



ANNUAL REPORT

2019-2020



Changing Climate, Weather Extremes

“Our research shows that global warming has increased the odds of record-setting hot events by about 80 percent across the globe, and doubled or even tripled the odds in the region of California and the Southwest that experienced extreme heat prior to the thunderstorms,” explained Kimmelman Family Senior Fellow **Noah Diffenbaugh**, after unusually intense August 2020 lightening sparked record setting fires across California. “By increasing the area burned by wildfire and the frequency of extreme wildfire conditions, global warming is also increasing the risk of the wildfires that produce harmful smoke conditions. In addition, although there are a lot of nuances to the air quality in any given location at a given time, our previous research suggests that global warming is likely to increase the kinds of air stagnation events that produce poor air quality, including over the western United States.”

Front Cover: Smoke from the CZU Lightning Complex fills the air over Stanford’s campus, similar to conditions affecting California after devastating wildfires in 2018 and 2019. **Credit: Andrew Brodhead/Stanford**

This page: Smoke blankets southern California skies during the 2018 Woolsey Fire. **Credit: iStock photo/Salameh Dibaei**

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).



A Word from Chris Field



In coastal oceans, strong currents moving in different directions can produce a maelstrom of dangerously swirling water. The past year has been one big maelstrom, with currents from the natural world, climate change, injustice, and politics colliding and swirling. It is not yet clear when or where the swirling stops, but if there is a single lesson from 2020, it is that we are all connected. The COVID-19 pandemic had its origins in human-wildlife interactions. Its breathtaking spread compellingly documents the connections among people around the world and, at least from an epidemiological perspective, the porosity of borders. Protests expressing revulsion about systemic racism spread even faster, circling the globe in days and uniting tens of millions in ongoing demonstrations for equality, diversity and institutional reform. Closer to home, the Bay Area's 30 consecutive "spare the air" days in August/September vividly confirmed the regional impacts of unprecedented fires. California's staggering experience with 2020 wildfires stands as a stark reminder that the climate crisis affects us all and that those of most responsible for causing it have a deep responsibility to act.

Those of us with the institute have all been working from home since March 13, and are fortunate we can continue our work without risking our health. Maybe everyone is tired of my Zoom background, but I am proud of the way the Woods community is delivering on its commitments, staying safe, and making a difference.

Events of 2020 put a giant exclamation point on the importance of our work. From documenting the changing occurrence of extreme fire weather to understanding the economic and political barriers that limit prescribed

burns, the institute's increasing focus on wildfire helps map pathways for reducing risk from an exploding problem that, with excruciating clarity, makes the point that impacts from the climate crisis are upon us now. Tracing the links between responses to the pandemic and greenhouse gas emissions provides insights into potentially useful as well as unacceptable options for future planned emissions reductions. In the same vein, using pandemic responses as probes for studying diverse aspects of Earth System function allows us to learn from this crisis and apply that knowledge to solutions in progress.

In addition to producing and sharing a staggering quantity of new research, the Woods community has played a major role in helping design Stanford's vision for a school focused on climate and sustainability, described in the May 26, 2020 announcement from Stanford President Marc Tessier-Lavigne. For all of us at Stanford who work on issues related to climate and sustainability, this expansive new vision for Stanford's sustainability work is a tremendous validation, but also a deep responsibility. It is validating to see the issues that have animated our work for decades come into crisp focus as a defining challenge of our era, and it is exhilarating to envision the progress that can come from a transformational investment.

It is frustrating to acknowledge that the challenges in climate and sustainability are classic "wicked problems" that are rapidly getting worse. Real progress will require a massive, coordinated effort across all segments of the university, the economy, government and civil society. All of us working with the institute are excited about the opportunity to contribute to the new era of climate and sustainability at Stanford.

Regards,

Chris Field

Perry L. McCarty Director

Seeking Pandemic Solutions

Stanford researchers have joined forces with colleagues around the world to intensify focus on pandemic-related research. While Woods scholars already were studying the intersection of pandemics, public health and the environment, many more have joined academia's collective pivot to COVID-19 research at this critical moment. Their efforts embody the spirit of collaboration and problem-solving at the heart of our mission. To ensure a sustainable future, we need the science to understand our trajectory, the analysis to understand our options and the innovation to develop practical solutions.

Woods-affiliated researchers have provided vital perspectives and data on various dimensions of COVID-19, ranging from disease transmission pathways to implications of unprecedented changes in human activity. Their work and Woods-hosted online events (see pages 15 and 16) have illuminated a host of scientific, health and policy dimensions of the current situation and the way forward.



Stanford researchers are studying effect of UV and sunlight on coronaviruses. Credit: iStockphoto

RESEARCH HIGHLIGHTS

Understanding COVID-19 Transmission

Much remains unknown about how SARS-CoV-2, the virus that causes COVID-19, spreads through the environment. [Alexandria Boehm](#), a professor of civil and environmental engineering (SOE) and Woods senior fellow, co-authored a viewpoint in *Environmental Science & Technology* calling for a broader, long-term and more quantitative approach to understanding viruses that spread through the environment. Boehm is also a principal investigator on a National Science Foundation-funded project to study the transfer of coronaviruses between skin and other materials, the effect of UV and sunlight on the coronaviruses, and the connection between disease outbreaks and virus concentrations in wastewater.

Modeling Social Distancing's Impact

How long does social distancing need to last? To explore this question and the consequences of lifting restrictions too early, Stanford biologist and Woods Center Fellow [Erin Mordecai](#) (H&S) developed an interactive website that models the spread of COVID-19 over time with different non-pharmaceutical interventions, such as social distancing and quarantine.



COVID-19 freeway sign in Ottawa. Credit: itooksomepics/Wikicommon/CC 4.0

The Energy and Environment Landscape After COVID-19

As people sheltered in place to slow the spread of COVID-19, daily carbon dioxide emissions dropped by as much as 17 percent globally, according to a study by the Global Carbon Project, an initiative led [Rob Jackson](#), the Michelle and Kevin Douglas Provostial Professor at the School of Earth, Energy & Environmental Sciences and a Woods senior fellow. Published in *Nature Climate Change*, the paper compiles government policies and activity data to pinpoint where energy demand dropped off the most and to estimate the impact on annual emissions.

COVID-19 Opportunities

Like the legendary falling apple that hit Isaac Newton and led to his groundbreaking insight on the nature of gravity, COVID-19 could provide unintended glimpses into how complex Earth systems operate, according to a paper led by [Noah Diffenbaugh](#), the Kara J Foundation Professor at Stanford's School of Earth, Energy & Environmental Sciences and the Kimmelman Family Senior Fellow at Woods. The perspective, published in *Nature Reviews Earth & Environment*, hypothesizes outcomes of unprecedented changes in human activity wrought by worldwide sheltering orders, and outlines research priorities for understanding their short and long-term impact on the global economy, food security and other sectors.

Read more about these projects and find other resources related to COVID-19, the environment and public health at: woods.stanford.edu/pandemic-experts-and-resources

Seeking Pandemic Solutions

RESEARCH INTERRUPTED

Like their colleagues around the world, Stanford researchers are working through the pandemic's disruptive effects on their fieldwork, collaborations and teaching. We asked Woods fellows Giulio De Leo (H&S), Erin Mordecai (H&S) and Rob Jackson (SE3) about adapting to a new research landscape shaped by COVID-19.

