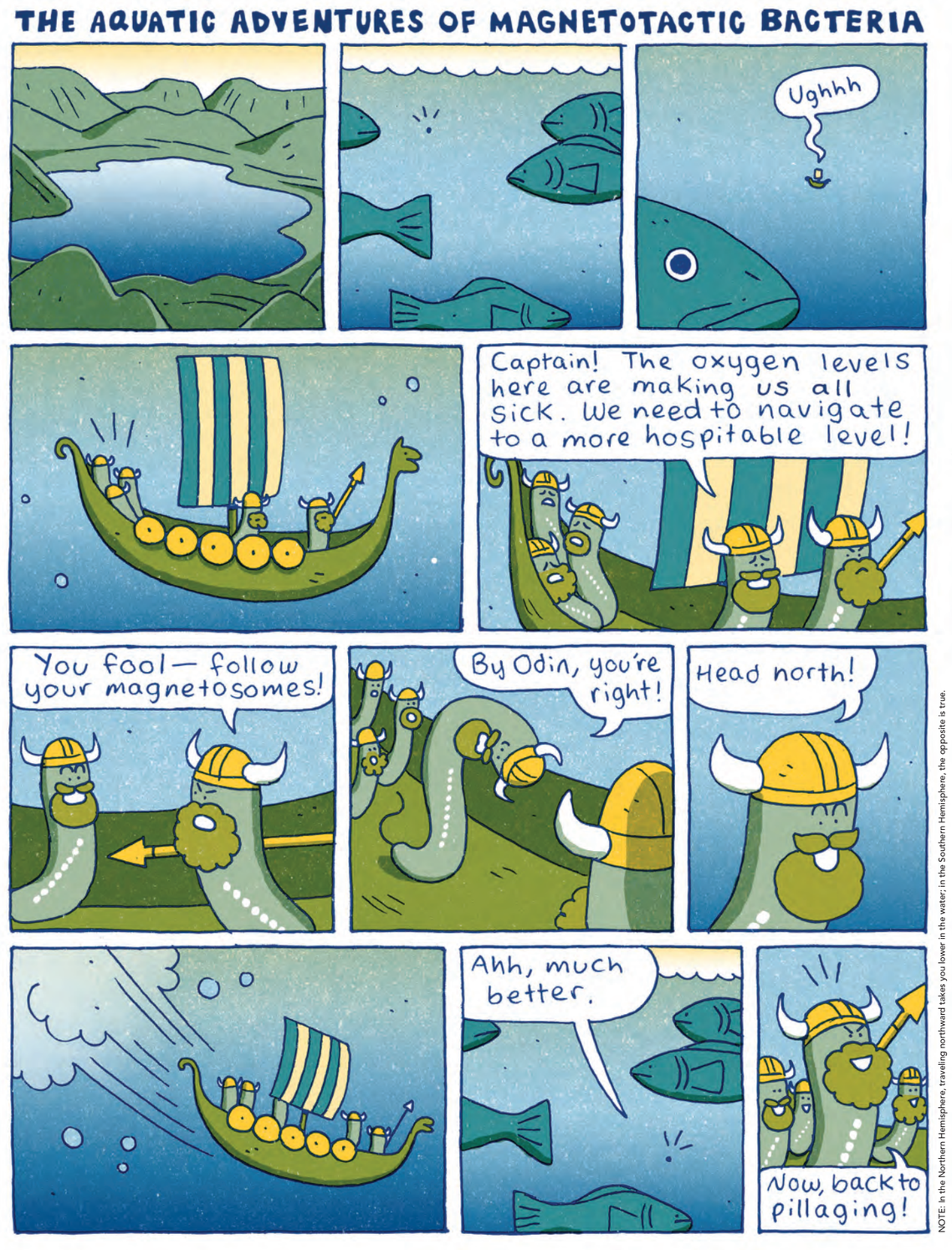
Back in the laboratory, Komeili's enthusiasm for basic science is infectious. Although the work is complex and time-consuming, the mood in the lab is light, with frequent social events and holiday parties, not to mention the presence of every possible magnetic toy on the market. That energy extends beyond the lab and into the classroom, where Komeili teaches a well-regarded undergraduate microbiology course that's small enough to give him plenty of one-on-one time with budding scientists.

And unlike the microbiologists of yesterday, Komeili maintains an active Twitter presence (@micromagnets), often highlighting the work of other people in his field. In part because of his own research—and in part because of his upbeat attitude and collaborative nature—magnetosomes are beginning to gain wide renown.

