Stanford
WOODS
INSTITUTE *for the*
ENVIRONMENT

ANNUAL REPORT

2018–2019

"The best plan is a flexible plan. We haven't figured out all the details yet, but we need to make the first step."

– Costa Rican President Carlos Alvarado Quesada, speaking at Stanford March 13

Turn to page 8-9 for more insights from our visiting speakers in 2018-19, including Katharine Hayhoe, William Hensley, Sally Jewell, Michael Mann, and Jonathan Pershing.

Woods-affiliated faculty, research staff and students span Stanford's seven schools. When noting affiliations, we abbreviate some Stanford school names, including Graduate School of Business (GSB); Graduate School of Education (GSE); School of Engineering (SOE); School of Humanities and Sciences (H&S); School of Earth, Energy and Environmental Sciences (SE3); Stanford Law School (SLS) and School of Medicine (Med).

Credit: Felix Miranda, Pixabay
Caption: Puerto Golfito Coastline, Costa Rica

A Word from Chris Field

Dear Friends,

We live in an era of unprecedented environmental challenges. The issues are made even more complicated by messy and inconsistent national and international politics. At times like these, I'm especially grateful to work with the incredibly dedicated scholars, staff and supporters of the Stanford Woods Institute for the Environment, as we channel our concerns about major global challenges into finding practical solutions and taking them to scale.

Last fall, my neighbors and I joined thousands of other California residents who went without power during several Public Safety Power Shutdowns implemented to reduce the risk of catastrophic wildfire like the one that destroyed the town of Paradise in Fall 2018. The horrifying surge of wildfires across California keeps a focus on the bleaker side of the environment, but also on the urgent need for innovative problem-solving.

The solution to a systemic, multifaceted problem like wildfire risk in California will have multiple components. One may be advanced fire retardants, like the preventative hydrogel moving into development with initial backing from a Woods seed grant. Or they might call for innovative new, systems-oriented approaches to fuel management. Such an approach—currently in proposal stage with a team of Stanford researchers including Kari Nadeau (Med), Eric Appel (SOE), Gabrielle Wong-Parodi (SE3), Noah Diffenbaugh (SE3), Michael Wara (Woods), and me—leverages Stanford expertise on climate forecasting, ignitions, fuel reduction, innovative forest products, smoke exposure, and rethinking community location and design. We're exploring a wide range of paths for advancing wildfire research-to-solutions, targeting a future with zero wildfire related deaths in California.

Projects like these are intensely collaborative, and require agile, interdisciplinary teams that can coalesce to generate knowledge, plans, and partnerships to solve specific problems. The Stanford Woods Institute was an early pioneer of this approach in a university setting, drawing on skills and perspectives from across the university and beyond to tackle environmental challenges. The aforementioned efforts, and many more featured in this report, beautifully illustrate Stanford's unique ability to create meaningful impact in the world. We are fortunate to have such tremendous supporters and partners in our work to meet this defining challenge of our era.

Sincerely,
Chris Field
Perry L. McCarty Director

Catalyzing Research

Confronting the world's staggering environmental threats requires not only new solutions, but new ways of thinking. Stanford's diverse community of innovators takes risks and works across disciplines, sectors and boundaries to develop critical knowledge and practical solutions at the vanguard of sustainability. The Stanford Woods Institute serves as a convener, incubator and support system for many of these groundbreaking research collaborations tackling the most pressing challenges facing us, and future generations.

Some of these initiatives take the form of research centers and programs (see page 16), while others are agile collaborations drawn together by Woods seed grants from Environmental Venture Projects (EVP) and the Realizing Environmental Innovation Program (REIP). Between 2004 and 2019 these programs have awarded 102 grants totalling $16 million, which have generated $60 million in follow-on funding. The support provided through programs are quite literally

Arial view showing treated and untreated areas of dried grass pre-treated with new fire retardent hydrogel.

enabling Stanford researchers to build the foundations of knowledge required to pioneer one practical solution at a time.

To follow are selected 2018-19 highlights from Woods-funded research projects and researchers:

- **Preventing Wildfires:** A new fire retardant hydrogel developed by Stanford researchers with support from a 2018 REIP could greatly reduce the incidence and severity of wildfires. The approach, outlined Sept. 30 in PNAS, involves an environmentally benign gel-like fluid that helps common wildland fire retardants last longer on vegetation. Applied to ignition-prone areas, these materials retain their ability to prevent fires throughout the peak fire season, even after weathering that would sweep away conventional fire retardants. The gel—now on the market through the REIP team's start up company LaderaTECH—is already being piloted for use through partnership with CalTrans and CalFire.
- **Safeguarding Marine Ecosystems:** Fishing practices that use gear dragged on the seafloor, such as bottom trawling, destroy and degrade marine habitats on continental shelves, the most productive areas of the global ocean. The findings from this EVP-seeded project provided the basis for a Marine Protected Area banning trawling in the Adriatic Sea. The research team published

subsequent findings in 2018 indicating fishing operations were able to maintain their catch levels by fishing outside the MPA area. In addition to justifying the permanent protection against trawling in the Adriatic, the results hold promise for other highly exploited areas around the world where enforcement is challenging.

Mealworms feast on polystyrene.

- **Tracking Lead Contamination:** In 2019 the prime minister of Bangladesh imposed restrictions on turmeric based on EVP-funded findings of lead contamination. The research has generated 3 studies and $2.8 million in follow-on funding, and has been disseminated to various government agencies tasked with improving food safety. The team is now exploring a lead detection device startup.
- **Recycling Plastic:** Mealworms can safely eat and digest polystyrene foam - and can in turn be used as a protein-rich feedstock for other animals with no ill effects, according to findings funded in part by a 2016 EVP. The findings, most recently updated last year in Environmental Science & Technology, have attracted widespread media coverage and captured imaginations around the world, leading to weekly calls to the project PIs from students and others eager to replicate their findings. The team now seeks to leverage these discoveries by developing new methods for plastic waste management and by establishing a citizen science community for crowdsourcing of plastic remediation strategies.
- **Tracking Water Quality**: Early support from an EVP helped Stanford researchers engineer a drone with a special remote sensing system designed to help measure sediment flow through rivers, bays, wetlands and other waterways. The drone's remote sensing system represents a major advance from current low-tech methods used to detect suspended sediment that can transport toxic pollutants and cause the formation of fish-killing red tides.

This is just a sampling of research outcomes in 2018-19. For a deeper dive, read the 2019 Stanford Environmental Research Year in Review or visit our website: https://woods.stanford.edu/news/evp-news

RECOGNIZED

Woods Senior Fellow Eric Lambin (H&S) was named the winner of the 2019 Blue Planet Prize, one of the most prestigious awards for contributions to environmental science. A measure of Stanford's leadership in this area is that Eric is Stanford's fourth winner in the prize's 28-year history, following in the distinguished footsteps of Paul Ehrlich, Hal Mooney, and Gretchen Daily.

Photo by Francesco Ungaro from Pexels

Inspiring Conversations

A Hub for Dialogue

One of the founding ideas of the institute is that solutions to environmental problems involve conversations rather than lectures. In that spirit, the institute invites high-level visitors to an environmental conversation where the topics and direction are chosen by the audience and the speaker working together. An inspiring group of government, corporate and academic leaders visited Woods in 2018-19, joining institute scholars for wide-ranging, informal conversations exploring the 'who, how, and why' behind major developments in environmental science and policy.

"I really believe that there's absolutely a direct connection between the culture and the future survival of our corporations and our ability on the land."

– Native Alaskan activist, author, legislator and professor **William Hensley**, speaking at Stanford on Oct. 30

Recap video: https://stanford.io/2RTBgMn

"It's very difficult to put regulations in place, and it's very difficult to take them out of place. We've set it up in a way where these rollbacks can be challenged."