“More than anything else, the pandemic has made me realize how lucky I am. That’s a blessing.”

—Rob Jackson

How has the pandemic and related shut-downs affected your work, specifically your field research?

Rob Jackson: The pandemic has ground field work and hiring to a halt. I've been especially concerned about students trying to complete their graduate degrees.

Erin Mordecai: We had planned to start field work in Costa Rica this past summer, to investigate the relationship between land use change,



Erin Mordecai

diversified agriculture, socio-ecological practices and dengue disease transmission. We had also planned to survey populations of the western tree hole mosquito and its naturally occurring ciliate parasite up and down the West Coast of the U.S. and British Columbia, which was postponed. At the

same time, since much of our research is computational, we were able to continue that work relatively uninterrupted.

Giulio De Leo: Our research currently includes research sites in Senegal, Cote d'Ivoire, Madagascar, Borneo, Brazil and Baja California. All our field activities have been shut down, with some exceptions when the local field team can still be operational and conduct planned work. We did gather a huge quantity of data in previous years which keep us busy, while we are waiting to go back in the field.

What about conferences and other contact and collaboration with colleagues?

Rob Jackson: We're all learning. Our annual meeting for the Ecological Society of America in August had 4,000 virtual attendees. Everyone taped their talks, with some live slots for Q&A. It worked surprisingly well. Going virtual has also made it easier to engage international colleagues. For the Global Carbon Project that I chair, we canceled our annual meeting in Australia, and held a series of shorter virtual meetings in June. They worked really well.

Giulio De Leo: We already had lots of international collaborations before the shutdown



Giulio De Leo

and published great papers emerging from virtual working groups with co-authors we never met personally, therefore we were already quite

proficient in coordinating collaborative work via Zoom. While this has escalated dramatically as the only way of interaction, we just continue to do it with renewed enthusiasm.

Has there been any silver lining from this time in terms of your work?

Giulio De Leo: I think we all realized that we can accomplish the same or more with much less travelling, considerable saving as for flying and lodging, a much smaller carbon footprint and spending more time with our local community and family.

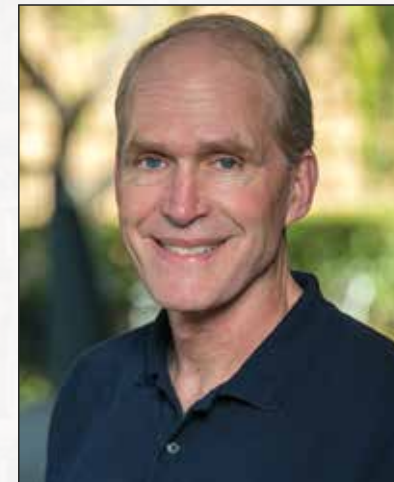
Erin Mordecai: Since our lab works on the ecology of infectious diseases, we've had an opportunity to apply our epidemiological modeling skills to try to help the pandemic response. Our COVID-19 modeling research has led to two preprints that are under review plus three additional and a supplemental grant from the National Institutes of Health. I've had opportunities to communicate in the media and with the public about the benefits of non-pharmaceutical interventions for slowing the spread of COVID-19.

Rob Jackson: I've had more time to plan, especially while finishing my sabbatical this year at CASBS, Stanford's behavioral sciences institute. I've signed a book contract with Penguin and am working to found a company.

Has the pandemic altered your research perspective or reaffirmed your focus?

Giulio De Leo: It has reaffirmed and strengthened my conviction that planetary health is a crucial concept. It has made clear that what happens on the other side of the world should matter to us, and that human health is linked to environmental health.

Erin Mordecai: I have started working on more applied questions around human disease, such as how to best estimate epidemiological parameters and dynamics from "noisy and messy" data, and how to model social distancing and COVID-19 transmission. At the same time, we've shifted focus on computational projects while pausing field-based projects.



Rob Jackson

Rob Jackson: More than anything else, the pandemic has made me realize how lucky I am. That's a blessing.

Earth Day Future 50

During the pandemic's early days, we gathered online with more than 600 faculty, students and friends to mark the 50th anniversary of Earth Day. Our virtual celebration, "Earth Day Future 50," featured a multi-generational group of Stanford alumni looking forward to the next 50 years of environmental innovation and leadership. Among them was Denis Hayes, '69 J.D. '85, who organized the first Earth Day in 1970. Hayes and other guests on the call—ranging from Stanford's president to faculty who remembered the first Earth Day on campus to current students—reflected on how far we have come on addressing pressing environmental challenges and how far we have yet to go.

"We are one planet, and we've got to address these things as a planet,"

– Stanford alumnus Denis Hayes, organizer of the first Earth Day



Photos from bottom left: Dennis Hayes; Campus coverage of the first Earth Day; Mark Tessier-Lavigne; Chris Field, Ken Alston, Molly Morse and Terra Weeks; Olivia Ames and Perry McCarty; Students shared Earth Day reflections in a video.



A panel moderated by Woods Director Chris Field, Ph.D. '81, discussed various mechanisms for positive change in the environment and energy space, and featured Stanford alumni Ken Alston, M.B.A and M.S. '12, Director of Mobility and Energy Storage, New Energy Nexus and CalCEF Ventures; Terra Weeks, M.S. '17, Senior Advisor to California Energy Commission Chair David Hochschild; and Molly Morse, M.S. '04 Ph.D. '09, CEO of Mango Materials, a startup company that uses methane to manufacture biodegradable substitutes for plastic. The event also featured a discussion between Perry McCarty, Silas H. Palmer Professor, emeritus, who was at the first Earth Day at Stanford in 1970, and Olivia Ames, '21, an undergraduate and Woods communications intern who studies sustainable agriculture and environmental justice.

Stanford President Marc Tessier-Lavigne reaffirmed the university's commitment to environmental stewardship and discovery. "Fifty years after the first Earth Day, Stanford is committed to ensuring a sustainable future," Tessier-Lavigne said, detailing major contributions Stanford has made and plans to build on through its long-range plans for sustainability.

The event concluded with reflections on Earth Day from Stanford students, faculty and audience members in light of the global pandemic and hopes for the next 50 years. This event was the first of many planned over Stanford's Earth Week, including a virtual panel on climate resiliency, a film screening and virtual lab tours.

Watch a video with Best Wishes for the Earth from Stanford students, faculty and staff:

<http://bit.ly/SUEarthDay50>



"We can establish policies to seed markets, help scale new technologies that allow for further breakthroughs, and help us push policy further,"

– Terra Weeks, M.S. '17, Senior Advisor to California Energy Commission Chair David Hochschild

Catalyzing Research

As extreme events become more severe and countries around the world battle a deadly pandemic, the need for solutions-oriented research is as urgent as ever.

Stanford researchers are pursuing the data, technologies and partnerships to meet momentous challenges ranging from wildfire (see inset) to the environmental drivers of disease. The institute supports their efforts by fostering interdisciplinary collaborations, convening experts across sectors, and driving innovation through strategic investments in research with the potential to move us closer to sustainability.