"Recently I was interviewing a high school student for a scholarship," Komeili recalls, "and she asked me about my work. When I told her, she said, 'Oh, we learned about magnetotactic bacteria in AP Biology,' and I was so excited that I had to run back into the lab and tell everybody."

When it comes to his graduate students, Komeili is committed to providing a wide range of challenges and opportunities. "This lab wasn't initially on my radar," says fifth-year PhD candidate **Carly Grant**. "But I took a class with Arash, and I decided that what I wanted from grad school was a really good mentor. He's given me the freedom and support to explore alternative research opportunities and work on projects that excite me."

The advantages of that freedom go both ways. The notion that bacteria make compartments "is still the most compelling idea that drives me," Komeili says, "but different people in my lab get excited about different aspects of this field, and that leads them down different paths, and then that gives me whole new ways of getting excited."



NOTE: In the Northern Hemisphere, traveling northward takes you lower in the water; in the Southern Hemisphere, the opposite is true.

A Kind of **Communion**

In both the classroom and the field, evolutionary ecologist Erica Bree Rosenblum listens closely for the answers

By Tom Levy
Photography by Elena Zhukova

For **Erica Bree Rosenblum**, PhD '05 Integrative Biology, the study and teaching of ecological genomics has always been as much about a spiritual connection with her subjects as an academic one. In the field, "you don't just bring your intellect to bear. You're in a kind of communion with the landscape, getting a sense of the interesting questions."

A groundbreaking evolutionary ecologist and educator in the College of Natural Resources, Rosenblum has focused her research on two linked, yet outwardly opposing, biodiversity questions: How do new species arise, and why are we now losing so many at such an alarming rate? Rosenblum believes that her weightiest findings, based on analyzing lizard speciation in New Mexico, reinforce insights into how the earth has come by its wealth of plant and animal life, a process still underway across the globe. "Little environmental changes can lead to new species forming," she says. "Taken over many millennia, that's how we ended up with this phenomenal amount of global diversity."

She first sought answers to the new-species question in the early 2000s as a grad student on a road trip. "I didn't choose my dissertation project by reading a stack of books to select a study system," says Rosenblum, now an associate professor of global change biology in the Department of Environmental Science, Policy, and Management. "As a graduate student, I drove across the country waiting to find a place that said, 'Pick me.' That's how I chose the White Sands system I've been studying for 20 years."

HOW SPECIES BEGIN AND HOW THEY END

What Rosenblum found in New Mexico's 275-square-mile White Sands National Monument, the world's largest gypsum dune field ecosystem, were three lizard species that are common across the Chihuahuan Desert: the little striped whiptail, the lesser earless lizard, and the eastern fence lizard.

Ordinarily these three species are dark-skinned. But during an evolutionary finger snap of perhaps 2,000 to 10,000 years, pale-skinned offshoots arose in the dune fields, replacing their darker ancestors. As evolutionary theory might have predicted, against the pale backdrop of the dunes, mutants that were even

"Doing cutting-edge, top-notch research without harming the populations we're studying brings the whole program into alignment with my values."

slightly lighter were less visible to predators—birds such as the greater roadrunner and the loggerhead shrike—and thus more likely to survive and reproduce. Their darker cousins likely became meals.

Over thousands of generations, this natural selection process led to dune fields populated by light-skinned lizards displaying two hallmarks of speciation that Rosenblum's research has uncovered. Not only is their DNA different from their ancestors', but they also exhibit distinctly different mating behaviors.

To answer the question of how species die out, Rosenblum has been examining several varieties of frogs threatened with extinction by the fungus *Batrachochytrium dendrobatidis*. Studies suggest that the deadly form of this ancient organism appeared within the past century and then spread worldwide, piggybacking on the global pet trade and exported goods such as agricultural products.

"While this aspect of globalization has implications for human health, it also has huge implications for wildlife, because we're moving around pathogens of agriculturally important plants and ecologically important animals," Rosenblum says.

She's studied fungus-affected frogs from Panama to Madagascar to California, where the mountain yellow-legged frog, once the Sierra Nevada's most common vertebrate, is now a federally listed endangered species.

With funding from the National Science Foundation, the National Park Service, and the U.S. Fish and Wildlife Service, Rosenblum and her research partners across institutions are learning how to protect the few remaining populations of mountain yellow-leggeds. Bug eaters in the middle of their ecosystem's food chain, the frogs—as well as their eggs—are food for larger predators such as birds, snakes, and coyotes, making them a key species.

