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ARE WE REACHING YOU?

The mission of *Breakthroughs* magazine is to help you—our alumni, donors, and friends—stay connected with the Rausser College of Natural Resources. We strive to tell inspiring stories about current happenings in the College and highlight the significant impact of the work being done by our faculty, researchers, students, and alumni.

If you no longer wish to receive *Breakthroughs* in print, please let us know and we'll email you an online version twice a year. If the recipient is no longer at this address, drop us a line so that we can reduce paper waste.

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Last fall, two Berkeley researchers joined an all-female delegation of leading scientists in Antarctica. Read more on page 28.

PHOTO: Iryna Dronova

BREAKTHROUGHS

UC BERKELEY RAUSSER COLLEGE OF NATURAL RESOURCES • SPRING 2020

A Commitment to Excellence

Gordon Rausser's landmark gift to the College

LETTER FROM THE DEAN

Twenty-five years ago, in the very first issue of *Breakthroughs,* Dean Gordon Rausser welcomed readers to the "new" College of Natural Resources after a period of administrative and programmatic transition. He introduced a vision of excellence that would help the College continue to generate significant benefits for all Californians. As dean, he was launching this magazine as a vehicle for ongoing connection with our alumni and friends.

Now, with this issue, I'm thrilled to also welcome you to a new college: the Rausser College of Natural Resources. With an extraordinary and generous gift, former dean and Professor Emeritus Rausser has laid the foundation for the College's enduring excellence. I am deeply grateful for his steadfast commitment to our community and mission and for his inspirational investment in success. Read more about Professor Rausser's distinguished career and longtime service to UC Berkeley on page 14.

In another exciting milestone, 2020 marks a campus-wide celebration of the 150th anniversary of the UC Regents' decision to admit women to the University. We'll be sharing stories of the exceptional women in our college on our website and social media throughout the year. Here, we feature Cooperative Extension specialist Peggy Lemaux, who has devoted her career to improving agriculture through the creation of more robust and resilient staple crops. We also share the story of an alumna and a current graduate student who traveled to Antarctica last winter as part of an all-female delegation of leaders in science, technology, engineering, math, and medicine (STEMM) fields.

For more on the future of Rausser College, as well as our priorities for the recently launched UC Berkeley–wide campaign, visit page 20.

I welcome your feedback at dackerly@berkeley.edu.

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PHOTO: Jim Block

SPRING 2020

Berkeley Rausser
College of Natural Resources

BREAKTHROUGHS

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Parks Stewardship Forum
The Institute for Parks, People, and Biodiversity has launched an open-access journal centered on issues of conservation and stewardship. Read online at **parks.berkeley.edu/psf.**

COVER: Photo by Keegan Houser

PHOTO: iStock

Cooling Demand Is Heating Up

As both incomes and average temperatures increase worldwide, so does air-conditioning use. In a paper published in *Nature Sustainability* last December, Berkeley researchers warn that global demand for cooling could drive huge increases in electricity usage.

Using daily temperature data from more than 14,500 weather stations, the group ranked 1,692 cities and 219 countries by "total cooling degree day (CDD) exposure," a common metric for cooling demand. Their results pinpoint eight countries with higher CDD exposure than the United States: India, Indonesia, Brazil, China, Pakistan, Bangladesh, Nigeria, and the Philippines.

Currently, the U.S. leads in electricity use for cooling. Some 400 terawatt-hours of electricity go to U.S. air-conditioning annually, representing 1.5 percent of all electricity consumption worldwide. But as middle classes in developing countries expand, significantly more people are expected to buy air conditioners.

Two factors that influence CDD exposure are population size and temperature. Although the population of the Philippines is just one-third that of the U.S., for example, the island nation's CDD is four times as high, owing to its hotter climate. Populous India leads with 28 percent of global CDD exposure, and Mumbai alone has a CDD exposure equivalent to 25 percent of the United States'.

Virtually everywhere on the planet is hotter than just two decades ago. Along a horizontal band through northern Africa, the Middle East, and southern Asia, vast areas are exposed to 3,000-plus and even 4,000-plus CDDs annually; by comparison, sweltering Phoenix, Arizona, has 2,700 CDDs.

"Increasing cooling demand will likely cause significant electricity-usage spikes worldwide," said co-author **Léopold Biardeau,** a PhD student in agricultural and resource economics. "But adaptation strategies may help mitigate the need for air-conditioning. For instance, architecture can play a critical part in controlling temperatures inside buildings."

— ADAPTED FROM A HAAS ENERGY INSTITUTE BLOG POST BY STUDY CO-AUTHOR LUCAS DAVIS

What Killed Off the Neanderthals?

For tens of thousands of years, modern humans and Neanderthals lived side by side. Neanderthals inhabited Europe and southwest Asia, while our ancestors lived in Africa. In the Levant—an area now containing Israel, Lebanon, and Syria—the ranges of the two groups overlapped. Then, some 40,000 years ago, Neanderthals suddenly went extinct, leaving *Homo sapiens* as the surviving human species on Earth.

The abrupt disappearance of the Neanderthals has remained a mystery to scientists. But a new study co-authored by researchers at UC Berkeley, Stanford University, and the Hebrew University of Jerusalem suggests that deadly diseases carried by modern humans may have been the cause.

Because Neanderthals and modern humans first evolved in separate ranges, the researchers hypothesized, each group would have harbored its own unique set of pathogens and immunities. Through mathematical modeling of disease transmission and gene flow, the researchers showed that when two species with unique diseases and immunities start to intermingle, a period of "stasis" often precedes the collapse of one species—which is precisely what happened in this case.

Comparison of modern human and Neanderthal skulls.

PHOTO: Wikimedia

"There was this period where the two species coexisted, and then, relatively quickly, modern humans triumphed over the Neanderthals," said **Wayne Getz,** a professor emeritus in the Department of Environmental Science, Policy, and Management and a co-author of the study, which appeared in *Nature Communications* in November.

"We wanted to know whether Neanderthal extinction could be explained by their having a less virulent, less diverse disease load that they brought with them when they met modern humans, compared with the disease load and the virulence of the pathogens that modern humans were bringing with them," Getz said. "And it turns out that it could."

— ADAPTED FROM AN ARTICLE BY KARA MANKE

How the Monkeyflower Gets its Spots

Using CRISPR-Cas9 gene editing, researchers produced monkeyflowers with altered red pigments.

PHOTO: Srinidhi Holalu

The intricate spotted patterns dappling the bright blooms of the monkeyflower plant may be a delight to humans, but they also serve a key function for the plant. These patterns act as "bee landing pads," attracting nearby pollinators to the flower and signaling the best approach toward the sweet nectar inside.

"They are like runway landing lights, helping the bees orient so they come in right side up instead of upside down," said **Benjamin Blackman,** an assistant professor in the Department of Plant and Microbial Biology.

In a new paper, Blackman and his group at UC Berkeley, in collaboration with researchers at the University of Connecticut, reveal for the first time the genetic programming that helps monkeyflowers—and likely other patterned flowers—achieve their spotted glory. The team used CRISPR-Cas9 gene editing to re-create the monkeyflower patterns found in nature.

The study, which is the first reported use of CRISPR-Cas9 editing to research the biology of monkeyflowers, was published in February in the journal *Current Biology*. — KARA MANKE

A Homey Atmosphere

As part of their HOMEChem study, researchers measure temperature, which affects emissions, while cooking stir-fry.

PHOTO: Callie Richmond

Scientists who study air pollution have traditionally taken measurements outdoors, in urban areas with industrial smokestacks and spewing tailpipes. But people stay inside 90 percent of the time, so some curious researchers have begun to focus on indoor environments as well.

One of these scientists is **Allen Goldstein,** a professor in the Department of Environmental Science, Policy, and Management. Using cutting-edge instruments to test for volatile and semivolatile organic compounds (VOCs and SVOCs) indoors, Goldstein and his collaborators have found surprisingly high and dynamic concentrations of chemicals from sources such as cooking, cleaning, building materials, personal care products, and even people.

In one study, they took hourly measurements of VOCs and SVOCs in two Northern California homes over several months. The results showed hundreds of different VOCs, with at least 50 percent at concentrations 10 times higher than outdoors and 80 percent at concentrations at least double those outdoors. HOMEChem, another study in which Goldstein's research group participated, used a test house to study emissions from specific activities like cooking and cleaning.

Measuring air chemistry indoors has proved extremely complex and is intriguing to researchers, as well as garnering a lot of broader interest.

Not only do everyday activities and indoor materials contribute chemicals to the interior atmosphere; some indoor emissions react with each other, resulting in new compounds. Heat, light, moisture, and interactions with surfaces can further alter chemical compositions and affect how they change over time.