– Former Secretary of the Interior **Sally Jewell**, speaking at Stanford January 30

Recap video: https://stanford.io/34qTYxu

"Inaction is the greatest threat to the economy and, by the way, the real growth industry is renewable energy and the countries that recognize that are the ones who are going to win out in this international economic competition over the next century."

– Climate Scientist **Michael Mann**, speaking at Stanford on Nov. 23

Recap video: https://stanford.io/2LZ7rGJ

"They're no longer tomorrow's problems for our grandchildren in some other country, they're our problems today in our country. That's new, and that gives me the sense that we may get enough pressure to drive change at the scale we need."

– Former U.S. Special Envoy for Climate Change **Jonathan Pershing**, speaking at Stanford March 13

Recap video: https://stanford.io/2Pov2Ct

"Interdisciplinary [work] is a very courageous journey. We're still on it, and we need it to try to understand the big picture. You need the natural and social sciences. You need systems thinking. You need cross-cultural understanding."

–**Julia Marton-Lefèvre**, former director general of the International Union for Conservation of Nature, speaking with Nicole Ardoin May 8

Recap Q&A: https://stanford.io/362m7Mc

Advancing Decisions

Six years after the Stanford Woods Institute for the Environment extended its external affairs operations with an office in Washington, D.C., the U.S. environmental policy landscape has dramatically changed. Yet, the urgency and relevance of Stanford environmental discoveries and expertise to policymakers in the U.S. and around the globe remains the same, if not greater.

The institute external affairs team cultivates and facilitates exchanges with key decision-makers from government, nongovernmental organizations, legislative offices and corporations. Team members produce and disseminate briefs based on published scientific papers, which target specific audiences and inform policy debates in Washington and Sacramento. They also organize in-person briefings, inform Stanford faculty of key environmental legislation and funding opportunities, and drive the institute's efforts to convene experts and stakeholders across sectors.

(L-R) Sherri Goodman, Fran Ulmer and Bob Litterman talk after Woods' EPA Endangerment Finding panel.

Serving as a witness at a congressional committee hearing is one of the most direct ways

Noah Diffenbaugh testifies to Congress.

to inform members of Congress and provide input into potential legislation. Individuals called to testify are generally trusted sources to committee staff recognized as experts in their field and as effective communicators. The Woods D.C. office has worked to familiarize key committee staff with Stanford scholars and research so that Woods fellows and affiliates are invited to serve in this capacity. Recent examples include Woods Senior Fellow Noah Diffenbaugh (SE3), who testified on May 23, 2019 at a Select Committee on the Climate Crisis hearing on "Creating a Climate Resilient America." Center Fellow by courtesy Marshall Burke (SE3) testified Sept. 11, 2019 at a House Financial Services Subcommittee on National

Security, International Development and Monetary Policy hearing on "Examining the Macroeconomic Impacts of a Changing Climate." As the year drew to a close, Woods Climate and Energy Program Director Michael Wara served as a witness at a Dec. 19 Senate Energy and Natural Resources hearing to examine "the Impacts of Wildfire on Electric Grid Reliability." His invitation to testify is one of the literally hundreds of requests he's received to address the topic; more than 183 media outlets–including the *New York Times, Washington Post, PBS NewsHour, Associated Press, NPR, Wall Street Journal and Forbes*–quoted Wara on PG&E and related wildfire topics in 2018-19.

MIchael Wara addresses U.S. Senate panel on PG&E.

Jim Leape facilitates an oceans and food workshop.

The external affairs team's main goal is to connect Stanford research with policy- and decision-makers in a position to improve environmental policy outcomes. An assessment over the past five years found those efforts have:

- Expanded policy capacity through the production of timely, policy-relevant research briefs which are distributed to a targeted audience from among our network of more than 1,000 environmental policy contacts;
- Broadened environmental policy discourse through a series of public events, Uncommon Dialogues and other meetings that bring together Stanford researchers with cross-sector stakeholders in a position to benefit from and inform new findings;
- Informed decision-makers by leveraging connections and meaningfully engaging with D.C.- and Sacramento-based Stanford alumni groups;
- Improved science communication capabilities through workshops and interactive sessions organized by the Rising Environmental Leaders Program and its annual Washington, D.C., and Sacramento Bootcamps for graduate students and postdoctoral scholars;
- Influenced policy decisions through an integrated approach of personal dialogue and written communications sustained over time on current policy priorities in which Woods has particular expertise.

The Convening Power of Stanford

Through Woods Uncommon Dialogues and workshops, the institute brings together leaders from government, nongovernmental organizations and business with experts from Stanford and other academic institutions to develop practical solutions to pressing environmental challenges. These dialogues equip leaders to make informed decisions for a sustainable future while creating a two-way flow of information that brings new perspectives and context to Stanford's environmental research.

The institute hosted and organized 55 meetings, workshops and events during FY18-19, ranging from high-profile events, such as a Stanford campus visit and address by Costa Rican President Carlos Alvarado Quesada and Woods' side-event

Carbon Emissions on the Rise panel: (L-R) Rob Jackson, Sally Benson, Sheila Bonini and Chris Field.

on the EPA Endangerment Finding held at the Global Climate Action Summit, to professional development workshops for Woods scholars and National Press Club briefings on rising carbon emissions research and environmental behavior change. Woods also hosted Conversations with Obama-era climate negotiator Jonathan Pershing (3/13), former U.S. Secretary of the Interior Sally Jewel (1/30), renowned climate scientist Michael Mann (11/29), and Alaska First Nations activist William Hensley (10/30). See quotes from these inspiring Conversations on page 5-6.

2018-19 Highlights

- **Emissions on the Rise:** At a Woods-orchestrated panel at the National Press Club, Stanford Earth scholars and Woods Senior Fellows Chris Field, Sally Benson and Rob Jackson discussed research showing an increase in global carbon emissions after a multi-year period of declining emissions. The February 2019 event attracted an audience of nearly 100 from government agencies, nongovernmental organizations, think tanks and media organization. It was followed by a briefing on Capitol Hill in which the panel speakers fielded questions from more than 80 legislative staffers and members of Congress. The briefing was convened in partnership with Duke University's Nicholas Institute for Environmental Policy Solutions and Resources for the Future.
- **California Water Quality:** Stanford scientists traveled to Sacramento for a Woods-organized panel discussion about their research on water quality issues, such as arsenic and chromium contamination; impacts of extractive industries on water; managing delivery and conveyance systems; and the state's aging water infrastructure. The panel, which attracted more than 80 state agency staff, water policy advisers and resource managers, featured keynote remarks from Joaquin Esquivel, chair of the State Water Resources Control Board.

Sacramento Water Quality Briefing: Newsha Adjami, Rob Jackson, Scott Fendorf and Chris Field.

- **Environmental Behavior Change:** As part of the Environment and Energy Panel Series in Washington, D.C., the institute held a July 31 discussion on individual behavior and decision making related to the environment. Panelists discussed factors, such as economic, psychological, environmental and social norms, and ways of influencing choices and actions. Woods Fellow and 2019 faculty recruit Gabrielle Wong-Parodi (SE3) joined Brett Jenks of Rare and Margaret Walls of Resources for the Future to discuss their latest research on environmental behavior.