In addition to vanguard research centers and programs, Woods seed grants from Environmental Venture Projects (EVP) and the Realizing Environmental Innovation Program (REIP) enable cross-disciplinary exchange and allow researchers to take risks in order to achieve practical, real-world impact.

Since EVP began in 2004 and REIP began in 2015, the Stanford Woods Institute has awarded more than \$17 million in grants to 112 research teams, which has generated more than \$60 million in follow-on funding. These programs empower Stanford researchers to pursue transformative discoveries, collaborate with local stakeholders, and link research to action.

2019–20 HIGHLIGHTS

- **Mapping Disease: Schistosomiasis**, a disease that impacts over 200 million people globally, is caused by a parasite carried by freshwater snails. Aided by a 2018 EVP grant, researchers at Stanford's Program for Disease Ecology, Health and the Environment in collaboration with other institutions showed how to better target snail control efforts. Looking at northwestern Senegal, the study found small-scale interventions can suppress transmission, but removing snails would be too inefficient. The team instead focused on easy-to-measure environmental proxies like snail habitat proved more effective than snail variables at predicting human infections. The findings were published



in the Proceedings of the National Academy of Sciences. This work shows the potential of using satellite- or drone-based precision mapping to identify high-transmission areas.

- **Pro-Environment Marketing for Cigarettes:** The cigarette brand Natural American Spirit has grown in popularity and marketed itself as natural and eco-friendly. With funding from a 2017 EVP grant, Stanford researchers studied whether the brand's messaging influenced adolescents' understanding of its health implications. The team found that adolescents perceived a health advantage for this brand of cigarettes because of the on-the-pack marketing as eco-friendly and pro-health. These findings, published in the Journal of Adolescent Health, fit with previous studies the team conducted showing the same impact on adult perception. With consumer misperceptions being found again and again regarding the false assumption of eco-friendly and healthy cigarettes, the researchers argue that eco-friendly messaging on cigarettes is a concern for public health and should be under consideration for regulatory intervention.
- **Monitoring Water Demand:** Managing demand for water is important for utilities trying to cope with population growth and climate change. Research suggests that consumer demand for water changes based on media

coverage of droughts, political responses to extreme events and other external factors but it is hard for utilities to predict their influence. Stanford researchers, enabled by a 2017



EVP grant, created a consumption change detection method that pinpoints the timing and magnitude of customer-

level water use shifts, allowing to see the effects of climate-related mass media and policy events. In times of water scarcity, this novel demand analysis tool can help water managers understand the influence that external social, political, and climatic stressors have on customer behavior.

• **Dynamic Norms and Eating Less Meat:**

Animal farming and livestock produces about 15% of all greenhouse gas emissions worldwide and is a significant contributor to global warming. Encouraging people to eat less meat could make a difference in lowering emissions from this sector, but getting people to change their behavior is not an easy task. With funding from a 2017 EVP grant, Stanford researchers tested an approach called “dynamic norm messaging” where people are informed that

others were already beginning to eat less meat. Using messaging on menus across 9 separate online and field experiments, the approach plays on the social nature of human beings and the will to keep up with trends. The team found a simple message, which has essentially zero cost, resulted in a positive bump in vegetarian meal preferences and purchases.

• **Drying Landscape and Habitat**

Degradation: Muskrats are on the decline in their native ranges in the Peace–Athabasca Delta in Canada. Using satellite data, trapping and population survey records, and ecological field studies, Stanford researchers developed models to show that drying of the landscape over decades has diminished the muskrat’s shoreline habitat, and inter-annual habitat deterioration was caused by excessive plant feeding by muskrats and exacerbating their die-off. The study, with funding by a 2016 EVP grant, shows how climate and ecological factors contribute to rapid species decline and die-off.

These are just some of our community’s research outcomes in 2019–20. For a deeper look, read the 2019 Stanford Environmental Research Year-in-Review or visit our website: <https://woods.stanford.edu/news/evp-news>

Wildfire Research



After decades of fire suppression, climate change, and development in the wild-land urban interface, California’s forests have become a matchbox. In

recent years, wildfires have killed hundreds of people, destroyed thousands of homes and cost billions of dollars in societal losses. With expertise in engineering, ecology, climate science, social science, public health, and policy, the Stanford Woods Institute fellows, affiliates and researchers are working on new technologies, mapping, prediction, management and policy innovations to address wildfire in California and beyond. Teams of researchers across the university are focused on fire retardant gel to prevent ignitions, mapping wildfire risk with remote sensing data, understanding the health impacts of wildfire smoke, and other solutions targeted at reducing risks from wildfires.

Visit wildfire.stanford.edu to learn more.

Compelling Conversations

A HUB FOR DIALOGUE

Innovative solutions often start with simple conversations. That's why fostering dialog between scholarly experts, practitioners and audience members is central to our cross-cutting series of in-person and online events. Over the past year, we pivoted from bringing well-known environmental leaders and scholars to campus to hosting a series of virtual events focused on topics ranging from the 50th Anniversary of Earth Day (see p. 8–9) to wildfire preparedness and pandemic recovery. These inspiring dialogs connect members of our community across disciplines and sectors for wide-ranging, informal conversations exploring the 'who, how, and why' behind major developments in environmental science and policy.



Conversation with David Beasley:

“Think about the big, big picture. Don't get too distracted by the small things.... Follow your heart, love your neighbor, that's the most powerful weapon on Earth and it starts... with your friends and your family. That's the most important thing.”

–**David Beasley**, executive director of the U.N. World Food Programme, speaking at Stanford Oct. 1, 2019.

Recap: <https://stanford.io/34Ouz4M>



Conversation with Katharine Hayhoe:

“To be somebody who cares about a changing climate, the only thing we have to be is somebody who lives on this planet, who cares about ourselves, our family, our friends, our community, our neighbors, people we know, the natural environment.”

–**Katharine Hayhoe**, director of the Climate Science Center at Texas Tech University, speaking on campus Oct. 7, 2019.

Recap: <https://stanford.io/38Tl5DY>



Conversation with Eric Lambin:

“It’s great that we still get enthusiastic about solutions, but at some point we need some reality checks and we need to make sure that people don’t lose sight of what the real challenge is with emissions.”

–**Eric Lambin**, professor, Stanford School of Earth, Energy and Environmental Sciences speaking on campus Feb. 19, 2020.

Recap: <https://stanford.io/3bdVg40>



Building Back Community Resilience:

“The importance of social network and social cohesion is so critical. A lot of times our communities are the first responders. When it comes to building back resiliently, we have to invest in the people infrastructure.”

–**Jalonne White-Newsome**, senior program officer at the Kresge Foundation, speaking online May 21, 2020.

Recap: <https://stanford.io/2YGDCJU>



Wildfire Preparedness:

“Almost every part of California is vulnerable to wildfires in some form or another... When we think about building new communities we need to think about if wildfires are going to be worse in 50 years than they are now.”

–**Kelly Martin**, Board Member of the International Association of Wildland Fire and former Chief of Fire and Aviation Management at Yosemite National Park, speaking online July 14, 2020.