Most studies are still in the early stages of understanding the emissions and the behavior of many of these organic chemicals, so it's too soon to draw meaningful conclusions about the consequences for public health.

"Most of our exposure to organic chemicals is happening in indoor air, and most of that is happening in residences," Goldstein told *Chemical & Engineering News* in November. "It's relevant to try to understand these things, but we certainly aren't trying to make a claim that we know a specific health effect that people should worry about from these chemistries."

— JACOB SHEA

PHOTO: Irene Yi

Student-Led Course Focuses on Sustainable Action

For students seeking to apply academics to environmental action, one UC Berkeley course stands out: Zero Waste: Solutions for a Sustainable Future, taught by fourth-year conservation and resource studies major **Sage Lenier.**

Part of the DeCal program—in which students create, teach, and facilitate classes with faculty oversight—Lenier's course educates students on how to incorporate environmental solutions into their lifestyles.

Lenier got her inspiration for the DeCal during her first year on campus. "We'd learn about huge problems like rising greenhouse gas emissions or topsoil collapse, but there wasn't much focus on what we could actually do about it," she said recently in a *New York Times* article about the course.

Lenier structured the class as a comprehensive environmental education for nonspecialists, starting with the relationship between consumerism and natural resources, climate change, and human rights. The class then covers such topics as the circular economy, industrialized food and agriculture, sustainable cities, and decarbonization.

"This course is an explanation of, and a call to action for, the necessary changes we must make as a society to not only avoid complete ecological catastrophe, but hopefully create a future that is more sustainable and equitable than today," Lenier said.

Since its inception, her DeCal has become exceedingly popular. When it was first offered in 2017, around 25 students enrolled. This spring, three years later, nearly 300 students signed up. In 2018, Lenier won an award for her curriculum at the annual California Higher Education Sustainability Conference.

— JACOB SHEA

Five Key Lessons

PLANT BIOLOGY 40

The (Secret) Life of Plants

By Nanticha Lutt

To human eyes, plants seem largely inactive. And yet, rooted to the soil in which they germinated, they silently perform a dazzling chemical reaction, using sunlight to make food. Without this photosynthesis, none of the food that humans consume would exist. Taught by Professor **Patricia Zambryski,** a molecular and cellular biologist, this course explains the fundamental scientific principles of botany to non–science majors. A few takeaways:

1 **Eat the sun!** Photosynthesis, the chemical reaction through which plants use sunlight to synthesize foods from carbon dioxide and water, is a key component to supporting life on Earth.

2 **Plants survived massive global extinctions.** There are many reasons: Plants' adaptations make them extremely resilient. They create their own food and can regrow when their limbs are chopped off. Often they carry extra copies of chromosomes, and they can make "clones" of themselves. Seeds can even carry embryos in a dormant state for hundreds of years or travel to distant favorable locations around the globe.

3 **Plant-gene editing: nature did it first.** *Agrobacterium*—a bacterium known for its ability to modify plant DNA—was the original gene-editing tool. It is still used by researchers, even as CRISPR and other biotechnological approaches rapidly change the field of genetic engineering.

4 **Flowers live luscious lives.** As plants' sex organs, flowers make gametes and seeds and are responsible for fruits and many vegetables: a fruit is usually just the ripened, seed-filled ovary or ovaries from one or more flowers. Fruit provides the mechanism for seed dispersal, with many animal species consuming plant parts and spreading them after digestion.

5 **New frontiers of food and fuel.** Emerging markets for biofuels and plant-based protein have the potential to help solve some of the problems brought on by climate change. It's the Wild West for food and energy solutions!

ON THE GROUND

Alumni in Academia

BY JACOB SHEA

A sampling of our alumni who have gone on to make big impacts as researchers and leaders at academic institutions.

CHRISTOPHER GARDNER

PhD '93 Nutrition

Rehnborg Farquhar Professor, Stanford Prevention Research Center, Stanford University

For over 25 years, Christopher Gardner has led groundbreaking research on the health outcomes related to particular foods and diet patterns. His research considers the links between food systems, public health, and a range of social issues, including animal rights, labor, and climate change. Gardner directs the Clinical and Translational Core at the Stanford Diabetes Research Center, sits on several American Heart Association committees, and was on the consensus panel for the American Diabetes Association's 2019 Nutrition Guidelines, among other distinctions.

ADELA DE LA TORRE

BS '76 Conservation of Natural Resources; PhD '82 Agricultural and Resource Economics

President, San Diego State University

Adela de la Torre has a long record of university leadership, including her current role as the first female president of San Diego State University. Previously, she was the vice chancellor for student affairs and campus diversity at UC Davis, where she was the first Latina to be designated a distinguished professor. She has also served as the director of the Center for Transnational Health and the chair of the Chicana/Chicano Studies Department at UC Davis, and as the director of the Mexican American Studies and Research Center at the University of Arizona.

BETH ROSE MIDDLETON

PhD '08 Environmental Science, Policy, and Management

Associate Professor and Chair, Department of Native American Studies, UC Davis

Beth Rose Middleton is a leading scholar on Native American land trusts. A member of the board of the Sogorea Te Land Trust, she has written two books and many articles about trust lands and tribal conservation. Middleton's other research interests include rural environmental justice, indigenous analysis of climate change, intergenerational trauma and healing, and Afro-indigeneity.

JAMES KIRCHNER

PhD '90 Energy and Resources Group

Professor of the Physics of Environmental Systems, Swiss Federal Institute of Technology (ETH), Zurich

For five years, James Kirchner directed the Swiss Federal Institute for Forest, Snow, and Landscape Research, and he now leads a research group at ETH Zurich that is studying mountain hydrology and geomorphology. Previously, he was the Goldman Distinguished Professor for the Physical Sciences at UC Berkeley and directed Berkeley's Central Sierra Field Research Stations. He is a fellow of the American Geophysical Union and a Bagnold medalist of the European Geosciences Union.

JILL McCLUSKEY

PhD '98 Agricultural and Resource Economics

Regents Professor and Director, School of Economic Sciences, Washington State University

Jill McCluskey researches sustainable labeling, preferences for new technology, and product reputation and quality. She has served as the president of the Agricultural and Applied Economics Association (AAEA) and is a member of the National Academy of Sciences' Board on Agriculture and Natural Resources. She is a fellow of the AAEA and the Western Agricultural Economics Association. For her work on how partner accommodation and work-life policies can affect the representation of women in STEMM disciplines, she won the WSU Samuel H. Smith Leadership Award.

JOSHUA SCHIMEL

PhD '87 Soil Science

Professor and Chair, Environmental Studies Program; Associate Dean of Sciences, UC Santa Barbara

Joshua Schimel's research focuses on microbial ecology, biogeochemistry, and ecosystem processes related to soil carbon from the Arctic to California. Currently the co-editor-in-chief of the journal *Soil Biology and Biochemistry*, he has published more than 180 scientific papers and the book *Writing Science*, a guide to academic publishing. He has chaired the National Science Foundation's Arctic System Science Steering Committee as well as the foundation's Office of Polar Programs Advisory Committee. Schimel is a fellow of the Ecological Society of America, an Aldo Leopold Leadership fellow, and a recipient of the Soil Ecology Society Career Achievement Award.

PHOTOS: From left, top to bottom, courtesy of: Douglas Sonders, San Diego State University, Scott Barrie, Xing Wang Deng, Zoë Reinhardt, James Kirchner, Jose Maria Sanchez Bustos, and John Stumbos.

XING WANG DENG

PhD '89 Molecular and Physiological Plant Biology

University Endowed Professor; Founder and Academic Chair, School of Advanced Agricultural Sciences, Peking University

An expert on light-mediated plant development and epigenetics, Xing Wang Deng founded the Peking University Institute of Advanced Agricultural Sciences in Weifang, China. He is a member of the U.S. National Academy of Sciences and an elected fellow of the American Association for the Advancement of Science. Prior to his current appointment, Deng was a member of the faculty at Yale University for over two decades, and he has served as a co-director of China's National Institute of Biological Sciences. He has published more than 300 papers in peer-reviewed publications, including the journals *Cell*, *Nature*, and *Science*.

PAMELA RONALD

PhD '90 Molecular and Physiological Plant Biology

Distinguished Professor, Department of Plant Pathology and the Genome Center, and Director, Institute for Food and Agricultural Literacy, UC Davis; Key Scientist, Joint Bioenergy Institute

Pamela Ronald has received many accolades, including the 2008 USDA National Research Initiative Discovery Award and the 2012 Tech Award for the innovative use of technology to benefit humanity. In 2015, *Scientific American* named her one of the 100 most influential people in biotechnology. Ronald co-authored the critically acclaimed book *Tomorrow's Table: Organic Farming, Genetics, and the Future of Food*. Her TED talk has been viewed nearly 1.8 million times. In 2019, she was presented with the American Society of Plant Biologists Leadership Award, given an honorary doctorate by the Swedish Agricultural University, and elected to the National Academy of Sciences.