Rosenblum and her collaborators are learning which groups of mountain yellow-legged frogs are more fungus-resistant, and thus a better choice for repopulating hard-hit areas. A 2016 study she co-authored—published in *Proceedings of the National Academy of Sciences of the United States of America*—showed that in Yosemite National Park some populations of the frogs are recovering, seemingly more resistant than previously thought.

She's also looking at other questions: Do different parts of the world host different strains of the fungus? Do any specific genes make some fungus strains deadlier than others? And are there specific genes that protect frogs or make them more susceptible?

"Little environmental changes can lead to new species forming. Taken over many millennia, that's how we ended up with this phenomenal amount of global diversity."

One recent piece of good news: According to a March 2018 *Science* article that Rosenblum co-authored, some Panamanian frogs, once exposed, appear to develop greater resistance to the fungus. It's not yet known if that resistance can be passed on genetically.

FIRST DO NO HARM

Rosenblum's frog research is hopping onto the latest genome-collecting advance: gathering "wild" DNA from, for example, pond water. Picture a frog swimming through a small pond and leaving a few cells in its wake. If the frog were infected with *B. dendrobatidis*, a few fungus cells might also be present.

"We can filter some of that water, sequence the environmental DNA—known as e-DNA—and use computer algorithms to help us identify the living things that passed through the water, whether bacteria, fungal pathogens, or frogs," Rosenblum says. "It's an amazing time in scientific history; we can now use technological advances better in line with our conservation ethos."

The pond-water scenario is just one example of nondestructive sampling, a research approach that couldn't be used to its full potential back in 2000, when Rosenblum began her PhD studies at UC Berkeley. At that time, it took months to analyze a single gene. And to get a usable tissue sample, she had to snip off a lizard's tail or a frog's toe.

But since then, dramatic technological advances have made it possible for Rosenblum and other researchers to gather DNA information from multiple species in the same amount of time without injuring them.

"I had let animal deaths turn into data points," Rosenblum says. "And that didn't feel comfortable anymore, because there are a lot of other ways to get data. Now we can literally take a Q-tip, rub it on a frog's belly or stick it in a lizard's mouth, take it back to the lab, and gather genomic information from it."

Researchers studying a wide array of other creatures are also excited about nondestructive sampling. "Bird folks can get DNA from a dropped feather," Rosenblum says. "Bear folks can get DNA from a bit of fur left in a tree by a bear scratching itself, and seal folks can get DNA from seal poop."

White Sands National Monument. PHOTO: Erica Bree Rosenblum

As she notes, answering genomic questions with such tiny samples requires partners that are able to analyze ever-smaller specimens and crunch ever-larger amounts of data. But Berkeley is blessed with several, including the two she frequently works with: the Vincent J. Coates Genomics Sequencing Laboratory and the Computational Genomics Resource Laboratory.

ANSWERING AN "INNER CALL"

Nondestructive sampling brings Rosenblum's research techniques into alignment with her love of nature. It's a bond she's cultivated since she was a toddler growing up near the Brooklyn Botanic Garden in New York. "I spent a ton of time playing in that patch of nature, on the little stone fox statues, in the pine needles, and watching fish in the ponds," she remembers.

Rosenblum's road from the Brooklyn of her childhood to White Sands—the New Mexico dune fields of her dissertation research—was a winding one. At Brown University, where she completed her undergraduate studies, biologist David Rand's evolutionary genetics class captivated her. She eventually became an undergraduate assistant in his lab, where, she says, her passion for research was born.

But after graduating in 1996—having earned a bachelor's degree with honors in ecology and evolutionary biology—Rosenblum chose adventures other than grad school. In Chicago, she helped design exhibits for a children's museum. She then taught high school science in South Africa, conducted research and led safaris in Botswana, and led an international summer student-exchange program in Togo. In Alaska, she worked as a naturalist and a teacher.

In San Francisco, she slowed down and for two years taught science to children at a private school. During weekends and summers, she pursued big-wall mountain climbing.

Contemplating the disparate threads of her life, Rosenblum eventually applied to grad school at UC Berkeley. "Maybe I could do all the things I like in one job," she recalls thinking. "I could teach, adventure, and do research all at once."

Rosenblum added another thread in graduate school: immersion into the ethos of the 110-year-old Museum of Vertebrate Zoology. It's more than a specimen collection, she says, and its emphasis on classic natural history research techniques seeped into her personal values and her teaching methods.

"When museum scientists went out to the field, they spent each day in deep observation of different environments and the life in them," she says. "That was what was passed down through the museum to me." Rosenblum practices what those previous generations of natural historians preached. "I go to the study system and walk around and camp and listen and journal and meditate. That's not weird; that's just good natural history," she says.