- **Oceans and the Future of Food:** Stanford's Center for Ocean Solutions and Center on Food Security and the Environment, with Springer-Nature, hosted a workshop focused on building a research agenda around the role of oceans within global food systems. Massive changes in the global food sector over the next few decades—driven by climate change and other environmental stresses, growing population and income, advances in technology, and shifts in policies and trade patterns—will have profound implications for the oceans and vice versa. While there is a large community of researchers addressing challenges in food policy and agriculture and a similar community in oceans and fisheries, there is very little interaction between them. This workshop brought together leaders across academia, business, policy and government to discuss food security, equity, poverty alleviation, marine ecosystems and environmental change.
- **Hydropower, Climate and Conservation:** In January 2019, the institute joined with Stanford's Steyer-Taylor Center for Energy Policy and Finance to host an Uncommon Dialogue on hydropower, climate solutions and conservation challenges in Washington, D.C. Following up on prior workshops in 2018 to advance climate change and conservation priorities related to hydropower facilities, this workshop reported on work-to-date and areas of potential agreement among participants, with an emphasis on accelerating upgrades of U.S. dams for hydropower production and decommissioning current dams with environmental, safety or economic problems.

Gretchen Daily addresses the Planetary Health Alliance Conference at Stanford.

- **Coastal Resilience:** Woods, the Hoover Institution, and the Wilson Center continued their joint collaborative project "Building Coastal Resilience for Greater U.S. Security" exploring coastal resilience to climate change through a series of dialogues and events. The series' fourth and fifth dialogues, in March and November, centered on legal and regulatory issues that emerged during earlier dialogues. The fourth event added wildfire resilience as a focus, considering both issues share vulnerabilities, lessons to be learned and relevance to California. Fire and coastal flood resilience have several overlapping themes, such as the importance of public education and risk disclosure.
- **Planetary Health:** Woods worked with the Stanford Center for Innovation in Global Health to host and co-sponsor the 2019 annual meeting of the Planetary Health Alliance. The event assembled more than 500 researchers and public health practitioners from around the world for conversations about global sustainability through the lens of human health. A number of Stanford faculty presented or facilitated panels at the conference.

Developing Environmental Leaders

Woods leadership and education programs help prepare students, early career scholars and faculty to extend the impact of their research far beyond campus. Whether they are leading interdisciplinary teams of researchers, forging cross-sector partnerships, or pursuing careers in the policy sector, Stanford scholars benefit from a diverse portfolio of programs that instill the skills, knowledge and networks to move knowledge into action. The institute's strategic approach to its education and professional development offerings helps current and emerging leaders develop skills essential to advancing sustainability while facilitating introductions to key contacts in government, non-governmental organizations (NGOs), think tanks and business.

Some of these programs take the form of coaching and internship opportunities, while others provide undergraduate and graduate students with funding to catalyze research in areas with the potential for practical environmental impact. To follow are 2018-19 highlights from Woods-funded leadership and education programs:

2019 RELP Cohort, DC Bootcamp.

- Leading Interdisciplinary Collaborations (LInC) is the newest Woods leadership program. Piloted over 2018-19 with nine Stanford faculty members, the program offers a retreat and ongoing coaching on collaborative leadership skills that invert traditional academic norms of one-way knowledge sharing. Designed for early- and mid-career Stanford faculty, LInC helps researchers amplify the impact of their findings through public science, interdisciplinary team building, and science communication and systems thinking skills.
- The Forum for Undergraduate Environmental Leadership (FUEL) program connects undergraduate students with emerging environmental leaders and seasoned professionals from the public and private sectors. Through the lens of a pressing environmental issue, FUEL allows undergraduate students to develop a better understanding of the environmental policy sector, investigate environmental career opportunities and learn more about the advances environmental leaders are making through policy and public service, and the private sector. In 2018-19, 11 students explored the challenges of "Chemicals in California" through meetings with leaders of California and local community-focused NGOs, legislative actors and California regulatory agencies to understand approaches they are taking to address toxics and the associated risks to environmental health.
- The institute's Rising Environmental Leaders Program (RELP) for graduate students and postdoctoral scholars affords Stanford

students across all seven schools the opportunity to engage with cross-sector experts in Sacramento as well as Washington, D.C. More than 34 policy experts, journalists, legislative and agency staff met with the 2019 cohort of RELP fellows at the program's Sacramento and Washington, D.C., "Bootcamp" events. The broad range of speakers represented the public and private sector, both sides of the political aisle and agencies ranging from the Environmental Protection Agency to the Senate Committee on Environment and Public Works.

FUEL participants visit Sacramento.

- The Stanford Environmental Policy Internships in California program (EPIC), offered in partnership with the Haas Center for Public Service, worked with a variety of California state agencies and the San Francisco Department of the Environment to create immersive summer policy internship opportunities for five undergraduate students selected from 50 applicants. Each student was matched with a faculty adviser before working at state agencies including the Governor's Office of Planning and Research; the Department of Conservation; the State Water Resources Control Board; the Ocean Protection Council and the San Francisco Department of the Environment.
- The Mel Lane Student Grants Program awarded nine grants totalling $11,665 to support independent, student-directed projects of environmental impact. Winning projects ranged from a pipeline for detection of waterborne pathogens in wastewater treatment trains to documenting indigenous Hawaiian water ecosystem restoration to the organization of a zero-waste week.
- The Mentoring Undergraduates in Interdisciplinary Research (MUIR) Program was awarded $72,400 by Stanford's Vice Provost for Undergraduate Education to provide summer funding for undergraduates, enabling mentorship as the students support Stanford faculty environmental research. Now in its 12th year, the program was able to fund ten of the 12 faculty/student project applications to provide summer stipends of $7,500 for undergraduates.
- The Young Environmental Scholars Conference (YES) brought together 85 environmental researchers from across Stanford for innovative dialogue and productive collaboration around the themes of environmental science, policymaking, and behavioral studies. The conference exposes master's and early-stage doctoral students to different aspects of environment-related research and engages later-stage doctoral students and post-doctoral scholars in discussions about interdisciplinary approaches to research problems and initiating collaborations.

Woods at 15!

The Stanford Woods Institute for the Environment celebrated 15 years of catalyzing environmental knowledge and solutions with a panel (see photo top left) reflecting on the institute's early days and the many strides taken since then. We're so grateful to the Woods Advisory Council and our other core supporters who have worked with Woods fellows, staff and students to forge a vibrant new model for interdisciplinary collaboration and innovative problem solving.

Photos clockwise from top right: 1) Noah Diffenbaugh (L), Christine Gardner and Akiko Yamazaki; 2) Ward Woods (L), Pricilla Woods; 3) Hal Mooney (L) and Rob Dunbar; 4) (L), Desiree LaBeaud and Christine Gardner.

Clockwise from Above: 1) (L-R) Chris Field, Joan Lane, Nona Chiariello and Fio Micheli; 2) (L-R) Buzz Thompson, Jeff Koseff and Chris Field; 3) Matt Barger (L) and Jim Fleming; 4) Ann Arvin; 5) Matt Higgins (L) and Pete Higgins; and 5) Jim Leape, Suki Hoagland and Kam Moler.

Research Centers & Programs

The Stanford Woods Institute for the Environment supports strategic research centers and programs designed to tackle major environmental challenges facing the planet. These interdisciplinary initiatives leverage Stanford's particular strengths to solve cross-cutting sustainability challenges at the intersection of climate change, food security, freshwater, and public health and the demands of a growing population on the natural systems that support life on Earth. To follow are selected 2018-19 highlights and publications from our hosted research centers and programs.