BACKGROUND PHOTO: Keegan Houser

PHOTO: Jim Block

Grains for **Change**

Cutting through controversy to make crops more resilient

By Nate Seltenrich

Peggy Lemaux wants to change the world through agriculture. It's a drive that has guided her work as a plant geneticist from the very beginning, one she traces to her childhood in northwestern Ohio. "Because of my upbringing on a small farm, and my close relationship with my grandfather, who was responsible for the farm, I made it my goal to do something positive for agriculture," she says.

Recent developments on our planet have only added to her sense of urgency. Chief among them is climate change, with its twin threats to agriculture: longer, more severe droughts and heat waves on one hand; wetter, more intense rainstorms on the other. In many regions of the world with undernourished and rapidly growing populations, climate-fueled crop losses can have devastating consequences.

"While you might have hoped in the past to just depend on evolution to help plants figure out how to survive huge floods or a long time without water, I don't think evolution can keep up now," Lemaux says. "Our opportunity as geneticists is to help tweak evolution, to take our knowledge and help plants figure out how to deal with changes in the climate."

Lemaux and colleagues at UC Berkeley, UC Agriculture and Natural Resources, and both the U.S. Department of Energy's Joint Genome Institute and the DOE's Pacific Northwest National Laboratory have recently used modern genetic technologies to learn more about how sorghum, a cereal crop valued around the world for its high tolerance for heat and drought, developed the means to survive arid conditions.

Native to Africa and Australia, sorghum is ranked fifth in total production among cereal crops globally and is a staple food crop in much of the developing world. It remains green and yields grain under conditions that render corn and wheat brown, brittle, and barren. A paper published in December in the journal *Proceedings of the National Academy of Sciences* provides possible clues to its success, offering the first detailed look at how sorghum switches off many genes—some involved with photosynthesis—at the first sign of water scarcity, then turns them back on when water returns.

SEEDS OF RESISTANCE

For nearly three decades, Lemaux has led groundbreaking research intended to improve the performance and quality of cereal crops. As a Cooperative Extension specialist in the Department of Plant and Microbial Biology (PMB)—a role that bridges the gap between the university and the public—she blends bench and real-world science in pursuit of more nutritious, robust, and resilient staple crops to feed the world.

While her mission is laudable, progress has not been easy. Among her research tools is what some see as a Pandora's box: genetic engineering, in which modifications are introduced into the genome of an organism to add desirable traits or remove undesirable ones.

It's an approach to crop improvement that Lemaux says holds significant technological promise. Over the years, her successes—in the lab, at least—have piled up. She was part of the first team to genetically engineer corn during the early days of her career, at DeKalb Genetics. She also helped develop, with PMB professor **Bob Buchanan**, barley that germinates quickly; a variety of wheat that is hypoallergenic and one that resists preharvest sprouting; sorghum that's easier to digest than the conventional kind; and a tool for using rice and other cereal grains to make large quantities of commercial products.

As part of the CLEAR program led by Cooperative Extension specialist Peggy Lemaux, graduate student Lorenzo Washington explains the process of pollination at a community event. PHOTO: Tuesday Simmons

From left: Lemaux's office decor reflects her lifelong passion for grains; Becky Mackelprang, PhD '17 Plant Biology, at a CLEAR event at the downtown Berkeley Farmers' Market. PHOTOS: Queena Xu, Courtesy of Becky Mackelprang

With the exception of this last development, now employed by a Colorado company to make medicinal products, none of Lemaux's major findings have made it into the field. This is due in large part to fears among regulators and the public that genetically engineered crops may be unsafe to consume (a worry not well supported by evidence, Lemaux believes) or pose a threat to the environment (a risk that can be mitigated through proper management, she says). "Because of the intensive backlash to genetic engineering, few of the things that we developed have gone anywhere," says Lemaux. "The seeds are all down in the basement."

CROP FOR A HOT CLIMATE

For her latest research on sorghum, Lemaux has taken a different approach. Both the December paper and one published in 2018—which describes how sorghum plants produce metabolites in their roots to summon aid from soil bacteria during times of drought stress—are part of an ongoing research project called EPICON (Epigenetic Control of Drought Response in Sorghum) that Lemaux helped develop, in part to avoid the conflicts surrounding traditional genetic engineering. Performed over multiple growing seasons in fields in the Central Valley, the work to date has not involved the engineering of genes—only the observation of how genes help sorghum survive drought. The field study is the first of its kind, providing a detailed look at the plant's entire development and response to drought, from germination to harvest.

"One of the reasons I got involved in EPICON was that it was not about doing genetic engineering to create a product but, rather, focused on using those tools to understand drought tolerance," Lemaux says. She is hopeful that the novel observational approach will produce results that lead to real-world applications.

Another EPICON study, published in *Nature Communications* in January, describes a different aspect of sorghum's interaction with certain microbes in the soil—specifically, important root-associated fungi that supply the plant with nutrients and minerals. The study shows that drought causes changes in the dynamics of which fungi colonize the leaves and roots, and it could provide insight into how researchers could introduce beneficial microbes or suppress harmful ones. With the end of EPICON fast approaching, Lemaux and her colleagues are responding to a call from the DOE for new five-year proposals to continue and expand the research. If the team can gain further insight through that effort into exactly how sorghum survives drought, then perhaps its findings can inform approaches to helping other plants survive in the same way. This may include traditional crossbreeding or, potentially, genome-editing technologies like CRISPR, a newer, highly precise approach to genetic modification that has so far eluded strict regulation in agriculture.

CONTINUING CONVERSATIONS

As Lemaux has shifted her attention from the production of genetically modified crops to less controversial observational studies, she has simultaneously expanded her efforts at outreach. Communicating about research with nonscientists has always been essential to her work, and she has given hundreds of lectures and interviews.

In 2015, with colleagues from UC Davis and UC San Diego, Lemaux launched CLEAR, or Communication Literacy and Education for Agricultural Research, a program designed to help UC Berkeley students at all levels practice communicating with the public about science. Backed by a grant from the UC Office of the President's Global Food Initiative, CLEAR provides funding for supplies, local travel, and other small expenses to support volunteer student-led science communication efforts.

One of its signature projects has been hosting a monthly table at the downtown Berkeley Farmers' Market, where CLEAR participants interact with the public on topics ranging from soil microbiomes to food waste. Students have also spoken at science-themed events at local pubs and are developing an exhibit on CRISPR ethics at the Lawrence Hall of Science. And in one impressive case, a CLEAR fellow created a curriculum around genome editing that reached more than 600 Bay Area and Los Angeles high schoolers last year.

To date, around 70 students have participated in CLEAR. For some, like **Becky Mackelprang**, PhD '17 Plant Biology, the program has offered a path away from bench science and toward a career in science communication or policy. After completing her PhD, Mackelprang continued working with Lemaux and CLEAR as a postdoctoral scholar for a year and a half.

"A lot of grad students want to use their scientific expertise for something other than scientific research," Mackelprang says. "I saw science being communicated in ways that were too complex for the general public or without the creativity that might generate an excitement for science."

Mackelprang next completed an American Association for the Advancement of Science mass media fellowship with the outlet *Ensia*. Recently, she began a position at a nonprofit that specializes in science policy, where she'll continue to put her communication skills to work.

One subject she expects to confront often, much as her mentor Lemaux has over the past three decades, is genetic engineering—and particularly the newer genome-editing techniques like CRISPR. She says she hopes to contribute to the discussion around how best to realize the full benefits of the technology while mitigating any potential downsides.

Yet if past experience is any indication, the issue is unlikely to be resolved soon, Lemaux notes. She's concerned that currently permissive attitudes toward new methods of plant-gene editing may one day flip, stifling more research and findings.

"If that happens, the real losers will be those in less developed countries," she says. "These new technologies could prove enormously beneficial for communities who don't have alternative approaches that might be available in more developed countries."

ECONOMIES OF GLOBAL GARBAGE

BY JACOB SHEA

In her new book, *Waste,* environmental science, policy, and management professor Kate O'Neill traces the emergence of the global political economy of waste over the past two decades. With chapters on topics including waste work, food waste, discarded electronics, and plastics, O'Neill investigates the complex interactions that make waste simultaneously a valuable resource, a livelihood, a public health risk, and an environmental disaster. Here are some surprising facts, detailed in the book, about the "world's only growing resource."