At Berkeley, Rosenblum reconnected with her future husband, a climber and professional environmentalist she had met at Brown. They now have two children: a daughter, 11, and a son, 7. Nature is a big part of their family life, which includes camping, climbing mountains, and sharing a four-generation Berkeley household with Rosenblum's mother and 102-year-old grandmother.

Rosenblum also considers the earth's nonhuman inhabitants, especially those that are endangered, part of her extended family, which sums up why nondestructive sampling exemplifies her approach to being a scientist.

"There's the inner call: 'I don't want any animals harmed in my research because I value life and it means something to me at a personal level,'" Rosenblum says. "But the other part is that I study a lot of endangered species, and one of the key motivations of my life is conserving biodiversity. If we can do cutting-edge, top-notch research without harming the populations we're studying, that just brings the whole program into alignment with my values." 311

PHOTO: Julie Gipple

Breaking Open the Classroom

Make a puppet representing what's stressing you out, bring it to class, and explain your creation. An odd assignment for graduate students in a professional development course, but not if the teacher is **Erica Bree Rosenblum,** an associate professor in the College of Natural Resources. She's as much provocateur as professor.

But one day Rosenblum was tested: A student brought in a puppet representing *her*. Unfazed, she gathered the class, faced the student and his puppet, and nimbly turned an unexpected teaching moment into performance art.

"You totally stress me out, Bree!" cried the student with the puppet. "You're supposed to be giving me deadlines and working me and telling me I have to publish 10 papers or I'm going to perish. And since you're not, I'm just left with my own inner fears." Once her shock had subsided, Rosenblum recalls, she thought, "OK, now we're getting somewhere."

As Rosenblum helped him work through his anxieties, she learned that mentoring PhD students can be intense. Some need more structure than others. But she also demonstrated to the student, and to the rest of the class, her vision of the PhD as a process, a journey in which two-way communication between adviser and advisee awakens and fosters mutual exploration and learning.

Rosenblum encourages her students to go inward for guidance, too, especially at field sites. "Go sit and listen. What does White Sands want you to know about it?" she asks them. What we hear, she tells them, informs the research directions we take.

And Rosenblum has another way of offering guidance, to all Berkeley undergrads: Berkeley Connect, the campus-wide mentoring and professional development program that she began directing in July, after having overseen the CNR branch since 2015. Grad student mentors meet regularly with small groups of undergrads, fostering student-to-student dialogue to build community and help make Berkeley feel more manageable. The program annually reaches nearly 2,000 students in 13 departments across four colleges.

For one CNR student, senior **Sharon Buttimer,** Berkeley Connect satisfied many needs: It was a place to talk informally about environmental issues, listen to other students discuss preprofessional struggles, and get reassurance that work experience before graduate school is a smart career strategy.

Perhaps the ultimate expression of Rosenblum's pedagogical creativity and concern for students' inner development, however, is her course The Environment and the Self. She designed the curriculum for undergrad students made fearful and anxious by our era's massive global climate and biological changes.

Students spend the semester analyzing their own worldview and examining other perspectives, such as rational materialism, humanism, existentialism, nondualism, and spiritual wisdom traditions. Each student pulls their semester's experiences together into a final project that can become their career foundation: a personal environmental worldview or "aspirational manifesto," as Rosenblum calls it.

Rosenblum revels in breaking open the conventional classroom experience. She looks for opportunities to encourage students to discover, and learn to trust, their inner teacher. "There isn't a rule book that can be implemented for all students, because each student is unique," she says. "The rule book for me is 'Listen, and act accordingly.'"

NEW DEAN AIMS TO SURPASS THE PACE OF CHANGE

DAVID ACKERLY

For the past eight years, David Ackerly has been getting to know Pepperwood Preserve in intimate detail. In 2013, he and members of his lab set up permanent forest plots in the 3,200-acre Sonoma County biodiversity hot spot to study long-term changes in the distribution of its evergreens and native oaks.

Then massive change arrived: The 2017 Tubbs Fire burned through most of the preserve. A crew from Ackerly's lab spent the past summer—the first since the fire—assessing tree mortality and will return periodically to monitor the forest's response.

By Jonathan Mingle | Photo by Elena Zhukova

"This is why you set up long-term research," says Ackerly, an expert on how California's native flora is responding to the pressures of climate change. "You never know when a surprise will come." This patient, on-the-ground work is essential to informing effective conservation efforts. But for Ackerly, it also happens to be a rewarding task. "I love going back to the same place after a fire or rainstorm, or from summer to midwinter, and seeing the changes," he says.