Recap: <https://stanford.io/30qTMQm>

Advancing Decisions

Connecting Stanford researchers with the policy community has taken on new urgency in the COVID-19 era. Decision-makers and practitioners are looking for guidance on immediate responses, as well as insights into how the current crisis can inform climate change solutions.

We've been meeting the increased demand for data, analysis and experts with a stepped-up schedule of briefings offered online to audiences that have more than tripled in numbers.

When combined with Woods-generated research briefs, private briefings and Twitter chats, these outreach activities facilitate an exchange of ideas and knowledge linking Stanford to leaders, stakeholders and other experts working in Sacramento and Washington, D.C., as well as organizations and agencies addressing environmental challenges around the globe.

In order to leverage Stanford expertise most effectively, our policy and engagement staff cultivates key relationships within government, industry and nongovernmental organizations. They stay current on major issues and topics of interest in the environmental and energy space, and keep Stanford faculty up to date on new legislation and funding opportunities.

Below are highlights from the institute's work with Stanford researchers to connect Stanford environmental findings and discoveries with those who can use them.

2019-20 HIGHLIGHTS

- **House Select Committee on the Climate Crisis Report:** The institute's policy and engagement team has been in close



Panelists discussed links between pandemic response and climate preparation during our 8/26 webinar.



communication with staff at the U.S. House of Representatives Select Committee on the Climate Crisis, serving as a resource for information on science and policy matters.

In June, the committee published a report, "Solving the Climate Crisis: The Congressional Action Plan for a Clean Energy Economy and a Healthy, Resilient and Just America." The report referenced a body of research produced by Woods Institute affiliates and fellows focused on understanding the costs of climate change-related economic damages and the potential economic benefits of mitigation and adaptation policies.

- **Forestry in the Climate Solutions Portfolio:** In the first installment of the Stanford Environment & Energy series to move online after the pandemic, Woods Senior Fellow Rob Jackson (SE3) joined leading experts from Resources for the Future, the Earth Innovation Institute and the World Wildlife

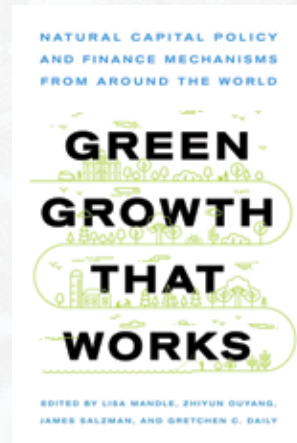
Fund for Nature in a panel discussion on the role of trees and forests in the climate solutions portfolio. The panel focused on what opportunities and challenges exist for expanding forests to capture and offset carbon emissions. Interest in the panel led to a subsequent invitation for panelists to privately brief members of the Edison Electric Institute, the association of U.S. investor-owned electric companies. The briefing included representatives from the Pacific Gas and Electric Company.



Clockwise: Chris Field, Margaret Levi, Inês Azevedo, Rob Jackson

• **Bringing Green Growth That Works to Washington:**

Last fall, Woods staff coordinated briefings for Natural Capital Project editors of the book *Green Growth That Works in Washington, D.C.* Stanford scientists Gretchen Daily, Lisa Mandle and Mary Ruckelshaus briefed congressional staff on practical conservation policy and finance



tools described in the book. The group discussed examples of successful programs within the United States and ways to protect coastlines, secure clean water and benefit urban populations by investing in natural capital. Legislative staff were particularly interested in nature-based solutions within cities, as well as the equity and inclusivity components of green growth. The Capitol Hill briefing was followed by a public panel at the National Press Club where the group was joined by Alvaro Umaña

Quesada, Director of the Environmentally Sustainable Development Group at the United Nations Development Programme. The panel highlighted new frontiers for valuing nature in decision making, and discussed opportunities to mainstream natural capital-based approaches within development banks and government agencies.

• **Building Back Resiliently:** Stanford Earth faculty Gabrielle Wong-Parodi, Jenny Sukale and Chris Field addressed the pandemic's impact on federal and state spending priorities in a May webinar joined by Jalonne White-Newsome, Senior Program Officer at the Kresge Foundation. Their discussion examined how federal spending to aid economic recovery from the COVID-19 pandemic might also help communities build greater resiliency to withstand future catastrophic events, such as those predicted from climate change. Discussion focused on issues relevant to communities that disproportionately bear the burden of these impacts, but are least prepared to deal with them. Involving affected communities in the decision-making process around management and preparation for disasters is critical to long-term success, panelists agreed.



• **Strategic Investments in Wildfire**

Preparedness: In advance of the increasingly deadly and destructive wildfires consuming Northern California, the institute hosted a discussion exploring how federal, state and local fire agencies can balance wildfire prevention and response under resource constraints. The discussion featured a panel of Stanford environment, health and policy scholars in conversation with Kelly Martin, board member of the International Association of Wildland Fire and former Chief of Fire and Aviation Management at Yosemite National Park.

They also focused on enhancing resilience and ensuring high-priority cost effective programs are funded in the future. Engagement in the webinar was so robust that dozens of questions remained unanswered by the end, providing the basis of a follow-up #wildfireprep Twitter chat Woods staff convened for the panel.

• **Learning from Pandemic Response:**

Global warming may unfold over a longer time horizon than the COVID-19 pandemic, but its impacts are expected to be similarly disruptive in scale. Woods joined with the Center for Advanced Study in the Behavioral Sciences in August to explore

how COVID-19 response can inform climate change preparedness. Woods Senior Fellows Rob Jackson (SE3), Inês Azevedo (SE3) and Margaret Levi (H&S) explored what interdisciplinary approaches drawing from economics, earth system and environmental science, behavior and decision-making science, and political science could help us better prepare for the future.

• **Fighting Illegal Fishing:** The illegal, unreported and unregulated (IUU) fishing industry makes up 20 percent of the world's catch and often uses bonded labor—a form of slavery—in addition to destructive and deceptive practices at the expense of local fisheries, coastal states and the environment. Center for Ocean Solutions researchers have been investigating the drivers and impacts of IUU fishing and paths forward to create a more sustainable ocean economy. An opinion piece by COS co-director Jim Leape published on the World Economic Forum's Agenda, addressed illegal fishing in the Pacific and its impacts on local and global economies, ocean health and resources, and human safety.

After discussing the egregious human rights violations and illegal activity connected to IUU fishing on the high seas, Leape pointed

to technological advances, such as Global Fishing Watch, which can track vessels from space, and industry efforts to screen illegal fish out of supply chains. He urged more states in the Asia-Pacific economic forum to ratify the UN's Port State Measures Agreement (PSMA), which asks all countries to ensure IUU catch cannot land in their ports.

A blue paper co-authored by Annie Brett, COS Hoffmann Fellow, examined the drivers of IUU fishing, how it's affected by climate change, and how it contributes to overfishing. The paper urges adopting global transparency in fisheries using new technology and tracking methods, enacting tighter controls at ports and supporting the PSMA, and enhancing collaboration among nations, regions, governments, businesses, and the financial, scientific and civilian sectors.