Waste can prompt consequential political outcomes. In 1979, Margaret Thatcher came to power in the U.K. amid rampant discontent when garbage collectors went on strike and waste piled up on the streets. In 2015, Beirut and a nearby river were buried in municipal waste following the closing of a major landfill, which sparked widespread protest.

Some landfills are unfathomably big and support entire communities. In Ghana, about 10,000 people live on or around one of the world's 10 largest "mega-landfills," and many of them salvage in the landfill. With at least 3.5 million tons of garbage produced around the world each day, such landfills are only growing.

Globally, a third of all food produced for human consumption is lost or wasted. If food waste were a country, it would be the third-largest greenhouse gas emitter after the U.S. and China. In the United States, much wasted food is thrown out by consumers and retailers. Cosmetic imperfections and a nonstandardized system for labeling—"use by" and "best by" labels often have little to do with actual spoilage—are in part responsible.

Recycled scrap is big business. In the U.S. alone, the industry is worth more than $105 billion annually and supports over 150,000 jobs, with an average wage of more than $75,000. In much of the developing world, this sector is informal but represents the major or sole mode of waste collection. In Brazil, for example, informal recycling accounts for a full 80 percent of cardboard recycling and 92 percent of aluminum recycling.

Climate change–fueled disasters have given rise to a whole new category of rubbish: disaster waste. In 2017, a string of hurricanes across North America, typhoons in Asia, and fires in California and Europe left building materials and hazardous waste in their wakes that have been difficult to dispose of, from sewage to toxic chemicals to human remains.

Disruptions in the global waste economy can have far-reaching impacts. Until it halted the practice in 2018, China took in staggering amounts of scrap. In 2016, it accepted 27 percent of all global waste and scrap imports, or 1,500 container ships' worth each day. Since the ban, U.S. recycling infrastructure has been overloaded as municipalities have scrambled to adapt, sometimes by burning recyclables or dumping them into landfills.

As in other markets, monopolization and big companies tend to threaten individual operators. A few companies based in the U.S. and Europe dominate the global waste sector. In Cairo, a community of 50,000 to 70,000 garbage collectors had long offered a profitable and highly efficient service, recycling 80 percent of the city's salvaged waste, when the Egyptian government restricted the practice in favor of multinational contracts. After years of persistence, the collectors remain active today.

Not all benefits from waste are strictly monetary. End-of-life ships and other structures can be sunk to provide habitat for marine life. Food waste, if diverted from landfills, can provide livestock feed or compost for crops while reducing greenhouse gas emissions. Some waste even becomes art: sculptures made from plastic refuse are displayed in museums and city squares around the world.

Waste work can be exceedingly dangerous. One study found that waste pickers in Mexico have a 39-year life expectancy—28 years lower than the national average. A March 2017 landfill collapse in Ethiopia killed no fewer than 113 people, and plastic incineration exposes communities to toxic chemicals like dioxins. The transnational Global Alliance of Waste Pickers advocates for human rights and better living conditions in 28 countries across Latin America, Asia, and Africa.

Plastic is a problem—big and small. The Great Pacific Garbage Patch is at least three times the size of France, and experts predict that by 2050 oceans will contain more tons of plastic than fish. As this plastic slowly breaks down, it releases microplastic particles, as do discarded consumer products like clothing and cosmetics. Microplastics are eaten by small marine organisms and move up the food chain—into humans. A preliminary study in 2018 found microplastics in people's feces across eight countries.

Our huge global e-waste output—13.4 pounds per person on Earth in 2016—is partially driven by built-in obsolescence. The practice is thought to date back to 1924, when industry leaders set an artificially low 1,000-hour standard for light bulb life spans. General Motors introduced the "model year" to prompt consumers to buy more cars. Today, a global backlash against throwaway culture, called the right-to-repair movement, is pushing companies to make products that are easier to fix.

PHOTO: Keegan Houser

A Commitment to Excellence

Gordon Rausser's visionary leadership and extraordinary gift

By Jon James Miller

At his home nestled in the Berkeley Hills, Professor **Gordon Rausser** sits in his office, surrounded by bookshelves filled with academic journals. Rausser's research has appeared in many of these publications over the course of his illustrious career, but before all that began, the award-winning economist pursued other paths as well. Also on display are a pair of golden boxing gloves and a framed picture of Rausser as a college student with fellow judges at an international dairy-cattle congress. Both are relics of his life before a more-than-four-decades-and-counting career at UC Berkeley's College of Natural Resources. They're part of an incredible journey, one that began amid humble roots on his family's small dairy farm near Galt, California. A journey of determination, values, passion, and a vision for a brighter future.

Along the way, Rausser spent time teaching at some of the country's most prestigious universities, and he has been a major influence on global economic policy. He was the chief economist at the State Department's U.S. Agency for International Development in Washington, D.C., for two years. He's an entrepreneur, a consultant, and an expert investor whose knowledge and instincts have enabled him to make a transformative contribution to the campus institution that will now proudly bear his name. Rausser's gift of $50 million to the newly named Rausser College of Natural Resources will go far in helping his home institution further its mission of preparing the next generation of economic, environmental, agricultural, natural resources, and health leaders to tackle the most pressing issues of the 21st century.

Determination and Focus

From a young age, Rausser helped his father manage the farm's business and livestock, while his mother and his sister handled cooking and housework. He also learned early on how to deal with adversity. Rausser was bullied day in and day out by an older neighborhood boy until a cousin intervened and taught him to defend himself.

"My older city cousin Brunsi took me out to our barn, hung a sack of hay from the rafters, and showed me how to spar," Rausser recalls. The next time the bully came to the farm, Brunsi called him out to the barn, where a 10-year-old Rausser was waiting for him. The fight was over in less than a minute. "It was a huge confidence builder," Rausser remembers. "Afterward, I became terribly interested in all things boxing."
For the next several years, Rausser pursued a boxing career while also working the farm. At the age of 13, he joined the only boxing gym in Stockton, which was many miles away, and was welcomed into the ethnically diverse community there. At just 15, he won his first amateur fight and subsequently became the sparring partner for the number one professional middleweight in the world. In the meantime, he also became an expert in evaluating dairy cattle and began to judge at regional 4-H fair and Future Farmers of America competitions. He found that he was a quick study with subjects that interested him, though he confesses that he rarely opened a book.

"I learned later that I was dyslexic," Rausser says. "But I also possess a photographic memory. I learn by seeing and memorizing details." Rausser trained hard, winning the California/Nevada Boxing Association's prestigious Diamond Belt. Pursuing his dream of participating in the Olympics, he entered the renowned Golden Gloves amateur boxing competition, but during what would turn out to be one of his last fights, a cut above one eye changed the trajectory of his life forever.

"I won the fight, but I started bleeding and it could not be stopped," he remembers. "That's when I realized, no amount of talent was going to change

"Without Rausser's ambitious and effective leadership, it's unlikely the College would have survived, much less become one of Berkeley's treasures."

— J. Keith Gilless

the fact that I cut easily. Looking back now, it was a blessing in disguise. Boxing gave me the gift of confidence I needed to turn my focus to academics."

On to Academics

Rausser earned his undergraduate degree in agriculture and statistics at Fresno State before enrolling at UC Davis to pursue a graduate degree in the Department of Agricultural and Resource Economics. After completing just two years of coursework, at the age of 24 he was hired on as a faculty member in the same department.

"By then I was married with two small children, one of whom was born at home in married student housing, and a third was on the way," Rausser remembers. "Shortly thereafter, my father died unexpectedly, and for the next three years I also managed the farm for my mother."

Even while shuttling between Davis and the farm, Rausser agreed to serve on the dissertation committees of seven fellow graduate students. After he completed his own dissertation in order to be eligible to sign off on those of the students, Davis offered him tenure. When his mother leased the farm and moved to a small rural town, Rausser, now 28, departed for a postdoctoral fellowship in economics and statistics at the University of Chicago, after which he was presented with more than 10 offers of full professorships from various universities.

At 29, he accepted a full professorship at Iowa State University in both economics and statistics. The following year, he took a faculty position at Harvard University, where he taught managerial economics and statistics decision theory until 1978.

In the fall of 1978, Rausser came to Berkeley as a professor in the Department of Agricultural and Resource Economics (ARE) at the College of Natural Resources. After only nine months, he was selected to chair the department. Never one to shrink from a challenge, Rausser immediately began building a community grounded in the values of intellectual rigor, generative collaboration, and—in UC Berkeley Chancellor **Carol Christ**'s words—"uncompromising standards of excellence."