Now, from his office in Giannini Hall, Ackerly is becoming immersed in yet another rich ecosystem, as the new dean of the College of Natural Resources. As a professor of integrative biology at Berkeley since 2005, Ackerly is new to CNR, but not to its core concerns. His research has long focused on better understanding biodiversity and ecosystem change and their implications for conservation. Most recently, he has applied his expertise in plant evolution, ecology, and phylogenetics—as well as cutting-edge data-analysis and modeling techniques—to studying how the spatial distribution of plants in California may change as temperatures rise.

"My interests in conservation and biodiversity have shifted in recent years," he says. "When we think about how these things play out in the world, they're not contained within a single discipline. So I've focused more and more on how to work across traditional academic boundaries and how to offer students richer training opportunities."

Ackerly's experience as an administrator, a student mentor, and a serial crosser of disciplinary boundaries makes him a natural fit for the Dean's Office. From 2010 to 2015, he held the Virginia G. and Robert E. Gill Chair in Natural History in the College of Letters & Science, and he served as the associate dean of the College's Biological Sciences Division from 2016 to 2018.

He has also taken on leadership roles in several multidisciplinary initiatives on campus and beyond, including the Climate Readiness Institute and the Berkeley Initiative in Global Change Biology. He's a senior fellow at the Berkeley Institute for Data Science and the principal investigator and director of Data Sciences for the 21st Century, a National Science Foundation–funded program that trains graduate students in the use of techniques from the data, social, and natural sciences for the purpose of studying rapid environmental change.

Biodiversity and the big picture

"I love new challenges that involve taking on the bigger picture," Ackerly says about his new job. "Being dean of CNR is an opportunity to think more comprehensively, across all our amazing faculty and departments, about how we integrate with the rest of the university."

This proclivity for mapping and making connections isn't new. As a plant ecologist, Ackerly has been doing that for decades. He helped develop the deeply influential concept of the velocity of climate change—the rate at which species' ranges must shift across the landscape to keep up with the changing climate.

"I'm grateful to be taking on this role when the College is in a really strong position."

"It's a way of calculating how fast conditions are moving," he explains. "For example, as the Bay Area gets warmer, climate conditions are shifting farther north." Given current trajectories, the velocity in this century could be more than five kilometers per year. "There's a reasonable scenario in which, by the end of the century, a lot of species won't be able to keep up."

Forging ahead, forging connections

Ackerly is energized by the prospect of leading a college that specializes in public outreach and in applying its research in a fast-changing world. "This is the biggest contribution we at Berkeley can make: to identify and address big societal challenges that cut across departments and disciplines."

He's also committed to improving students' access to a CNR education, helping graduate students manage the rising cost of living in the Bay Area through more competitive stipends and scholarships, and increasing overall diversity among graduate students, postdocs, and faculty.

Ackerly credits CNR's robust institutional health to his predecessor, J. Keith Gilless. "I'm incredibly grateful to be taking on this role when the College is in a strong position," he says. "Dean Gilless and his team were very careful stewards of university resources. Under his tenure, the College's endowment and scholarship giving increased."

Maintaining that momentum, as the University continues to go through budget challenges, will be Ackerly's central task. "Hiring and maintaining the best faculty in the world, providing the right environment and culture for success, attracting the best graduate students—that's the job of the Dean's Office and will always be our top priority."

David Ackerly and graduate students Rachael Olliff and Andrew Weitz measure water deficits in plants as soil dries—an expected impact of a warming climate. PHOTO: Peg Skorpinski

Q&A

The UC Berkeley Institute for Parks, People, and Biodiversity

By Kirsten Mickelwait | Photography by Jim Block

Hosted by the College of Natural Resources, this initiative was launched in 2017 to advance the research, management, and protection of our treasured public parks and lands.

Jon Jarvis

Executive Director
Former Director, National Park Service (NPS)

What inspired the creation of the Institute for Parks, People, and Biodiversity?
At UC Berkeley's 2015 conference "Science for Parks, Parks for Science," university leadership, faculty, and park professionals met to discuss the concept of an institute here that would generate new science and applications to address the most pressing issues facing public parks and lands: climate change, environmental justice, and the preservation of biodiversity across large landscapes. We immediately recognized that this would require an interdisciplinary approach. To be most effective, the institute would need to be a bridge between park professionals and the academic community, both at Berkeley and across the entire UC system.

How do the institute's vision and goals support Berkeley's legacy with the national park system?
Berkeley's impact can clearly be seen in how national parks are managed today. Without Stephen Mather's vision, we would not have the iconic park ranger, and without the policy recommendations of Starker Leopold, wolves would not be back in the Yellowstone ecosystem. The institute's mission is to continue this tradition by working to understand the most complex issues through robust research and putting ideas into practice with a new generation of park managers, some of whom will be trained at UC Berkeley.