Brett and Leape also led a comment in the journal *Nature* arguing for wider sharing of ocean data and information to enable mitigation of climate change, control overfishing, stem pollution and combat illegal fishing. Specifically, the authors stressed the need for federated data networks to connect disparate ocean databases and new incentives and business models for data sharing.

Developing Environmental Leaders

Today's rising environmental leaders are keenly aware of the growing need for sound science in policy and decision-making. Whether they seek out careers as government researchers or entrepreneurs, policy analysts or academics, the scholars participating in Woods leadership and education programs are seeking opportunities to leverage their education and professional efforts for public good. We're working to equip these students, postdoctoral scholars and early career faculty with research support, career insights and networks to help realize their aspirations. Some of our 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. Collaboration and collective leadership are central to our faculty offerings, which value listening, engaging and co-creating solutions with others.

In this model, a leader mobilizes a group to action by steering people toward a shared vision and considering all dimensions of a challenge, no



matter how complex. This involves navigating conflict through an iterative process that enables people to serve in their most effective operational roles. Outcomes are more geared toward tools that enable groups to self-organize and transform systems in a networked way, rather than simply improving personal skills and taking positions as new challenges arise.

No Woods program demonstrates this approach more than the Leopold Leadership Program, which has entered a new phase with a new name after 20 successful years. Now known as the Earth Leadership Program, this celebrated initiative welcomes new partner Future Earth,

a global network of scientists, researchers and innovators who are collaborating for a sustainable planet. Together we are embarking on a bold mission to scale the impact of academic researchers globally to solve sustainability challenges by co-designing and internationalizing our leadership training.

More than 200 Leopold Fellows—exceptional, mid-career environmental scientists from North America—have already participated in the program since its launch in 1999. This network of scholars and leaders has become a driving force in pioneering research and solutions, public awareness, and influencing policy. In response to our mounting sustainability challenges the program has evolved from a focus on media literacy to comprehensive training on collective leadership and empowering fellows to engage in bringing “knowledge to action.”

Amid these changes, we remain committed to the fundamental principles that have made the Leopold Leadership Program so effective: interdisciplinary learning, building future leaders empowered to collaborate and innovate, and strengthening the connections among all of our scholars—past, present and future—in the service of sustainability research and solving global challenges.

HIGHLIGHTS

- The 2020 cohort of Rising Environmental Leaders participated in a virtual Washington, D.C., “Bootcamp,” getting a sense of how the government and policy sector has moved activities online to maintain momentum despite limitations imposed by the pandemic. The group of 20 graduate students and postdoctoral scholars participated in 10 sessions including intros to various federal agencies and how they engage with science; the inner workings of



2020 RELP Cohort, DC Bootcamp.

congressional offices and roles of legislative committees; insight into science lobbying, and the world of think tanks, non-profits and advocacy organizations. Participants had access to 20 diverse members of the D.C.

policy community hailing from the World Bank; Council on Foreign Relations; Offices of Senator Markey and Rep. Scott Peters; World Resources Institute, Resource for the Future, Natural Resources Defense Council, and Environmental Defense Fund; and federal agencies including the Department of Energy, Environmental Protection Agency, National Ocean and Atmospheric Administration, and U.S. Geological Survey.

- Six Stanford students were able to intern remotely with a range of California State agencies, one municipality and one NGO as part of the Stanford Environmental Policy Internships in California program (EPIC). Operated in partnership with the Haas Center for Public Service since 2017, the program creates summer environmental policy internship opportunities and matches interns to Stanford faculty and research staff advisers. As the COVID-19 crisis set in, staff explored the possibility for host agencies to adapt and pivot from their original intentions, asking them to develop projects, work plans and communication plans that enable interns to work in a meaningful capacity while developing mentoring relationships remotely in 2020. These opportunities allow Stanford students to gain hands-on



State Capitol Building, Sacramento, California.

environmental policy and management experience, while supporting state efforts to address critical environmental issues. This year’s EPIC employers include the Strategic Growth Council, CA Governor’s Office of Planning and Research; Office of Information Management and Analysis, CA State Water Resources Control Board, CA Environmental Protection Agency; Office for Environmental Justice & Community Air Monitoring Program, CA Air Resources Control Board, CA Environmental Protection Agency; Pesticide Action Network North America; Toxics Reduction and Healthy Ecosystems Program, San Francisco Department of the Environment; and the California Ocean Protection Council, CA Natural Resources Department.

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 2019-20 highlights and publications from our hosted research centers and programs.

Center for Ocean Solutions (COS)

The Stanford Center for Ocean Solutions (COS) is focused on creating innovative solutions to the pressing challenges facing the ocean—moving from insight to impact to sustain ocean ecosystems and the people who depend on them most.

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

oceansolutions.stanford.edu/

HIGHLIGHTS

- COS has partnered with the Stanford Center for Food Security and the Environment, the Stockholm Resilience Centre, Springer Nature and the EAT Foundation to produce the first comprehensive examination of foods produced in marine and freshwater systems: the Blue Food Assessment. A robust understanding of the roles, challenges and possibilities of aquatic foods into the heart of the global food policy agenda. A team of more than 50 scientists from around the world is now preparing nine articles addressing different aspects of aquatic foods, to be published in *Nature* journals. The set, along with a synthesis and a summary for decision-makers, will be presented at the United Nations Food Systems Summit in 2021. COS is actively engaged in the summit preparatory process to ensure

that key priorities for aquatic foods are built into the gathering's agenda and outcomes.

- In 2018, the President of Palau asked COS and the Palau International Coral Reef Center to convene an international expert working group to provide scientific guidance for the implementation of the Palau National Marine Sanctuary. In December 2019, COS directors Micheli and Leape presented our final report to the president and to a meeting of the full



national leadership—ministers, governors and members of Congress. COS continues to work with partners in Palau and Stanford researchers in support of the implementation of the Palau National Marine Sanctuary.

- In collaboration with the World Economic Forum, the Pew Charitable Trusts and SeaBOS (the 10 largest seafood companies), COS has been working to close the Pacific to illegal fishing. COS is working with APEC

to mobilize a region-wide commitment to prevent landing of illegal fish. The center also is working with leading industry groups to forge a “meta-coalition” committed to addressing illegal fishing in its supply chains.

- COS and the Stanford Center for Human Rights and International Justice are working together to address modern slavery in the seafood sector. The centers are building a collaboration with the International Seafood Sustainability Foundation, representing 70% of the canned tuna sector, and two of its member companies; the Indonesia Ocean Justice Initiative; and other partners to explore the potential for tools that increase transparency and accountability in tuna supply chains.

COS PUBLICATIONS

Members of the COS team published important research this year in the scientific literature, and also co-authored three [Blue Papers commissioned by the High Level Panel for a Sustainable Ocean Economy](#) (composed of 14 heads of state), addressing ocean technology, illegal fishing and equity.