Gordon Rausser teaching Harvard MBA students in the late 1970s.

By the mid-1980s, the department had become a powerhouse, setting new standards for recruitment, research, and economic policy reform. After two three-year terms as chair, Rausser took a leave of absence to accept several appointments in Washington, D.C. In 1985, he was a resident fellow at Resources for the Future. From 1986 to 1987, he served as senior economist on the President's Council of Economic Advisers, with responsibilities in the areas of finance, trade, and agriculture. From 1988 to 1990, he served as the chief economist at the U.S. Agency for International Development (USAID), managing over 500 economists working throughout the developing world. During Rausser's tenure at USAID, and subsequently as a co-founder and the first president of the Institute for Policy Reform (IPR), an organization that helped transition economies in Eastern European countries after the Soviet Union collapsed, he developed new guidelines for country strategy statements that define a path to sustainable economic development, and he received a special State Department award for leadership.

Rausser speaking at a conference while president of the Institute for Policy Reform.

Top: Gordon Rausser with children and grandchildren at his ranch in Grass Valley. Above: Rausser with his nine grandchildren.

"It was exciting to work closely with my fellow chief economists at the International Monetary Fund and the World Bank at a time when U.S. policy was guiding the development of market economies that were springing up around the globe," he says.

Rausser published many papers on collective decision-making and governance structures while serving in D.C. Conventional wisdom was to "get the price right" in emerging open markets, but Rausser believed that focusing on setting up appropriate governance structures in developing countries was the first priority. Eventually, the Washington consensus came around to his line of thinking, and this emphasis on public interest over self-interest would serve Rausser well upon his return to UC Berkeley in the early 1990s. "I wanted to take what I had learned about bargaining and negotiating for the public interest and bring my department and the College to the next level," he says. "Little did I know how important those experiences would be at a crucial time in the College's history."

Pioneering Leadership

From 1993 to 1994, while still president of the IPR, Rausser again served as the chair of ARE at Berkeley. In 1994, he was appointed the dean of the College and tasked with leading it through a critical juncture. "At the time, the UC Division of Agriculture and Natural Resources wanted to eliminate our campus designation as an agricultural experiment station. The pressure was on Gordon to do something extraordinary," recalls Chancellor Christ, who was then serving as vice chancellor and provost. "Through a five-year, $25 million partnership with Novartis, he was able to negotiate a first-of-its-kind agreement with industry that greatly benefited the College. Gordon didn't give up, even in the face of great resistance, and paved the way for future partnerships that make Berkeley stronger and a clear leader in research as well as our academic aims."

Rausser remained the dean of the College until 2000, all the while pioneering a paradigm-shifting model of an entrepreneurial university at Berkeley. His visionary leadership revitalized the College's research efforts, expanded its role in undergraduate and professional education, enhanced engagement in Cooperative Extension programs, and increased administrative and budgetary efficiency. Under his watch, the College's faculty and budget increased significantly, the number of faculty chair and professorship appointments grew, new undergraduate majors were introduced, and the number of graduate applications rose. Endowed funds and annual giving to the College increased dramatically as well. As J. Keith Gilless, the dean of the College from 2008 to 2018, puts it, "without Rausser's ambitious and effective leadership, it's unlikely the College would have survived, much less become one of Berkeley's treasures."

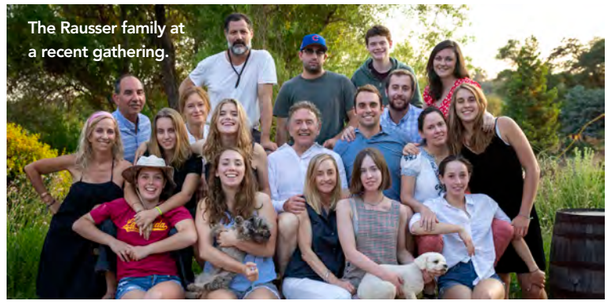
"As dean, Gordon Rausser did more for the College than all of the previous deans combined," observes Henry Vaux Sr., a UC Berkeley professor emeritus of forestry and a former chairman of California's Board of Forestry.

Taking Berkeley to the Next Level

In addition to his leadership both on campus and in government and global policy, Rausser has had a remarkable impact as a professional in his field and in entrepreneurship and business. His creativity and productivity as a scholar have been honored with no fewer than 29 professional awards. He has been

"Gordon's legacy of outstanding leadership at the College in and of itself left an indelible mark on our campus and community."

— Chancellor Carol Christ



The Rausser family at a recent gathering.

recognized for original discoveries in the design and implementation of public policy, multilateral bargaining, collective choice and statistical decision theory, the design of legal and regulatory infrastructure supporting sound governance, modeling dynamic stochastic processes, and innovation in environmental and natural resource economic analytical frameworks. Rausser has been elected a fellow of the American Association for the Advancement of Science, the American Statistical Association, and the Agricultural & Applied Economics Association (AAEA). Recently, the executive board of the AAEA voted unanimously to name—in perpetuity—the opening keynote address at its annual meetings after Rausser. This distinction honors his trailblazing research and intellectual leadership, outstanding editorial work for academic journals, and exceptional teaching and mentorship.

Still, Rausser's enduring legacy will always be centered here at Berkeley, where he continues to make an indelible impact on both the College and his students. Among these scholars, Rausser is deeply respected for supporting their academic success and serving as a sounding board for ideas and concerns. **Scott Kaplan**, BS '14 Environmental Sciences and Environmental Economics and Policy, notes that Rausser was a primary influence driving his passion for economics. "I feel lucky and honored to have had such a distinguished scholar be the first to teach me the field of microeconomics," says Kaplan, now a fifth-year PhD candidate in ARE. "I will be forever grateful for the meaningful mentorship I received from Gordon as a first-year undergraduate, and now as a PhD student."

Rausser with his granddaughter Ava (far left) and daughters Stephanie (left) and Paige (right) at the Festschrift event held in his honor in 2019.

PHOTO: Jim Block

In November 2019, Rausser's colleagues and former students—many of whom have gone on to prestigious careers in fields including economics, law, international trade, public policy, and global poverty and development—convened for a four-day symposium (two days in Berkeley and two days at Rausser's ranch in Grass Valley) honoring his career and celebrating his scholarly contributions. Throughout the event, their deep appreciation for his guidance and collaboration was widely recognized. In a commemorative book for the event, James Davis—Rausser's former research assistant and now a doctoral student in economics at the University of Georgia—commented, "If there is a singular individual who has done the most to shape modern agricultural and resource economics, it is Gordon Rausser."

Rausser's support of students has also taken the form of ongoing philanthropy. In 2000, he established the Gordon Rausser Honorary Scholarship Fund to assist exceptional ARE graduate students as well as undergraduates majoring in environmental economics and policy. He has continued to add to this endowment, the current market value of which is more than $620,000, with his contributions matched through an incentive program for faculty and staff who give to Berkeley.

A Lasting Legacy

Now, Rausser's entrepreneurial and business acumen has enabled him to make a new philanthropic commitment, one that reflects his profound dedication to Berkeley and the College of Natural Resources. "I can think of no other institution in California that's had a greater impact on our past, or has a greater power to shape our future, than Berkeley, and I take great pride in the

On February 29, 2020, UC Berkeley announced Gordon Rausser's generous naming gift to the College of Natural Resources. Rausser is also a co-chair of the UC Berkeley Light the Way campaign.

PHOTOS: Keegan Houser

fact that CNR is one of the cornerstones of this remarkable institution," Rausser says. "Given the right resources, I know what the College is capable of, and I want to ensure that the College achieves an unparalleled level of excellence." "I'm so proud to be able to give back in this way," he adds. "Berkeley has always been the center of gravity for my career and my family, and is the place that I want to be remembered most. I've spent my academic life working for the public good, and there is no better place to keep my life's mission alive than here at my beloved College."

The majority of the funds will remain in an unrestricted endowment, used at the direction of the dean in consultation with the faculty leadership to support a variety of needs and opportunities across the College's five departments. "An endowment gift of this size and nature provides the College with a permanent funding source that will fuel innovation and creativity, enhance the quality of our programs, and help us

"I can think of no other institution in California that's had a greater impact on our past, or has a greater power to shape our future, than Berkeley."

— Gordon Rausser

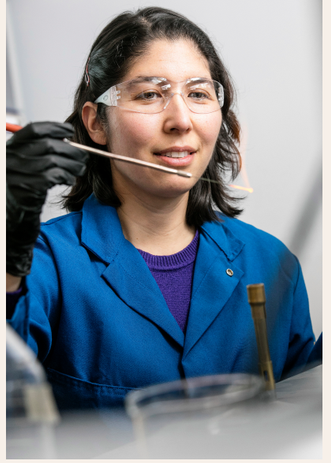
stay competitive—it is truly extraordinary," says **David Ackerly**, the dean of Rausser College. "We will invest in graduate student support to recruit and train the world's best scholars and support innovative interdisciplinary research to tackle major problems at the state, national, and global levels."