Program for Disease Ecology, Health and the Environment (DEHE)

DEHE, a joint initiative with Stanford's Center for Innovation in Global Health, draws on Stanford experts in public health, ecology, engineering, computer science, medicine and the social sciences to discover ecological solutions to humanity's health challenges and to develop the

DEHE leads Sanna Sokolow and Giulio DeLeo conduct field research.

next generation of planetary health innovators. In 2018-19, the program's work focused on the tropical disease schistosomiasis and its transmission through snails and local water sources in Northern Senegal. DEHE researchers continued their examination of ecological interventions to prevent and manage pathogens transmitted between animals and humans, understanding local perspectives in Northern Senegal on water contact behavior for controlling schistosomiasis, how prawn aquaculture impacts poverty alleviation and schistosomiasis control, how emerging human infectious diseases are linked to global food production, and how fishes in the lower Senegal River basin may help control schistosomiasis by preying on the disease-carrying snails and parasites. The program is also focused on broader communication of science to the through published research, curriculum development and efforts to expand the scope and coordination of human and planetary health research.

Faculty Director: **Giulio De Leo**

ecohealthsolutions.stanford.edu/

Highlights

- Joined with Stanford Office of Science Outreach and Silicon Valley nonprofit Ignite to expand a K-12 outreach program including development of a Planetary Health curriculum specifically oriented to middle school students and instructors.

- Partnered with Stanford's Natural Capital Project—the recipient of DEHE's first faculty-led mini-grant of $25,000–for a feasibility study and prototyping for the development of software modules to assess health risk associated with the construction of water management infrastructure in tropical and sub-tropical countries, with specific focus on malaria and schistosomiasis.
- Initiated study of the relationship between health care, rainforest conservation and human well-being and to evaluate the impact of a related 10-year program in Borneo, with follow-on support from Stanford Center for Innovation in Global Health.

DEHE Publications

Habitat area integrates over spatial and temporal variability in snail abundance to predict human urinary schistosomiasis burden. *Proceedings of the National Academy of Sciences*

Ecological interventions to prevent and manage zoonotic pathogen spillover. *Philosophical Transactions of the Royal Society B*

Unavoidable Risks: Local Perspectives on Water Contact Behavior and Implications for Schistosomiasis Control in an Agricultural Region of Northern Senegal. *American Journal of Tropical Medical Hygiene*

Modelled effects of prawn aquaculture on poverty alleviation and schistosomiasis control. *Nature Sustainability*

Emerging Human Infectious Diseases and the Links to Global Food Production. *Nature Sustainability*

Potential biological control of schistosomiasis by fishes in the lower Senegal River basin. *American Journal of Tropical Medicine and Hygiene*

Center on Food Security and the Environment (FSE)

FSE, a joint effort with the Freeman Spogli Institute for International Studies, addresses the challenges of feeding the world's growing population without depleting the planet's natural resources. FSE's team of interdisciplinary scholars addresses global hunger, poverty and environmental degradation by generating vital knowledge and policy-relevant solutions. Scholars with expertise in economics, political science, biology, civil and environmental engineering, law, earth sciences, medicine, anthropology, education, and history are engaged in more than 20 research projects. They offer courses for graduate and undergraduate students interested in issues of hunger, rural development, global resource and environmental degradation, agricultural technology, climate impacts on food security, and agricultural trade and policy.

Faculty Director: **David Lobell**

fse.fsi.stanford.edu/

Highlights

- Made significant strides in a portfolio of research projects focused on sustainable palm oil development in Indonesia, climate impacts on agricultural production, data science applications, public health and fisheries and aquaculture management.
- Partnered with Stanford Center for Ocean Solutions to launch research initiative that tackles issues ranging from seafood's potential to provide more resilience in the overall food system to the role that fish typically used in animal feeds could play in solving micronutrient deficiencies suffered by up to 3 billion people.
- Collaborated with FSI / FSE visiting scholar Ertharin Cousin, former executive director of the World Food Programme and U.S. ambassador to the UN Agencies for Food and Agriculture.

FSE Publications

The impact of a Solar Market Garden programme on dietary diversity, women's nutritional status and micronutrient levels in Kalalé district of northern Benin. *Public Health Nutrition*

A new spin on an old debate: Errors in farmer-reported production and their implications for inverse scale-Productivity relationship in Uganda. *Journal of Development Economics*

Predicting Economic Development using Geolocated Wikipedia Articles. *In Proceedings of the 25th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*

Smallholder maize area and yield mapping at national scales with Google Earth Engine. *Remote Sensing of Environment*

The role of irrigation in changing wheat yields and heat sensitivity in India. *Nature Communications*

Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences*

Climatic Constraints on Aggregate Economic Output. *National Bureau of Economic Research*

Air Pollution and Infant Mortality: Evidence from Saharan Dust. *National Bureau of Economic Research*

Selling low and buying high: an arbitrage puzzle in Kenyan villages. *Quarterly Journal of Economics*

Research Centers & Programs

Global Freshwater Initiative (GFI)

GFI is an interdisciplinary research effort that studies the long-term viability of freshwater supplies for people and the environment. The program focuses on developing and water-scarce regions throughout the world, and considers threats from climate change, shifts in land use, increasing population and decaying infrastructure. In 2018-19, GFI focused on freshwater vulnerability in a variety of water use sectors, with concentrated study on Jordan and India. The program has also continued to work on water resources in Colorado and ecohydrologic problems in Canada and globally.

Faculty Director: **Steven Gorelick**

globalfreshwater.stanford.edu

Highlights

- The program's Food-Water-Energy for Urban Sustainable Environments (FUSE) project analyzed food, water and energy competition in Pune, India and Jordan. The $2.4 million project is led by Gorelick and co-P.I. Roz Naylor with co-researchers in Germany and Austria.
- Jordan's Ministry of Water and Irrigation officially endorsed FUSE
- The GFI-led 2018 paper "Indigenous Communities, Groundwater Opportunities" downloaded more than 2,400 times (the abstract was downloaded more than 18,800 times).

GFI Publications

Water service programs do not materially enhance streamflow: Insights from watershed simulations around the world. *Global Environmental Change*

Food-water-energy for Urban Sustainable Environments (FUSE): Integrated Analyses Focused on Pune, India and Amman, Jordan. *AGU Fall Meeting*

The Hidden Value of Private Water Markets in Jordan: Simulating Spatial Price Equilibria in a Coupled Hydro-Economic Model. *AGU Fall Meeting*

Evaluation of Water Security in Jordan using a Multi-Agent Hydroeconomic Model: Climate, Crises, and Stability. *AGU Fall Meeting*

Natural Capital Project

Also known as "NatCap" this Stanford-led partnership pioneers science, technology, and partnerships to enable people and nature to thrive. NatCap works through purposeful engagement and uses cutting-edge science and technology to drive a global transformation toward inclusive, green growth. From Stanford, NatCap operates as a global partnership of influential actors in academia, conservation, government, development banks, private investment, and business. Their powerful network currently includes more than 50 research institutions and 200 implementing partners worldwide, allowing for direct engagements in over 60 countries and for their InVEST software platform to be used in an additional 125 countries.

Faculty Director: **Gretchen Daily**

naturalcapitalproject.stanford.edu/

Highlights

- NatCap convened nearly 400 attendees from more than 30 countries for its annual symposium, bringing together leaders from academia, NGOs, government, and private industry to highlight research innovation, discuss advances in practice, and together work toward a shared goal of a more sustainable, livable planet.

Participants from the 2019 Natural Capital Symposium.

- Expanded urban InVEST software models capable of mapping, measuring, and valuing nature's contributions to people in cities. The software suite now includes several additional models in beta testing, including urban cooling and flood risk mitigation. The team has been applying and testing these models in on-the-ground engagements in the San Francisco Bay Area, Minneapolis/St. Paul, Paris, and 5 cities in China.
- NatCap launched Green Growth That Works: Natural Capital Policy and Finance Mechanisms from Around the World. Edited by NatCap lead scientist Lisa Mandle and Gretchen Daily, the guide features more than 70 contributing authors from across the Natural Capital Project partnership. Made up of case studies and real-world examples, the book is designed to serve as a toolbox of proven techniques for planning and carrying out economic development that makes environmental sense.