COVID-19 reveals vulnerability of small-scale fisheries to global market systems. *The Lancet Planetary Health*

Scaling up Solutions for a Sustainability Transition. *One Earth*
Ocean data need a sea change to help navigate the warming world. *Nature*

Marine heat waves threaten kelp forests. *Science*

Documenting baseline value chains of Palau's nearshore and offshore fisheries prior to implementing a large-scale marine protected area. *Marine Policy*

Environmental DNA reveals seasonal shifts and potential interactions in a marine community. *Nature Communications*

Global targets that reveal the social–ecological

interdependencies of sustainable development. *Nature Ecology and Evolution*

Palau's National Marine Sanctuary: Managing Ocean Change and Supporting Food Security. Palau International Coral Reef Center and the Stanford Center for Ocean Solutions

Technology, Data and New Models for Sustainably Managing Ocean Resources. High Level Panel

Illegal, Unreported and Unregulated Fishing and Associated Drivers. High Level Panel

Towards Ocean Equity. High Level Panel

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

The DEHE program, 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 next generation of planetary health innovators. In 2019-20, the program focused on collaborative keystone projects, such as creating incentives to reduce logging in Borneo and designing an ecologically and economically sustainable water infrastructure for informal settlements in rapidly growing urban areas of low- to middle-income countries. The program also focused on developing and launching an undergraduate course in Human and Planetary Health for fall quarter 2020.

Faculty Director: **Giulio De Leo**

ecohealthsolutions.stanford.edu/

HIGHLIGHTS

- DEHE research on links between dams and disease in Senegal and links between logging and healthcare in Indonesia was featured in a compendium for classroom instruction: *Planetary Health Alliance Case Studies, An Anthology of Solutions*.
- Working with researchers in the School of Medicine, DEHE organized a series of meetings with the broader Stanford community to present a vision for Human and Planetary Health studies. This effort resulted in the inclusion of planetary health as a pillar of the university's sustainability initiative.



- A National Science Foundation (NSF) grant project led by DEHE began integrating field data with drone and satellite imagery and artificial intelligence to 1) identify potential transmission hotspots for schistosomiasis in Senegal, and 2) use this information to develop a surveillance system to optimize intervention strategies

Research Centers & Programs

- A second NSF grant project led by DEHE researchers focused on understanding the effect of future climate and land use change on the risk of schistosomiasis in Cote d'Ivoire and Brazil, the development on integrated aquaculture with biological control of schistosomiasis and the development of computer vision for the automatic classification of snails and parasites of medical importance.
- A Packard Foundation grant project enabled DEHE researchers to collaborate with the NGO Health in Harmony to assess the impact of COVID-19 on illegal logging in Borneo.

DEHE PUBLICATIONS

Concomitant Immunity and Worm Senescence May Drive Schistosomiasis Epidemiological Patterns: An Eco-Evolutionary Perspective. *Frontiers in Immunology*

Cost-effectiveness of combining drug and environmental treatments for environmentally transmitted diseases. *Proceedings of the Royal Society B*

Development, environmental degradation, and disease spread in the Brazilian Amazon. *PLOS Biology*

Precision mapping of snail habitat provides a powerful indicator of human schistosomiasis transmission. *Proceeding of the National Academy of Science*

Models with environmental triggers offer a plausible mechanism for the rapid spread of infectious disease outbreaks in marine organisms. *Scientific Reports*

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



Credit: Steven Baird

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**

Deputy Director: **Marshall Burke**

fse.fsi.stanford.edu/

HIGHLIGHTS

- Made significant strides in a portfolio of research projects focused on data science applications in sustainable development, sustainable palm oil development in Indonesia, climate impacts on agriculture and other economic activity, public health and fisheries and aquaculture management.
- Partnered with the Stanford Center for Ocean Solutions to launch a 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.
- Continued engagement with public sector partners and policymakers, including the U.S. State Department, the World Bank, and the World Food Programme (WFP)
- Hosted a symposium on food security and humanitarian aid with current and previous WFP directors general,

as well as symposium on innovations for food security with visiting scholar Christopher Barrett, Cornell University.

FSE PUBLICATIONS

Dust pollution from the Sahara and African infant mortality. *Nature Sustainability*

On the role of anthropogenic climate change in the emerging food crisis in southern Africa in the 2019–2020 growing season. *Global Change Biology*

Weakly Supervised Deep Learning for Segmentation of Remote Sensing Imagery. *Remote Sensing*

Water-food-energy challenges in India: political economy of the sugar industry. *Environmental Research Letters*

The Changing Risk and Burden of Wildfire in the U.S. *National Bureau of Economic Research*

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 2019–20, 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 ecologic 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 is analyzing food, water and energy competition in Pune, India and Amman, Jordan. The \$2.4 million project is led by Gorelick and co-PI Roz Naylor



Amman City. Credit: FUSE

with co-PIs in Germany and Austria.

- FUSE held a series of six stakeholder workshops in Pune and Amman with a total of ~200 participants, and the project recently conducted a food-water-energy survey of more than 1,800 households in Pune.
- Jordan's Ministry of Water and Irrigation officially endorsed FUSE.
- In India, Gorelick and his colleagues analyzed the political economy of the sugar industry and its impacts on food-water energy, publishing their findings in *Environmental Research Letters* (Lee et al., 2020)

- GFI has produced a series of papers involving new remote sensing analysis methods for improved estimates of plant water use, impervious (non-porous) areas, a comparison of the impacts of land-cover change on streamflow around the world and a collaboration with the Fendorf lab on arsenic in groundwater induced by managed freshwater injection.
- Under the GFI FUSE project, two undergraduates over the summer of 2020 worked on equitable water allocation in Pune, and analysis of drought indices, respectively.
- FUSE had a series of presentations at the 2019 December AGU meeting with another eight to be presented at the 2020 meeting.

GFI PUBLICATIONS

Water-Food-Energy challenges in India: political economy of the sugar industry. *Environmental Research Letters*

Insights on Expected Streamflow Response to Land-cover Restoration. *Journal of Hydrology*

Distribution of small seasonal reservoirs in semi-arid regions and associated evaporative losses. *Environmental Research Communications*

Extracting Impervious Surface from Aerial Imagery Using Semi-Automatic Sampling and Spectral Stability. *Remote Sensing*

Controlling Arsenic Mobilization during Managed Aquifer Recharge: The Role of Sediment Heterogeneity. *Environmental Science and Technology*

Insights from watershed simulations around the world: Watershed service-based restoration does not significantly enhance streamflow. *Global Environmental Change*

Research Centers & Programs

Natural Capital Project

NatCap pioneers science, technology and partnerships that enable people and nature to thrive. This Stanford-led partnership works through purposeful engagement and uses cutting-edge science and technology to drive a global transformation towards inclusive, green growth. NatCap operates as a global partnership of influential actors in academia, conservation, government, development banks, private investment and business. Its powerful network currently includes more than 50 research institutions and 200 implementing partners worldwide, allowing for direct engagements in over 60 countries and for the NatCap InVEST software platform to be used in more than 185 countries.

Faculty Director: **Gretchen Daily**

naturalcapitalproject.stanford.edu/

HIGHLIGHTS

- At the World Economic Forum in Davos this past January, Faculty Director Gretchen Daily represented NatCap on the global stage and spoke about how natural capital is inherent to cultivating a connected food system. Later in the spring, Managing Director Mary Ruckelshaus presented

to the High Level Panel for Sustainable Ocean Economy about her work on a transition to a sustainable ocean economy.