Other portions of Rausser's gift will establish the Gordon Rausser Endowed Chair in ARE and will help set up the Rausser-Zilberman Program Endowed Fund for the Master of Development Practice program.

In addition to this landmark gift, Rausser, who formally retired in 2019, is still finding new ways to support the institution he loves. As a co-chair of the Light the Way campaign for Berkeley, he hopes to encourage others to follow in his footsteps in supporting the University. He is also spearheading a potential campus partnership with NASA Ames that would develop a portion of Moffett Federal Airfield, near Mountain View, California, into a mixed research, education, and housing site. It's yet another highly innovative way Rausser is contributing to ensure the future excellence and prestige of both UC Berkeley and the larger Bay Area community.

Rausser's gift, the largest donation ever received by the College and the largest naming gift to any academic unit at UC Berkeley, will help Rausser College continue its tradition of excellence and address key economic, social, environmental, and health challenges around the world. It's a gift that represents an unparalleled vote of confidence in the College, the University, and their mission, according to Chancellor Christ.

"Gordon's legacy of outstanding leadership at the College in and of itself left an indelible mark on our campus and community," she says. "His willingness and ability to now provide a strong financial foundation for the College's future is a contribution whose true value is beyond measure."



RAUSSER COLLEGE OF NATURAL RESOURCES:

A Vision for the Future

When we celebrated UC Berkeley's 150th anniversary two years ago, we didn't yet know the exciting future that would present itself to our College today. Now, as we begin the new decade as the Rausser College of Natural Resources, our core commitment to excellence and access—along with our unique stewardship of Berkeley's land-grant mission—remains unwavering. Gordon Rausser's transformational gift will support our fundamental research addressing the world's most pressing environmental and health challenges; allow us to continue training the next generation of scientists, social entrepreneurs, nonprofit leaders, policy makers, and industry experts; and help us ensure that our work reaches a broad range of stakeholders.

This extraordinary gift will establish an unrestricted endowed fund through which the dean and future leadership can invest in core priorities to strengthen and enhance the excellence of the College. A portion of the gift will also create an endowed fund for the UC Berkeley Master of Development Practice program and an endowed chair supporting a full or associate professor in the College's Department of Agricultural and Resource Economics.

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PHOTOS: Keegan Houser and Jim Block

Some opportunities and priorities for initial funding over the next few years include the following:

- We will make critical investments to bolster support for our graduate students. Recruiting the world's best graduate students and supporting their success is vital to advancing our academic excellence and impact. This gift will also help us to inspire others to follow in Professor Emeritus Rausser's footsteps and continue to make generous investments in our students.

- We will make informed, strategic investments—in consultation with faculty leadership—in our core enterprises: innovative research, effective teaching, and active outreach to communities across the world. We will prioritize investments in interdisciplinary work that demonstrates strong potential for societal impact.

- We will maintain a strategic investment fund to support faculty recruitment, critical facilities and capital projects, and advances in creating a more diverse, equitable, and inclusive College.

We are extremely grateful for the generosity of Professor Emeritus Rausser—and all our donors—and we know that our work is more important than ever. There's much to be done, and we're excited to share our goals for the newly launched Campaign for Berkeley on the next page.

LIGHT THE WAY

THE CAMPAIGN FOR BERKELEY

Driven by the motto *Fiat Lux*, UC Berkeley projects a brilliant light as the world's best public university. We are set apart by our unique combination of comprehensive excellence in research and our public mission. Light the Way: The Campaign for Berkeley is a call to action in support of this unique and priceless public good.

Launched publicly on February 29, 2020, the Campaign aims to raise $6 billion—the University's largest-ever fundraising goal and one of the largest campaigns of any public university to date—by the end of 2023. We invite the entire Cal community to play a direct part in supporting Berkeley—our students, staff, faculty, and programs—to ensure that we illuminate knowledge today and for the future.

The College's original goal for the Campaign—which started a silent fundraising period in 2014—was $125 million. Since Gordon Rausser's incredible gift has helped us reach that target earlier than expected, we've increased our goal to $150 million by 2023.

OUR CAMPAIGN PRIORITIES

Support Our Graduate Students
Endow graduate student fellowships ($1 million each) and support PhD students with stipends aligned with the prestigious National Science Foundation fellowship. Top-off awards for immediate use ranging from $5,000 to $25,000 have a meaningful impact when coupled with other sources of campus support for our students.

Empower Our Undergraduate Students
Support our 2,400 undergraduates with programs including SPUR (Sponsored Projects for Undergraduate Research), travel grants, PAL (Peer Advising Leadership Program), the Summer Internship Program, and SAL (Student Ambassador Leadership Program).

Enhance Spaces for Innovation and Teaching
Transform our area of campus into a hub for environmental research, training, and outreach. The centerpiece would be a new lab building, and upgrades would be made to existing classrooms, collaboration spaces, and offices. We also seek funds to renovate the Cal Teaching Kitchen into a state-of-the-art facility to address nutrition training and food insecurity and to support the food entrepreneurship ecosystem at Berkeley.

Expand Endowment for Faculty and Cooperative Extension
Endow new chairs at $3 million for tenured faculty and $1 million for untenured faculty to help Rausser College remain competitive across all our departments and fields of study. Increasing funds for Cooperative Extension specialists is also a priority.

To learn more about how you can support Rausser College, visit nature.berkeley.edu/give.

CRAFTING THE MESSAGE

'17 MASTER OF DEVELOPMENT PRACTICE

RISHI KHALSA

When he joined the California Department of Justice as a press secretary in January 2019, **Rishi Khalsa** figured he'd put his Spanish-translation skills to use eventually. As it turned out, he was tapped right away, to help craft the Spanish-language response that California Attorney General Xavier Becerra would give to President Donald Trump's State of the Union Address just a few weeks later. "To immediately have the opportunity to work on such an important speech on the national stage was a thrill," Khalsa says.

By Kristin Baird Rattini

PHOTO: Courtesy of Capital Fellows Programs

The ability to convey a message clearly, no matter the stage, has long been a valuable skill for Khalsa. Whether during his high school days in India, his time studying abroad in Spain during college, his two years teaching English with the Peace Corps in Costa Rica, or his translation work with the nonprofit *Global Press Journal,* Khalsa's aptitude for communication—in English, Spanish, and Punjabi—has served him well.

Eager to build on his experiences and explore global development, he applied to the UC Berkeley Master of Development Practice (MDP) program after completing his Peace Corps assignment. "It seemed like a natural segue from doing development work to understanding how that work fits in the bigger picture," Khalsa says. "I knew Berkeley would be a great place to develop a theoretical background."

A grounding in theory

Enrolling at Berkeley marked a coming home for Khalsa. In his early childhood, he had lived just blocks from campus and heard the Campanile tolling daily. "Listening to those bells, I knew that, someday, I would go to Berkeley," he says.

One of Khalsa's first classes proved to be the most influential: International Economic Development Policy with **Alain de Janvry,** a professor of agricultural and resource economics. "We discussed the differences between various approaches to development—everything from Angus Deaton's concerns about aid undermining social contracts to Esther Duflo and Abhijit Banerjee's studies that assess the impact of development interventions," Khalsa recalls.

He took advantage of the MDP's flexible structure and chose courses that would help him develop an emphasis in international media. "I was interested in working in the foreign service, perhaps as a communications officer," he says. "And I was already working as a researcher and translator with *Global Press Journal,* which trains and employs women around the world as journalists. I was able to bring those interests together in the MDP."

Meet the press

After graduation, Khalsa joined California governor Jerry Brown's communications team through the Capital Fellows Programs at Sacramento State. "It's a fantastic program for people who have limited experience with state government to dive in at the highest level," Khalsa explains. He eventually found himself involved in the Global Climate Action Summit, for which Brown invited environmental ministers from around the world to San Francisco. "When I was in the MDP, there was a contingent from Berkeley that participated in the Paris climate accord discussions. At the time, I told my department director, 'That's what I want to do,'" he recalls. "It was remarkable to then be able to attend a meeting of ministers at the summit in San Francisco and to be in the room for such a high-level political process."

Khalsa transitioned from the fellowship into an assistant press secretary role with the governor before pivoting to the California Department of Justice, where he is one of three press secretaries. "The department touches on nearly

"My job really runs the gamut. I'm learning all the time."

all the different facets of state government," he says. "We represent various departments and agencies as our clients, but then our office also proactively tackles issues on behalf of residents or the state. My job really runs the gamut. I'm learning all the time."