What are the greatest challenges to our parks today?
Our greatest challenges include adaptation to a rapidly changing climate, developing sustainable financial models, maintaining biodiversity when parks are mere islands in a changing landscape, and managing large crowds during high seasons. These challenges are often exacerbated by divisive politics, inconsistent funding, and a lack of appreciation for the many benefits to society that come from the good stewardship of parks.

How is the institute working to meet those challenges?
In the spring of 2018, we hosted a graduate seminar in which students, faculty, and guest speakers had lively discussions about the major issues facing parks: biodiversity loss, connecting people to parks, climate change adaptation, the economics of parks in gateway communities, the gentrification of urban communities through green space, and wilderness management. Students prepared papers on these issues, and we're seeking funding for their research. We plan to host additional gatherings of field managers and faculty to further refine the issues and their possible resolutions. Then we'll publish the results in open-source journals specifically geared to application by field managers. We also hold a monthly "brown bag" event where students can learn about climate change, conservation, and careers with the NPS.

How does our human use of parks affect biodiversity?
Biodiversity is directly affected by human interaction. And the degree of human visitation is determined by a park's

Human use of parks directly affects biodiversity, says executive director Jon Jarvis.

type and size as well as how its roads, trails, and visitor amenities are designed and integrated. For instance, the low level of development and visitation in Alaska's parks results in minimal impact to biodiversity, whereas high volumes of visitors in a park like Yosemite can cause resource impacts and displacement of wildlife. That said, with my 40 years of park experience, I believe that there are many more worrisome threats to biodiversity than visitor use. And, of course, welcoming the public into parks builds its understanding and support. Without public support for their protection, our parks would be lost to development, and with them the biodiversity they foster.

Steve Beissinger

Faculty Co-Director
Professor, Department of Environmental Science, Policy, and Management (ESPM)

Can you briefly describe the institute's major initiatives?
We're moving forward with four major pillars of activity. First, "Science for parks, parks for science," which encompasses multidisciplinary research on such issues as biodiversity, climate change, business models, and health benefits. Our second pillar, "Parks and living landscapes," is where governance comes in—the intersection of science and law. We need to think more about how parks can be good neighbors and work with their surrounding communities—for instance, where wildlife is killing livestock on nearby ranching properties. The third pillar, "Engaging people in parks," is about increasing interest and access across all demographics, especially among underrepresented groups that haven't traditionally had the opportunity to interact with nature. Finally, "Combining America's two best ideas: the National Park Service and public education." When we were doing research around a centennial event for the NPS, we realized that those two seminal ideas grew up together right here at Berkeley. Both were founded on the principle of public access.

Where does Berkeley's research intersect with the focus of the institute?
The institute connects faculty and research across several colleges on campus. My own work on the Grinnell Resurvey Project has been looking at how climate change has influenced species distributed throughout California, and many of our resurvey locations have been in parks and other protected areas. CNR researchers have also been exploring fire and ecosystem changes, and the School of Public Health is investigating the connection between nature and human health: A growing body of evidence suggests that spending time outdoors results in healthier people. Berkeley Law is considering questions around governance—where the law, science, and biodiversity interact. Faculty in ESPM and the Department of Integrative Biology are working to determine the impacts of climate change: How do we manage our wilderness as the planet's climate continues to warm? The conditions that helped to create that wilderness may not be here for us in the future.

Why is Berkeley the best place to host such an institute?
As I mentioned, both Berkeley and the NPS were designed around public access. Three of the first four directors of the NPS were from Berkeley, and Joseph Grinnell trained many of the key people who became the first park administrators, educators, researchers, and creators of inventories. Then we looked around and saw so many Berkeley faculty doing cutting-edge work around questions that really inform these management and conservation issues in parks and protected lands. As a world-class public institution, Berkeley has the stature to create open forums and training on parks and biodiversity. We're continuing the traditions that Stephen Mather and Horace Albright set in motion, convening thought leaders and scientists to examine issues both locally and internationally.

Research suggests that spending time outdoors results in healthier people, says faculty co-director Steve Beissinger.

As director of the California Outdoor Engagement Coalition, Jenny Mulholland-Beahrs works across sectors with more than 175 partners.