NatCap Publications

Nature and mental health: An ecosystem service perspective. *Science Advances*

Deploy diverse renewables to save tropical rivers. *Nature*

Integrating fisheries management into sustainable development planning. *Ecology and Society*

The Geographic Spread and Preferences of Tourists Revealed by User-Generated Information on Jeju Island, South Korea. *Land*

The Value of US Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption. *Ecosystems*

Realizing the values of natural capital for inclusive, sustainable development: Informing China's new ecological development strategy. *Proceedings of the National Academy of Sciences*

Reimagining the Potential of Earth Observations for Ecosystem Services Assessments. *Science of the Total Environment*

Integrating fisheries management into sustainable development planning. *Ecology and Society, 2019*

Greenhouse gas footprints of palm oil production in Indonesia over space and time. *Science of the Total Environment*

Measuring What Matters: Actionable Information for Conservation Biocontrol in Multifunctional Landscapes. *Frontiers in Sustainable Food Systems*

Research Centers & Programs

Center for Ocean Solutions (COS)

COS catalyzes research, innovation and action to improve the health of the oceans for the people who depend on them most. Over 300 million people around the world depend on the oceans for their livelihoods, and over three billion people rely on oceans for food security. But oceans are in an era of upheaval, propelled by climate change, overfishing, coastal development, pollution and other stresses. The Stanford Center for Ocean Solutions (COS) is creating the innovations needed to sustain ocean health in the face of these threats —translating insights from research into solutions at scale for oceans and people.

Co-Directors: **Jim Leape, Fiorenza Micheli**

oceansolutions.stanford.edu/

Highlights:

- Through partnerships with FSE, Stockholm Resilience Centre, Springer Nature, EAT Foundation, World Economic Forum and World Resources Institute, COS created the "Blue Food Assessment." Launched in June 2019, the high-impact assessment aims to elucidate how aquatic foods contribute to nutrition, environment, equity and economic outcomes from local to global scales. Findings will be integrated into the upcoming 2021 UN Food Systems Summit.
- At the request of the President of Palau, COS and the Palau International Coral Reef Center convened an expert working group analyzing how best to implement a new marine sanctuary, while also achieving food security and economic development goals. The team presented their recommendations to the President and other key leaders in Palau in December.

- COS continues to lead efforts for the Friends of Ocean Action—a group of leaders convened by the UN and World Economic Forum—focused on accelerating action on illegal fishing through data technology, supply chains and policy efforts. In 2019, COS worked with 14 heads of state and the 10 largest seafood companies to secure a commitment by the G20 governments to close the net on illegal, unreported and unregulated (IUU) fishing.
- COS partnered with Georgia Tech, Scripps, Monterey Bay Aquarium, Monterey Bay Aquarium Research Institute and the Smithsonian Ocean Portal to hold the first-ever Oceans Visions Initiative Summit. The scientist-driven ocean solutions venture aims to foster collaboration between top researchers, conservationists and entrepreneurs committed to solving some of the biggest challenges facing ocean health.

COS Publications

Marine protected areas lower risk of abalone fishery collapse following widespread catastrophic mortality events. *The American Naturalist*

Quantifying coconut palm extent on Pacific islands using spectral and textural analysis of very high-resolution imagery. *International Journal of Remote Sensing*

Prioritizing reef resilience through spatial planning following a mass coral bleaching event. *Coral Reefs*

Incorporating change in marine spatial planning, a review. *Environmental Science and Policy*

Chemistry of the consumption and excretion of the bumphead parrotfish (Bolbometopon muricatum), a coral reef mega-consumer. *Coral Reefs*

Recent pace of change in human impact on the world's ocean. *Scientific Reports*

Modelled effects of prawn aquaculture on poverty alleviation and schistosomiasis control. *Nature Sustainability*

Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services. *IPBES*

Bridging climate science, law, and policy to advance coastal adaptation planning. *Marine Policy*

Remote sensing of three-dimensional coral reef structure enhances predictive modeling of fish assemblages. *Remote Sensing in Ecology and Conservation*

Ending Illegal Fishing: Data Policy and the Port State Measures Agreement. *World Economic Forum*

Osa & Golfito Initiative (INOGO)

Rapidly developing regions around the world need thoughtful plans to ensure sustainable futures. The Osa and Golfito Initiative—known by its Spanish acronym INOGO—is an effort to support sustainable human development and environmental stewardship in Costa Rica's Osa and Golfito region through work with local communities, government, the private sector and nongovernmental organizations. The goal is to generate a living process for sustainable development led by stakeholders in the region. INOGO programs have continued their development with the aim of providing critical tools and analyses to inform sustainable development in Costa Rica.

Faculty Directors: **Rodolfo Dirzo, William Durham, Larry Crowder**

inogo.stanford.edu/

INOGO faculty co-director Rodolfo Dirzo works with student researchers in Costa Rica.

Highlights:

- INOGO's Experimental Sustainable Palm Laboratory—which studies the ecological processes and productivity of moving away from typical monoculture style palm oil plantations—has recovered from devastating 2017 storm damage and is producing useful data for both Stanford-led and collaborator studies. Its plots of palms interspersed with other plants are in full bloom moving the project forward into an exciting phase of data production.
- The Stanford Environmental Leadership and Language Program (SELAL), developed by Stanford in collaboration with local leaders, is in the final stage of transitioning to operation by a local Costa Rican organization. The SOMOS Foundation has assumed the leadership for SELAL, and local staff will transition over the next few years from engagement with Stanford to working with the SOMOS Foundation.
- DynaMAR—Dynamic Marine Animal Research—a project using satellite tags to improve management and conservervation of protected species in recreational and commercial fisheries—has made progress tagging 33 marlin and 14 sailfish, in addition to exploring historical data from past tagging efforts and fishing reports.

Photo by Matthew Rissel

Research Centers & Programs

Program on Water, Health & Development (WHD)

WHD focuses research activities on water's role in advancing global health and well-being, pursuing topics such as sustainable infrastructure, wastewater management, urban stormwater treatment and health and hygiene education. Current research projects engage more than 17 faculty and student researchers in the field, spanning several countries including Zambia, Uganda, Fiji, India, Ghana, Indonesia and local sites in the Bay Area. The team continues to expand its global collaborations, participating in strategic planning sessions and workshops with international organizations, government officials and practitioners also committed to addressing global water challenges.

Highlights:

- WHD researchers partnered with World Vision and Sesame Workshop on WASH UP! Zambia to evaluate the impacts of combined infrastructure and education interventions on the knowledge and health of young schoolchildren. The curriculum was found to have a strong positive impact on children's knowledge of the connections between water, sanitation and health, though changes were often inhibited by lack of latrine functionality.
- Efforts supporting the Conrad N. Hilton Foundation Safe Water Strategy Measurement, Evaluation and Learning continued with a focus on developing practical tools and methods to use.WHD supported the Millennium Water Alliance's Ethiopia program by designing and developing a problem diagnosis and response workshop with participants from health facilities, NGOs and officials from North Mecha. Jenna Davis also attended Stockholm Water Week, where she presented this work as part of a session on "Reaching the Most Vulnerable Sustainably."

WHD students, research staff and partners for the Uganda rural water maintenance project. Credit: Dan Smith

- Davis and PhD candidate Dan Smith launched a cluster randomized controlled trial of professionalized preventative maintenance services for rural water hand pumps in northern Uganda, in partnership with the NGO International Life Fund and social enterprise WellDone. Davis and Smith are conducting a trial that quantifies both the effective demand for improved water point reliability and the fiscal and economic benefits of the service.