While his areas of focus include labor, housing, civil rights, and criminal justice reform, his communications work has also recently dealt with immigration. In November, the U.S. Supreme Court heard oral arguments in the lawsuit against the Trump administration over the government's attempts to rescind the Deferred Action for Childhood Arrivals (DACA) policy. Khalsa collaborated with the multiple plaintiffs' communications teams—including the University of California's press office—to help present a unified message and amplify the state's perspective. At a time when DACA was national news, he wrote press releases, organized press conferences, and crafted responses to federal talking points.

"One of the reasons I ultimately decided to work in state government instead of the foreign service is because it offered the chance to work on issues from a policy perspective that aligns more closely with my own beliefs, particularly in regard to immigration," he says.

One press conference that he helped organize crystallized for Khalsa what he has been working toward since he first entered the MDP program. At the conference, Attorney General Becerra spoke with a number of DACA recipients, including an individual who is a plaintiff in the case. "To be able to witness firsthand the courage and tenacity of people whose livelihoods and lives are at stake," Khalsa says, "was an incredibly rewarding experience."

Rishi Khalsa supporting Governor Jerry Brown during a press gaggle outside the China Pavilion at the Global Climate Action Summit in San Francisco.
PHOTO: Courtesy of the Office of Governor Jerry Brown

Q&A

Cooperative Extension Specialists: Incubating Climate Change Solutions

By Kirsten Mickelwait | Photography by Jim Block

Founded in 1914 in partnership with the U.S. Department of Agriculture and the nationwide land-grant university system, the Cooperative Extension System supports research and community outreach programs in agriculture, the environment, health, natural resource management and conservation, and other fields. UC Berkeley was California's first land-grant institution, and today the Rausser College of Natural Resources is home to 18 Cooperative Extension (CE) specialists in four departments. Our specialists and more than 100 others in the UC system constitute a core program within the UC Division of Agriculture and Natural Resources.

They conduct both applied research and public outreach, working with communities and decision makers to foster land stewardship across the state. Three of our newest CE specialists are using their scientific expertise and communication skills to provide practical, research-based advice to Californians on issues related to climate change. Each of them holds one or more degrees from the University of California, and all see their work as a natural extension of the public university's mission.

Theodore (Ted) Grantham

Assistant Cooperative Extension Specialist, Adjunct Professor
Environmental Science, Policy, and Management (ESPM)

Ted Grantham's research examines the relationships between hydrology and ecology in rivers and streams. His outreach seeks to translate this research into sustainable, cost-effective solutions for managing water and the environment.

What is the intersection between your work and climate change? How much is data analytics, and how much is working in the field?
My research is framed around the effects of human activity and climate change on freshwater ecosystems, particularly California's rivers and streams. For example, in the future, California is going to become a much less hospitable place for salmon. If current trends continue, about three-quarters of our 31 salmon and trout species could disappear by the end of the century. Much of my research explores approaches to water management that will protect salmon and other sensitive species while also satisfying human needs.

Some of my work involves hydrologic modeling, such as simulating natural stream-flow patterns. But my lab also conducts field studies to understand how sensitive stream ecosystems are to change. At one study site, we are able to artificially modify flow in a stream by controlling the release of water from a reservoir. We observe how those changes in flow affect the growth, health, and survival of juvenile salmon; what we learn can be used to guide management actions.

Why is your work so well suited for Cooperative Extension?
Climate change is already impacting our state and beyond, and we urgently need solutions that are scientifically sound but also work for communities. At Cooperative Extension, we cultivate and sustain lines of communication between UC and the public. By tackling real-world problems in a collaborative manner, our work has the potential to make a big difference.

Why do you think such outreach is so important?
The Cooperative Extension model is a two-way exchange of information. We're moving the science beyond academia, working closely with a network of boots-on-the-ground practitioners and decision makers to translate knowledge into action. At the same time, theirs are the voices that inspire and guide our work, so that the research we conduct is relevant.

As CE specialists, we have limited teaching responsibilities, and much of our time is spent engaging with stakeholders, observing social and environmental conditions, and learning how our science can best serve others. It's a real privilege to have the time and license to do such outreach.

Ted Grantham researches the intersection of hydrology and ecology in rivers and streams.

Ellen Bruno

Assistant Cooperative Extension Specialist
Agricultural and Resource Economics

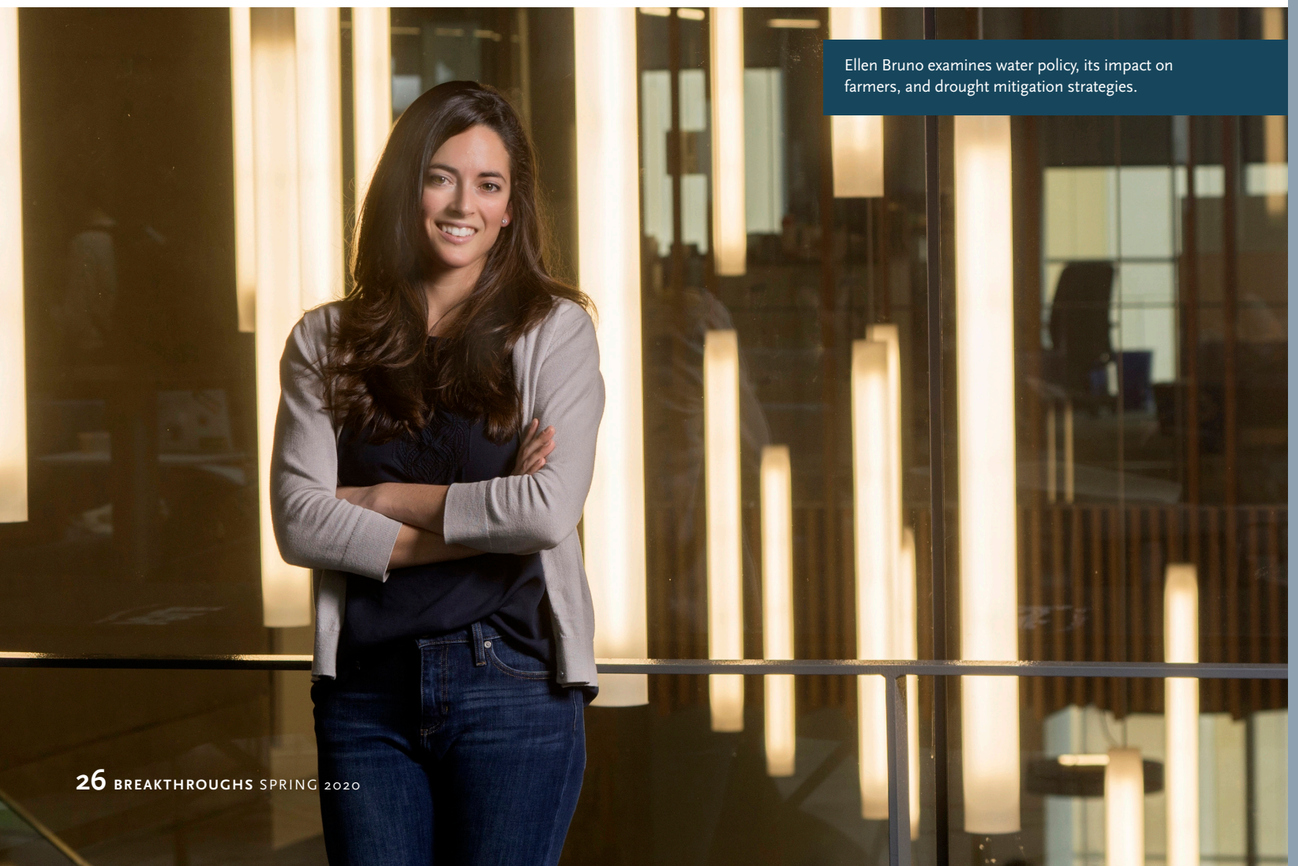
Ellen Bruno's research examines water-related policies and their impacts on farmers. Her work as an extension economist centers on water use, with a particular focus on strategies to mitigate the economic costs of drought and climate change.

As an economist, how do you interact with the external community?
I engage with farmers, engineers, water utility practitioners, environmental groups, and policy makers to gather data and understand the issues in the real world. For example, one current study looks at how farmers respond to water prices, whether by reducing water use, fallowing fields, or switching crops. I examine the data, using historical water-usage patterns and past price changes to build models of agricultural land use. Finally, I share my research findings through lectures, conferences, and outreach articles. I try to align my research agenda with state priorities; there's a lot of potential for reforming past water-use inefficiencies.