- After deciding to cancel its annual symposium in early March due to the COVID-19 pandemic, NatCap began to work with partners to frame its work in the context of the virus, with a goal of helping to build back



Gretchen Daily at the 2020 World Economic Forum.
Credit: World Economic Forum

better. This work includes ongoing projects with the Inter-American Development Bank, World Bank and other multilateral institutions interested in how they can target stimulus funding to governments in ways that encourage green, inclusive growth.

- This summer, NatCap launched its first InVEST Virtual Workshops Series as a way to continue engaging with software users and grow the NatCap community while sheltering in place. The three workshops were led by NatCap researchers and software experts, who guided users through the software platform and conducted “deep dives” into two popular InVEST models. They welcomed more than 700 attendees from 86 countries over the course of the series. They also launched their new free online course through Stanford, Introduction to the Natural Capital Project Approach. In its first four months, more than 900 people registered for the course.
- NatCap continued work to build new metrics to measure natural capital, including a Gross Ecosystem Product (GEP) metric with partners at the Chinese Academy of Sciences, and their paper on GEP was published in June. With the World Bank, NatCap is working to pilot a “natural capital index” for reporting alongside the Bank’s “human capital index.” The ultimate goal is to calculate changes in natural capital stocks, biodiversity, and ecosystem service value (both monetarily and related to human health) for every country in the world.
- Gretchen Daily was awarded the 2020 Tyler Prize for “illuminating and quantifying

the economic value of our natural environment” alongside NatCap collaborator Pavan Sukhdev from World Wildlife Fund. She was also recognized as one of 2019’s highly cited researchers, demonstrated by the production of multiple highly cited papers that rank in the top 1% by citations for field and year in Web of Science.

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*

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 wellbeing and environmental stewardship in Costa Rica’s Osa and Golfito region through work with local communities, government, academic institutions, the private sector and nongovernmental organizations. INOGO programs have continued their progress with the aim of providing critical tools and analyses to inform a living process for sustainable development led by stakeholders in the region.

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

inogo.stanford.edu/

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



Students in the SELAL program learn about eco-tourism. Credit: Fundacion SOMOS

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 conservation 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.

INOGO PUBLICATIONS

Community-as-pedagogy: Environmental leadership for youth in rural Costa Rica, *Environmental Education Research*

Research Centers & Programs

Program on Water, Health & Development (WHD)

WHD's research focuses on the role water plays in advancing global health and well-being. Program researchers pursue topics such as sustainable infrastructure, wastewater and stormwater management, poverty reduction, and health and hygiene education. While the COVID-19 pandemic has created challenges and limited most field-based research, it also has offered opportunities such as a new project examining how the coronavirus moves through the environment. This year, WHD has launched three newly funded projects focused on sub-Saharan Africa. One aims to enhance the poverty-alleviation benefits of infrastructure investment. Another will analyze changes in water resources and services in three countries over the next five years. The third will build capacity in the private and non-profit sectors for in-depth problem diagnosis that leads to more sustainable solutions.

Faculty Director: **Jenna Davis**

water.stanford.edu

HIGHLIGHTS

- Professors Alexandria Boehm (SoE) and Krista Wigginton (U. Michigan), are principal investigators on a project examining how

SARS-CoV-2 moves through the environment and may be used as an indicator of cases in a region using wastewater based epidemiology. The research project aims to address key knowledge gaps in the connection between disease outbreaks and virus concentrations in wastewater, the transfer of coronaviruses between skin and other materials, and the effects of UV and sunlight. This data proves critical in identifying virus circulation early in community outbreaks and estimating outbreaks trends, controlling surface transmission, and predicting persistence in water treatment and the natural environment.

- WHD researchers completed baseline data collection for a cluster randomized controlled trial of professionalized preventative maintenance services for rural water supplies in northern Uganda, in partnership with the NGO International Life Fund and social enterprise WellDone. The study will quantify demand for improved water point reliability and the fiscal and economic benefits of the service.
- Developing and testing new approaches to water and wastewater management in cities of the Global South continued in Fiji as the Revitalizing Informal Settlements and the Environment (RISE) project kicked off. Led by Monash University with a global

consortium of partners including Stanford RISE aims to transform the lives of more than 3,000 Fijians living in informal settlements. The project will strengthen access to water and sanitation services and protect communities vulnerable to extreme weather impacts.



An informal settlement in Suva, Fiji. Credit: RISE

WHD PUBLICATIONS

Wastewater-Based Epidemiology: Global Collaborative to Maximize Contributions in the Fight Against COVID-19, *Environmental Science & Technology*

Estimating energy expenditure of head-hauling water and grain grinding from heart rate monitor measurements in northern Mozambique, *Public Health Nutrition*

Validation and Mechanism of a Low-Cost Graphite Carbon Electrode for Electrochemical Brine Valorization, *ACS Sustainable Chemistry & Engineering*

Ruminant Fecal Contamination of Drinking Water Introduced Post-Collection in Rural Kenyan Households, *International Journal of Environmental Research and Public Health*

Soil ingestion among young children in rural Bangladesh, *Journal of Exposure Science & Environmental Epidemiology*

Water in the West (WitW)

WitW develops and promotes innovative solutions to key water challenges in California and the western U.S. Researchers worked in 2019-20 to support effective implementation of California's Sustainable Groundwater Management Act (SGMA) through scientific research, workshops, reports and collaborations. Urban water work has focused on how local and state agencies can encourage community water conservation and develop more resilient water portfolios. The program also continues to identify and support ways to encourage environmental water transactions and to explore the nexus of water management and ecosystem services in partnership with the Natural Capital Project.

Faculty Director: **Barton "Buzz" Thompson**
waterinthewest.stanford.edu

HIGHLIGHTS

- Newsha Ajami, head of WitW's urban water program, along with PhD student Jose Bolorinos, used machine-learning methods to examine water conservation efforts in Southern California during droughts. The team found that a high percentage of customers implemented conservation efforts during times of heightened public awareness associated with state-level policy actions and drought media coverage, and most of the conservation occurred before imposed water restrictions. Water utilities are using

the information to inform resource planning and water conservation campaigns.

- WitW-affiliated researchers completed a multi-year research project evaluating the effectiveness of data platforms as a tool in water management decisions. The research focused on four independent water data platforms and involved meeting observations, a literature review and interviews with



The border of Huntington Beach and Costa Mesa, California—the city studied by Newsha Ajami and Bolorinos examining water conservation during drought. Credit: Flickr/J. Les Gainous)

agency decision-makers, tool developers and stakeholders. A project landing page provides key findings and guidance materials.

- WitW released several research publications to guide SGMA implementation, including studies that 1) examine the evolution of groundwater governance in the state, finding additional interventions may lie ahead if basin management plans cannot meet

sustainability goals; 2) look at how farmers' perceptions of fair groundwater allocation and dispute resolution can aid achievement of groundwater sustainability by 2040, and 3) evaluate multi-benefit land use planning in California's San Joaquin Valley, providing a strategic blueprint for habitat restoration amid land use changes. See titles below.