WHD Publications

Effect of in-line drinking water chlorination at the point of collection on child diarrhea in urban Bangladesh: a double-blind, cluster-randomised controlled trial. *Lancet Global Health*

Age-related changes to environmental exposure: variation in the frequency that young children place hands and objects in their mouths. *Journal of Exposure Science & Environmental Epidemiology*

Broad approaches to cholera control in Asia: Water, sanitation and handwashing. *Vaccine*

Sanitation for Low-Income Regions: A Cross-Disciplinary Review. *Annual Review of Environment and Resource*

Systematic review and meta-analysis of decay rates of waterborne mammalia n viruses and coliphages in surface waters. *Water Research*

Predictors of Enteric Pathogens in the Domestic Environment from Human and Animal Sources in Rural Bangladesh. *Environmental Science & Technology*

Achieving Gender and Social Equality More Than Gender Parity is Needed. *Academic Medicine*

The WASH Benefits and SHINE trials: interpretation of WASH intervention effects on linear growth and diarrhea. *Lancet Global Health*

Water in the West (WitW)

A joint program with Woods and Stanford's Bill Lane Center for the American West, develops and promotes solutions to key water questions in the West, including better groundwater management, more sustainable urban water use and use of markets to help western states cope with water scarcity. The program strives to bridge the gap between research and practice. Its work in urban water has spurred ideas about how communities can use innovative finance techniques and create resilient water portfolios. The program also continues to investigate water transactions in the Colorado River Basin and explore the nexus of water management and ecosystem services in partnership with the Natural Capital Project (NatCap).

Faculty Director: **Barton "Buzz" Thompson**

waterinthewest.stanford.edu

Highlights

- WitW launched a western water dashboard entitled "License to Pump" in May 2019. The dashboard is a state-of-the-art toolbox for understanding how different states approach groundwater permitting. It was created for a broad audience interested in learning more about groundwater withdrawal permitting and intended to inform policymakers currently in the process of writing Groundwater Sustainability Plans under California's Sustainable Groundwater Management Act.

Groundwater pumping permitting is studied in WitW's "License to Pump" project.

- WitW researchers Newsha Ajami and Kimberly Quesnel teamed up with the Spatial Sciences Institute at the University of Southern California to examine the effectiveness of irrigation on urban green space during periods of climate-induced drought. Using water use and remote sensing data of properties in Redwood City, California before and during the state's 2012-2016 drought, their analysis focused on commercial, industrial and institutional customers irrigating with recycled or potable water. The team found that under extreme climatic stress, even with consistent irrigation, vegetation may not be able to thrive and that solutions such as shifting to climate-appropriate landscaping, creating more shaded areas, implementing drip irrigation and nighttime watering are helpful water management practices. These findings provide important insights for efficient water conservation management as droughts become more frequent and severe due to a changing climate.
- WitW and NatCap scholars collaborated to assess the benefits of different rangeland management practices. The study investigated key processes governing the interactions between grazing and seasonal water yield using two models, NatCap's Rangeland Productivity Model and Texas A&M's Soil Water Assessment Tool.

WitW Publications

Managing Wastewater in a Changing Climate. *Public Policy Institute of California*

Mapping Saltwater Intrusion with an Airborne Electromagnetic Method in the Offshore Coast Environment, Monterey Bay California. *Journal of Hydrology: Regional Studies*

Reduced Moisture Transport Linked to Drought Propagation Across North America. *Geophysical Research Letters*

Modeling Land Subsidence Using InSAR and Airborne Electromagnetic Data. *Water Resources Research*

A Guide to Water Quality Requirements Under the Sustainable Groundwater Management Act. *Water in the West*

Shifting Landscapes: Decoupled Urban Irrigators and Greenness Patterns During Severe Drought. *Environmental Research Letters*

Tools for Assessing Groundwater-Surface Water Connectivity Under the Sustainable Groundwater Management Act. *Water in the West*

Fellows & Research Staff

Fellows

Nicole Ardoin, Senior Fellow | Graduate School of Education

Ines Azevedo, Senior Fellow | Energy Resource Engineering (SE3)

Jeremy Bailenson, Senior Fellow | Communication (H&S)

Michele Barry, Senior Fellow | School of Medicine

Eran Bendavid, Senior Fellow | School of Medicine

Sarah Billington, Senior Fellow | Civil & Environmental Engineering (SOE)

Alexandria Boehm, Senior Fellow | Civil & Environmental Engineering (SOE)

Marshall Burke, Center Fellow, by courtesy | Civil & Environmental Engineering (SOE)

Bruce Cain, Senior Fellow | Political Science (H&S)

Karen Casciotti, Senior Fellow | Earth System Science (SE3)

Craig Criddle, Senior Fellow | Civil & Environmental Engineering (SOE)

Larry Crowder, Senior Fellow | Hopkins Marine Station (H&S)

Lisa Curran, Senior Fellow | Anthropology (H&S)

Gretchen Daily, Senior Fellow | Biology (H&S)

Jennifer Davis, Higgins-Magid Senior Fellow | Civil & Environmental Engineering (SOE)

Giulio De Leo, Senior Fellow | Biology (H&S)

Noah Diffenbaugh, Kimmelman Family Senior Fellow | Earth System Science (SE3)

Rodolfo Dirzo, Senior Fellow, Biology (H&S)

Rob Dunbar, Senior Fellow | Earth System Science (SE3)

William Durham, Senior Fellow, Emeritus, by courtesy | Anthropology (H&S)

Paul Ehrlich, Senior Fellow, Emeritus, by courtesy | Biology (H&S)

Stefano Ermon, Center Fellow, by courtesy | Computer Science (SOE)

Wally Falcon, Senior Fellow, Emeritus | Freeman Spogli Institute for International Studies (DOR)

Scott Fendorf, Senior Fellow| Earth System Science (SE3)

Chris Field, Perry L. McCarty Director & Senior Fellow | Biology/Earth System Science

Chris Francis, Senior Fellow | Earth System Science (SE3)

David Freyberg, Senior Fellow | Civil & Environmental Engineering (SOE)

Steven Gorelick, Senior Fellow | Earth System Science (SE3)

Elizabeth Hadly, Senior Fellow | Biology (H&S)

Robert Jackson, Senior Fellow | Earth System Science (SE3)

Mark Jacobson, Senior Fellow | Civil & Environmental Engineering (SOE)

James Holland Jones, Senior Fellow | Earth System Science (SE3)

Don Kennedy, Senior Fellow, Emeritus | Biology (H&S)

Julie Kennedy, Senior Fellow, Emerita | Earth System Science (SE3)

Charles Kolstad, Senior Fellow| Stanford Institute for Economic Policy Research (SIEPR & DOR)

Alexandra Konings, Center Fellow, by courtesy | Earth System Science (SE3)

Jeffrey Koseff, Senior Fellow | Civil & Environmental Engineering (SOE)

Desiree LaBeaud, Senior Fellow | Pediatrics, MED

Eric Lambin, Senior Fellow | Earth System Science (SE3)

Jim Leape, Senior Fellow | Stanford Woods Institute for the Environment, (DOR)

Mike Lepech, Senior Fellow | Civil & Environmental Engineering (SOE)

Margaret Levi, Senior Fellow | Political Science & CASBS (H&S)

David Lobell, William Wrigley Senior Fellow | Earth System Science (SE3)

Stephen Luby, Senior Fellow, School of Medicine

Kate Maher, Senior Fellow, Earth System Science (SE3)

Pamela Matson, Senior Fellow, Earth System Science (SE3)

Meagan Mauter, Center Fellow, by courtesy, Civil & Environmental Engineering (SOE)