How does your work lend itself to Cooperative Extension?
For my research to be focused on real-world problems, it has to be informed by stakeholders and their needs. For example, my doctoral research was inspired by the Sustainable Groundwater Management Act of 2014, a law regulating California's groundwater. Today, public concern about the economic impacts of this legislation is prevalent.

How does CE advance UC's mission as a public university system, and why is that so important?
Taking research out of academia's ivory tower is fundamental to UC's mission. In order to discover and advance new practical knowledge, we need people who are dedicated to understanding the state's policy needs while translating their work for a wider audience. Cooperative Extension helps broaden the University's impact, better conveying its research to Californians who could benefit.

It's no coincidence that I got my degrees at UC San Diego and UC Davis, then came to work in Cooperative Extension at Berkeley. I grew up in California, so I looked to my state's public university system as my first option for a quality education. After having the chance to participate in research as an undergraduate, I was inspired to get my graduate degrees in agricultural and resource economics. As a grad student, I worked with a CE specialist and met a lot of people fulfilling the land-grant mission. Now I feel so lucky to conduct and disseminate applied research through this position.



Ellen Bruno examines water policy, its impact on farmers, and drought mitigation strategies.

Daniel Sanchez's carbon-sequestration research involves encouraging the use of forest-waste biomass for construction of buildings, transportation fuels, or other high-value chemicals. This photo was taken in the Cathedral of Christ the Light in Oakland, the interior of which is an example of mass timber construction.

Daniel Sanchez

Assistant Cooperative Extension Specialist
ESPM

Daniel Sanchez is an engineer and energy-systems analyst whose Carbon Removal Lab studies the use and commercialization of energy technologies that remove carbon dioxide (CO_2) from the atmosphere. He also works with policy makers and technologists on issues involving bioenergy, forest management, wood utilization, and climate policy.

How does your work on sustainable negative-emissions technologies tie into the energy and industrial sectors?
I research a broad range of technologies and products that remove CO2 from the atmosphere. For example, through my work with the California Joint Institute for Wood Products Innovation, I help develop new wood products that create value and sequester carbon from the air. We aim to collect low-value and waste biomass from our forests and lumber industries and transform it into new structural wood products (including buildings up to 18 stories tall), transportation fuels, or other high-value chemicals. Right now, most of this wood is left to decompose or is burned in large piles in the forest.

Other parts of my work focus on designing and deploying bioenergy technologies—operating off of grasses, plants, trees, or other waste—to help California reach its climate goals. By running energy-systems models, my collaborators and I learn where the biomass is, how much the technology costs, and where and how we might use it. We hope that California can take the lead in developing negative-emissions technologies, which would help the state meet its goal of being "net carbon neutral" by or before 2045.

Why is Cooperative Extension the best outlet for your work?
As UC Agriculture and Natural Resources vice president Glenda Humiston often says, Cooperative Extension is the original incubator, moving ideas from the research lab to wide-scale adoption across the state. We work to promote and scale up new technologies.

California takes climate change seriously and is on the leading edge of combatting the issue. We really need the land sector—farmers, ranchers, forest managers—to play a role in fighting climate change, and CE is engaging in a proactive knowledge transfer to introduce new technologies and products. CE has historically been about translating science to solve natural resource problems, but tackling climate change now needs to be addressed and scaled across the country.

How do you see CE as part of UC's mission as a public university system?
The whole land-grant mission is absolutely central to Cooperative Extension. A place like Berkeley is essential to training not only scientists but also technology-adept policy makers. Personally, I believe that there would be a benefit if most faculty positions across campus had an outreach component—not just in the agricultural and natural resource sectors but across public health, engineering, chemistry, law, and design.

PHOTOS: Iryna Dronova (left and middle), Valeri Vasquez (right)

Mission South

A delegation of women in STEMM tours Antarctica

By Kari Lydersen

The iceberg appeared to be breathing. Slowly undulating in the frigid water, its cerulean blue base glowed below the surface. Antarctica's glaciers have calved and sent icebergs adrift in the ocean for millennia. But watching this scene from a Zodiac boat in December, **Iryna Dronova**, PhD '12 Environmental Science, Policy, and Management (ESPM), saw both a metaphor and a warning.

"We knew that with each splash of water, the iceberg wasn't breathing; it was melting," says Dronova, who is now an assistant professor in Berkeley's Department of Landscape Architecture and Environmental Planning. "It awoke a sensation of time running out, an urgency to act on climate change." She and **Valeri Vasquez**, a PhD candidate in the Energy and Resources Group (ERG), were among a group of women who traveled to Antarctica last winter as part of the largest-ever all-female delegation to the frozen continent.

Their expedition was convened by the Australia-based initiative Homeward Bound, which was launched in 2016 to create a global collaboration of 1,000 female leaders in science, technology, engineering, math, and medicine (STEMM) fields. One hundred women are selected to take the trip each year. Those in the 2019 group—the fourth so far—came from more than 30 countries and from disciplines directly and indirectly related to climate change: among them, marine science, oceanography, wildlife biology, public health, energy, astronomy, biosecurity, and botany.

The participants toured the Antarctic Peninsula, a rugged collection of snow-and-ice-covered mountains and islands that stretches toward Argentina and Chile. The western Antarctic Peninsula is one of the fastest-warming places on Earth, with a mean annual temperature increase of 2.8 degrees Celsius between 1950 and 2005, according to the *International Journal of Climatology*.

The concept behind the delegation was that, after experiencing the spectacular, fragile continent firsthand, the women would return home inspired to push for Antarctic protection and energized in their work as it pertains to climate change and related issues. Vasquez says that Antarctica "allowed us a glimpse of the rich biodiversity we were there to learn how to protect."

Modeling mosquitoes, mapping wetlands

Prior to her graduate studies at Berkeley, Vasquez worked for the U.S. State Department as an adviser on international climate policy. Among other things, she helped broker the negotiations at the U.N. Framework Convention on Climate Change, during which 195 nations crafted the Paris Agreement to curb greenhouse gas emissions. Her desire for a deeper understanding of the science underlying mitigation and adaptation efforts brought Vasquez to ERG, where she modeled the human health–related economic costs of carbon dioxide emissions for her master's thesis.

Now, for her doctoral work, Vasquez develops computational models to explore options for using a genetic engineering approach called gene drive to curb the spread of disease-carrying mosquitoes. Such novel approaches are expected to be increasingly important for controlling the incidence of illnesses like malaria as climates change around the globe. In the future, Vasquez hopes to investigate applications of gene drive in agriculture and conservation as well.

Dronova uses remote sensing techniques (like capturing images from sensors on satellites, aircraft, or drones) to monitor the health, biodiversity, and function of wetlands and to inform decisions about their management and conservation. She also utilizes thermal satellite images to examine how green spaces in urban environments provide cooling benefits, depending on how the cities are designed and planned. And she's collaborating with Berkeley colleagues and alumni on two projects assessing carbon sequestration in restored wetlands, including one with ESPM professor **Dennis Baldocchi** and his Biometeorology Lab.

Global climate connections

While their work does not involve Antarctica directly, Vasquez and Dronova both say that the journey underscored the deep linkages between ecosystems worldwide—in particular, those involving the drivers and impacts of climate change. The Southern Ocean, which surrounds Antarctica, drives ocean currents and regulates the global climate. Warming temperatures can melt previously stable ice sheets and hasten the calving of glaciers. Antarctica's ice sheet is thought to hold more than 60 percent of the world's fresh water, and an influx of fresh water from the melting ice sheet could interrupt the circumpolar current that influences climate across the globe. In September, an Intergovernmental Panel on Climate Change report predicted with "very high confidence" that Antarctica's melting ice sheet could trigger a sea level rise of several meters within a few centuries.

"Even though we think about Antarctica as a vast pristine space, it is so fragile and so connected to what's happening in the rest of the world," says Dronova.

"It was incredible to observe how this landscape is shaped by geology, time, climate, and animals and to witness how these connections evolve even in this relatively extreme environment," she adds. "We saw penguins building their highways across the snow, water and ice carving landscape features that then provide habitat for nesting birds and animals, and ice blocks that support organisms under the water like krill and phytoplankton."

The delegation traveled to Antarctica on the 60th anniversary of the Antarctic Treaty, a multinational agreement that set aside the continent for the peaceful pursuit of science. Vasquez—like many Antarctic scientists and policy advisers—describes the treaty as an inspiring example of international cooperation.

"It shows the scale of collaboration we're going to need," Vasquez says, "as countries, communities, and individuals, to preserve this incredible place for generations to come."