Jenny Mulholland-Beahrs

Director, California Outdoor Engagement Coalition

What is the California Outdoor Engagement Coalition's relationship to the Institute for Parks, People, and Biodiversity?
The coalition was launched in 2015 after that year's "Science for Parks, Parks for Science" summit and is now an initiative within the larger institute, with the mission of expanding equitable access to the outdoors for all Californians through cross-sector partnerships and collective impact. We have more than 175 members across a variety of sectors, including national, state, regional, and city parks and other public land and water agencies; K–12 education; higher education; health and wellness organizations; transportation; nonprofits; and the private sector.

How does equitable access to the outdoors ultimately affect the whole society?
The impacts are across the board. First, the long-term conservation and protection of our planet is dependent upon everyone having meaningful connections with the outdoors and understanding the benefits of our natural environments. Second, nature is educational—a complex, living laboratory in which to learn about science, reading, writing, math, art, music, and other academic areas. Third, spending time outdoors can lead to mental and physical health and well-being. Fourth, access to nature is a social justice issue, because many low-income communities have much less access to green space than more affluent ones. Fifth, time spent outdoors can lead to increased leadership development and resiliency. And finally, economic development: According to the Outdoor Industry Association, in California alone the outdoor-recreation economy generates $92 billion annually in consumer spending, 691,000 jobs, $30.4 billion in wages and salaries, and $6.2 billion in state and local tax revenue.

What are some of the coalition's most successful programs?
From our inception, we've worked with our multi-sector partners to expand the impact of the incredible work that's already being done by our members. One of our greatest assets is collective impact, a structured form of collaboration to solve a complex problem—in our case, expanding equitable access to the outdoors. We're working with a very committed group of partners who have formed the Richmond Outdoors Coalition, an initiative in the East Bay city of Richmond. The partners have identified the priorities of transportation to parks, communication with the community about getting outdoors, and collecting meaningful data to guide the direction of our collaboration.

Tessa Emmer harvests seaweed in Mendocino County.

MAVENS OF MARICULTURE

SALTPOINTSEAWEED

Wherever they go, they're known as "the seaweed girls." Tessa Emmer, '16, Avery Resor, '16, and Catherine O'Hare—the women behind the Bay Area–based company Salt Point Seaweed—are on a mission to offer locally and sustainably harvested, nutrient-rich seaweed products and transform the way that aquaculture is implemented along the Golden State's coastline and beyond.

By Molly Oleson

PHOTO: Courtesy of Salt Point Seaweed

Launched in 2017, Salt Point Seaweed reflects the trio's shared backgrounds in sustainable agriculture and food systems, as well as their time spent working and studying in East Africa. "What started as a hobby turned into a project, and now it totally absorbs our lives," Emmer says. The three harvest California kombu, California wakame, and wild nori—products used for culinary seasoning—and sell the seaweed in their online store.

Emmer and Resor—graduates of CNR's Master of Development Practice (MDP) program—and O'Hare, who attended Oberlin College as an undergraduate with Emmer, were first introduced to the world of California seaweed at UC Berkeley's Jepson Herbarium, which houses one of the best algae collections in the world. Together, they began harvesting wild seaweed on the California coast for fun four years ago. But it was while working in Tanzania—where cultivating seaweed is a livelihood strategy, primarily for women—that they learned firsthand about the logistics and challenges of growing, harvesting, and selling it. "We went there to see what we could learn from these women," Resor says. "And we always kept in mind how we could share what we learned with folks around the world."

The seaweed farmed in East Africa, as well as in other parts of the world, Emmer says, is sold on the global market. So when she and Resor returned to California, they were intrigued by the idea of harvesting and farming native seaweed as a local product. "There's an abundance of native varieties of seaweed growing right here in the Pacific Northwest that have traditionally been eaten," Emmer says, "but we were surprised to learn that close to 95 percent of the seaweed that we eat in this country is imported."

The bureaucracy of mariculture

The women were excited to harvest wild seaweed varieties in the Bay Area—which is well-known for its local and sustainable food movement and has a sizable population willing to pay more for traceable products. But when they dove into the prospect of actually farming their own seaweed in California, they encountered some significant barriers. One of the biggest, they say, is the state's complex, expensive aquaculture framework, which was set up to regulate large-scale companies.

"It's hard as a small business to get permitted to farm seaweed," Resor says. "And we're part of this movement to work with regulators, different mariculture businesses, and policy groups to try to make a more accessible route for small, sustainable businesses."

In an effort to test the integration of seaweed into an existing coastal business, in September 2017 the Salt Point trio launched an innovative pilot farm—the first of its kind in California—with the shellfish farmers at Hog Island Oyster Co. in the North Bay. The women are assessing the growth rate of the native seaweed genus *Gracilaria* in Tomales Bay and recording carbon and nitrogen absorption.