Mike McFaul, Senior Fellow, Political Science (H&S)

Fiorenza Micheli, Senior Fellow, Hopkins Marine Station (H&S)

Harold "Hal" Mooney, Senior Fellow, Emeritus, Biology (H&S)

Kari Nadeau, Senior Fellow, Medicine & Pediatrics, (SOM)

Rosamond "Roz" Naylor, Senior Fellow, Earth System Science (SE3)

Morgan O'Neill, Center Fellow, by courtesy, Earth System Science (SE3)

Kabir Peay, Senior Fellow, Biology & Energy Science Directorate (H&S/SLAC)

Erica Plambeck, Senior Fellow, Graduate School of Business

Aditi Sheshadri, Center Fellow, by courtesy, Earth System Science (SE3)

Debbie Sivas, Senior Fellow, Environmental Law Clinic (SLS)

Erik Sperling, Center Fellow, by courtesy, Geological Sciences, School of Earth, Energy & Environmental Sciences

Jenny Suckale, Center Fellow, by courtesy, Geophysics, School of Earth, Energy & Environmental Sciences

Sindy Tang, Senior Fellow, Mechanical Engineering, School of Engineering

William Tarpeh, Center Fellow, by courtesy, Chemical Engineering, School of Engineering

Barton H. "Buzz" Thompson, Senior Fellow, School of Law

Peter Vitousek, Senior Fellow, Biology, H&S

Gabrielle Wong-Parodi, Center Fellow, Earth System Science (SE3)

To view the full list of 64 Woods Fellows as well as our 204 affiliated Stanford faculty, visit: https://woods.stanford.edu/people/faculty-researchers

Research Staff

(Postdoctoral scholars and students are not listed. For listing of all Stanford researchers affiliated with the Institute, visit: https://woods.stanford.edu/people/staff

Newsha Ajami, Director of Urban Water Policy, Water in the West

Katherine Arkema, Lead Scientist, Natural Capital Project

Benjamin Bryant, Research Associate, Water in the West

Rebecca Chaplin-Kramer, Lead Scientist, Natural Capital Project

Susanne Sokolow, Executive Director, Program on Disease Ecology, Health & the Environment

Anne Guerry, Chief Strategy Officer & Lead Scientist, Natural Capital Project

Lisa Mandle, Lead Scientist, Natural Capital Project

Tara Moran, Research Associate and Program Lead, Water in the West

Mary Ruckelshaus, Managing Director, Natural Capital Project

Richard Sharp, Software Architect, Natural Capital Project

Adrian Vogl, Lead Scientist, Natural Capital Project

Michael Wara, Director, Climate & Energy Policy Program, Stanford Woods Institute

Leadership & Staff

Advisory Council

Ward W. Woods, ’64 – Chair

Priscilla B. Woods

Matt Barger, MBA ’83

Kelly Davis

James B. Fleming, Jr., ’84

Christine Gardner, ’88

Pete Higgins, ’80, MBA ’83

Patsy Ishiyama, ’74

Katharine Janeway, ’76

Paul Tudor Jones II

Bill Landreth, ’69

Joan Lane

Mel Lane (1922–2007), ’45, CRT ’78
(In Memoriam)

Robert Litterman

Franklin M. (“Lynn”) Orr, Jr., ’69

Daniel Oros, ’03

William J. Patterson (1966–2010), MBA ’89
(In Memoriam)