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*

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FELLOWS

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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>

Senior 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>)

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Adrian Vogl, Lead Scientist, Natural Capital Project

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

Mele Wheaton, Senior Research Scholar, GSE & Stanford Woods Institute

Leadership & Staff

RESEARCHERS

More than 64 senior fellows, 206 affiliated faculty, 12 research staffers and 41 postdoctoral scholars are associated with the Stanford Woods Institute for the Environment. For a full listing by research focal areas and contact information, visit the people section of our website:

woods.stanford.edu/people

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2019–20 ANNUAL REPORT

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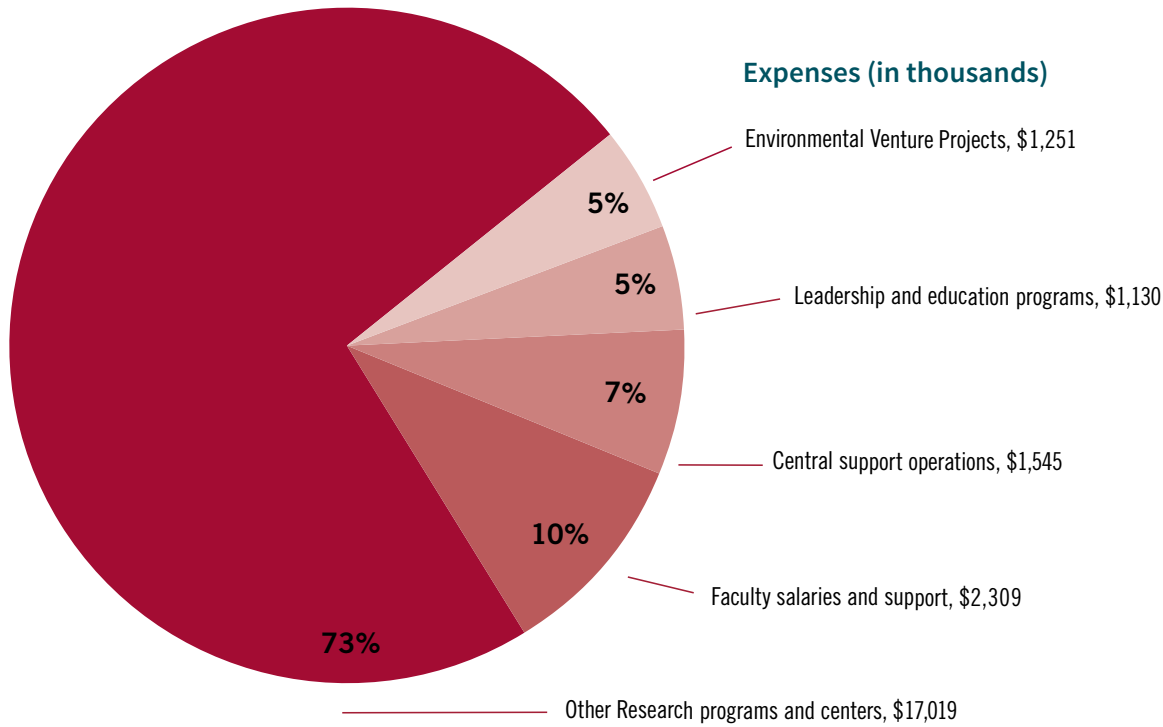
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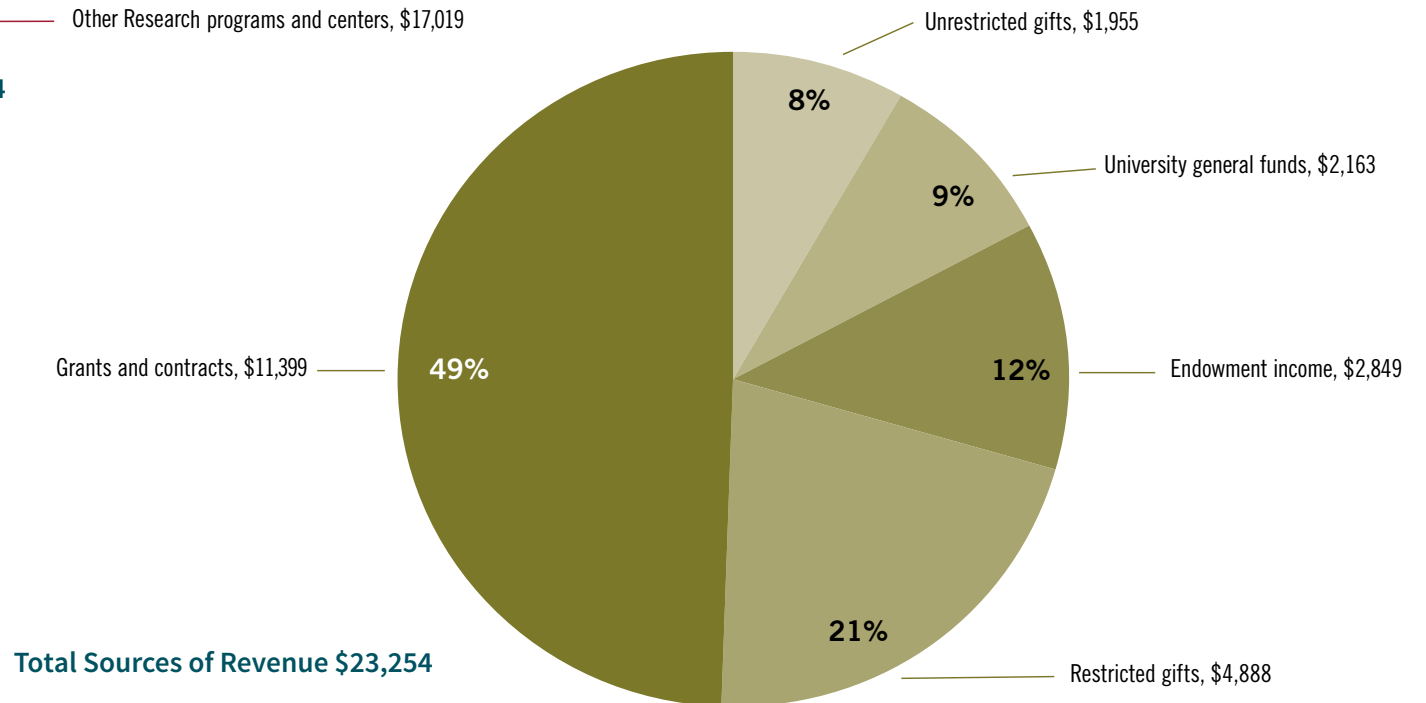
FISCAL YEAR 2019–2020

Sources of revenue which support the Stanford Woods Institute for the Environment in fiscal year 2019–2020 amounted to \$23.3 million, of which 9 percent originated from university general funds, 12 percent from endowment income, 29 percent from gifts, and 49 percent from grants and contracts. Expenses during the fiscal year 2019–2020 amounted to \$23.3 million. Woods largest expenditure includes Environmental Venture Projects and other research programs and centers, totaling \$18.3 million, or 78 percent of the institute’s annual budget.



Total Expenses \$23,254

Sources of Revenue (in thousands)



Total Sources of Revenue \$23,254



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