Resor says that they're conscious of the fact that the market for local seaweed—which doesn't require pesticides, fertilizer, fresh water, or land to thrive and, in fact, can benefit the environment in which it's grown—is flourishing. "In order to keep up with

"What started as a hobby turned into a project, and now it totally absorbs our lives."

that growing demand, we believe that farming is a more sustainable option for the future than relying on our current business model of only wild harvesting."

Economics and ecosystems

The practice-based approach of the MDP program, which both Emmer and Resor say they were drawn to for its interdisciplinary learning format, helped inform the grant-funded pilot seaweed farm.

The program also focuses on economics and how such pilot systems work, Resor explains, noting the many parallels between land-based agriculture and water-based food production. She points to the research of her CNR adviser, **Claire Kremen,** on ecosystems, valuing ecosystem services, and integrated agriculture as key to Salt Point Seaweed's progress. "Our pilot farm is really looking at how, with integrated mariculture, we can measure these ecosystem services and maximize them."

Salt Point Seaweed's wild-harvesting operation, Emmer says, has been a great opportunity to build the market for California seaweed. But data collected from the pilot farm, which will conclude in November, could help advance seaweed farming across the state. "We've learned a lot just by putting together this pilot," she says, "doing it on a small scale and then seeing what it looks like in action."

Catherine O'Hare, Avery Resor, and Tessa Emmer are on a mission to sell sustainably harvested seaweed. PHOTO: Shaun Wolfe

THANKS TO YOU

The Annual Fund helps CNR think big and feel small

At the College of Natural Resources, we pride ourselves on providing the personalized approach and close attention of a small college within a world-renowned public university. One of the reasons behind our success is the close-knit community of alumni, parents, faculty, staff, and friends that shows its support year after year through the Annual Fund. By the end of our 2018 fiscal year in July, we had received a total of $529,036 in annual gifts.

ANNUAL FUND FACTS

This year, roughly **1,200** members of the CNR community provided unrestricted support through their Annual Fund gifts to:

- Berkeley Fund for Natural Resources
- CNR Graduate Student Support Fund
- CNR Alumni Association Endowed Scholarship Fund
- Don Dahlsten Outreach Fund

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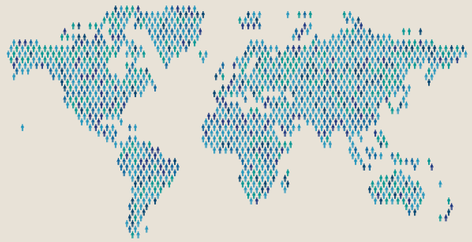

For the first time in CNR's history, we received gifts from alumni and friends in **all 50 U.S. states.** We also received donations from around the world, from alumni in:

Argentina	Germany	Italy	Singapore
Australia	Greece	Mexico	Slovenia
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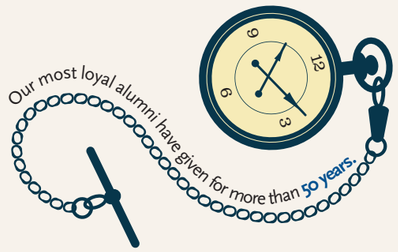

1950-2018

We received gifts from alumni in every class from **1950** to **2018.**

Such unrestricted support from our loyal community enables CNR to:

- facilitate research opportunities for more than half of our undergraduate students, who either join a faculty project or design their own
- offer one of the lowest student-to-adviser ratios on campus, helping students to achieve their goals and navigate their academic path
- support our faculty of world-renowned experts, including 16 National Academy of Sciences members, 40 Fulbright Fellows, and 7 MacArthur Fellows

We're tremendously grateful for your continued support—a big factor in UC Berkeley's global #1 ranking in Environment/Ecology by *U.S. News & World Report*.

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Sierra Nevada Epidemic | Photo by Clayton Boyd

Rising temperatures and invasive pathogens are threatening Sierra Nevada forests, which provide critical ecosystem benefits for California, including water and carbon cycling. Environmental science, policy, and management PhD candidate **Joan Dudney** is collaborating with government agencies—including the U.S. Geological Survey, the National Park Service, and the U.S. Forest Service—to investigate the impacts of mountain pine beetles and white pine blister rust on five pine species. Working in the lab of Professor **John Battles,** Dudney uses surveys, computer modeling, leaf-isotope analyses, and dendrochronology to identify which trees are most vulnerable to climate change. Preliminary data indicates that the sugar pine is declining in two national parks, but no blister rust was found on foxtail pines (pictured here). The foxtail pine is among the world's longest-living pine tree species.