George Phipps, MBA ’91

Kristina Emanuels Phipps, ’91, JD ’98

Jay A. Precourt, ’59, MS ’60

Alison Wrigley Rusack, ’80

Cristián Samper

Varun Sivaram, ’11

Faculty Director

Christopher B. Field,
Perry L. McCarty Director

Associate Directors

Christine Black, Communications & Events

Patti Hines, Administration

Margaret Krebs, Leadership Programs

Lea Rosenbohm, External Affairs

Brian Sharbono, Programs

Luis Tam, Finance & Administration

Clare Wildenborg, Development,
Environment & Energy Institutes

2018–19 Annual Report

Editorial Staff

Christine Black, Creative Director/Editor

Rob Jordan, Writer

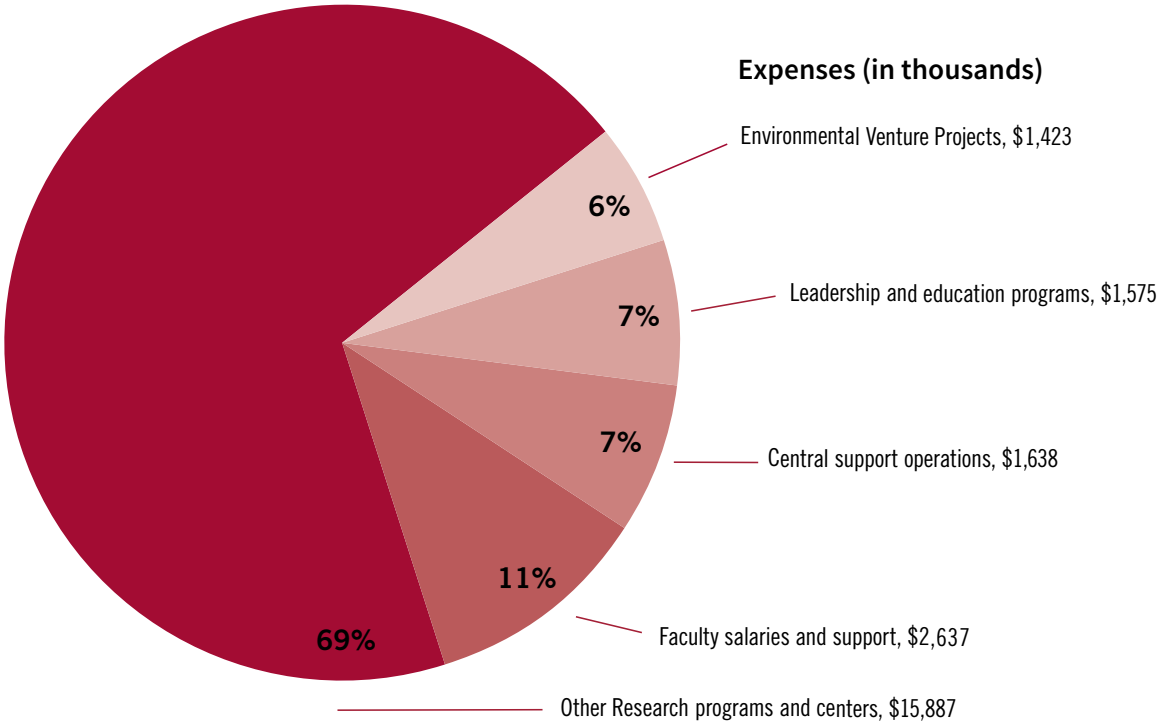
Isabella Tilley, Writer

Graphic Design

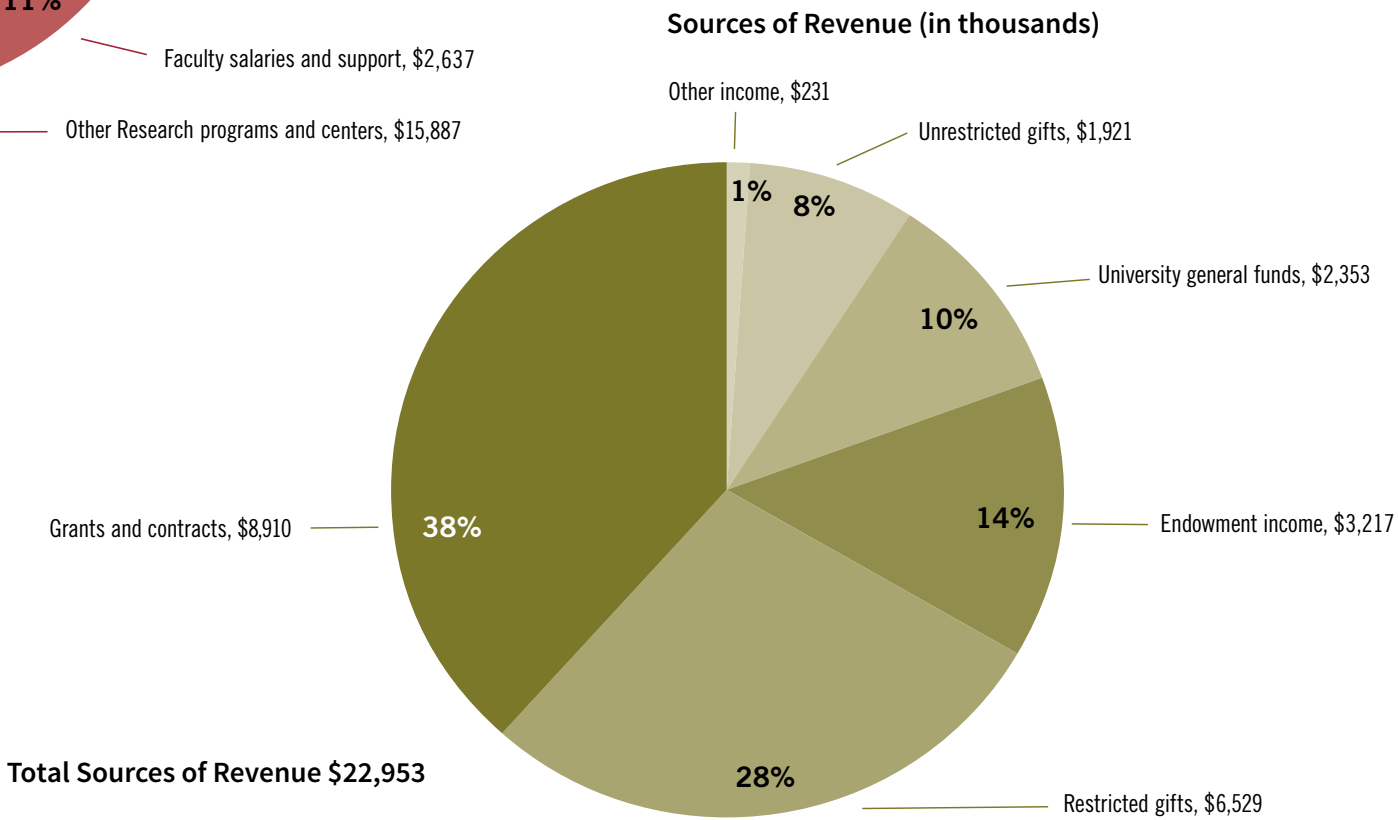
Cheri M. Arellano, Conscious Creative

Fiscal Year 2018-2019

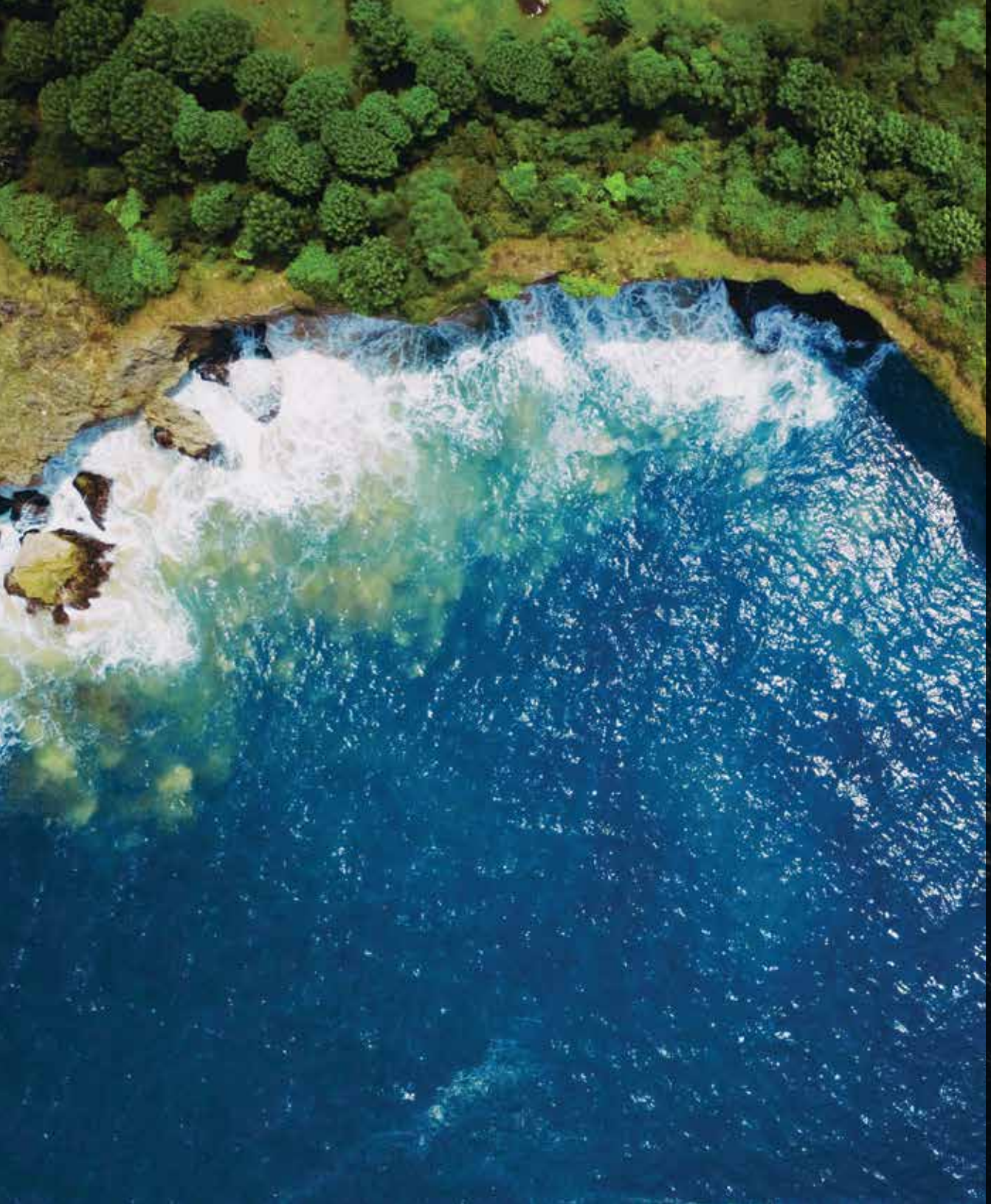
Sources of revenue which support the Stanford Woods Institute for the Environment in fiscal year 2018–2019 amounted to $23.2 million, of which 10 percent originated from university general funds, 14 percent from endowment income, 36 percent from gifts, and 38 percent from grants and contracts. Expenses during the fiscal year 2018 –2019 amounted to $23.2 million. Woods largest expenditure includes Environmental Venture Projects and other research programs and centers, totaling $17.3 million, or 75 percent of the institute's annual budget.



Total Expenses $22,953



Total Sources of Revenue $22,953



Stanford
WOODS
INSTITUTE *for the*
ENVIRONMENT

Jerry Yang & Akiko Yamazaki Environment & Energy Building—MC 4205

473 Via Ortega
Stanford, CA 94305

Phone: 650.736.8668
Fax: 650.725.3402

Email: environment@stanford.edu