


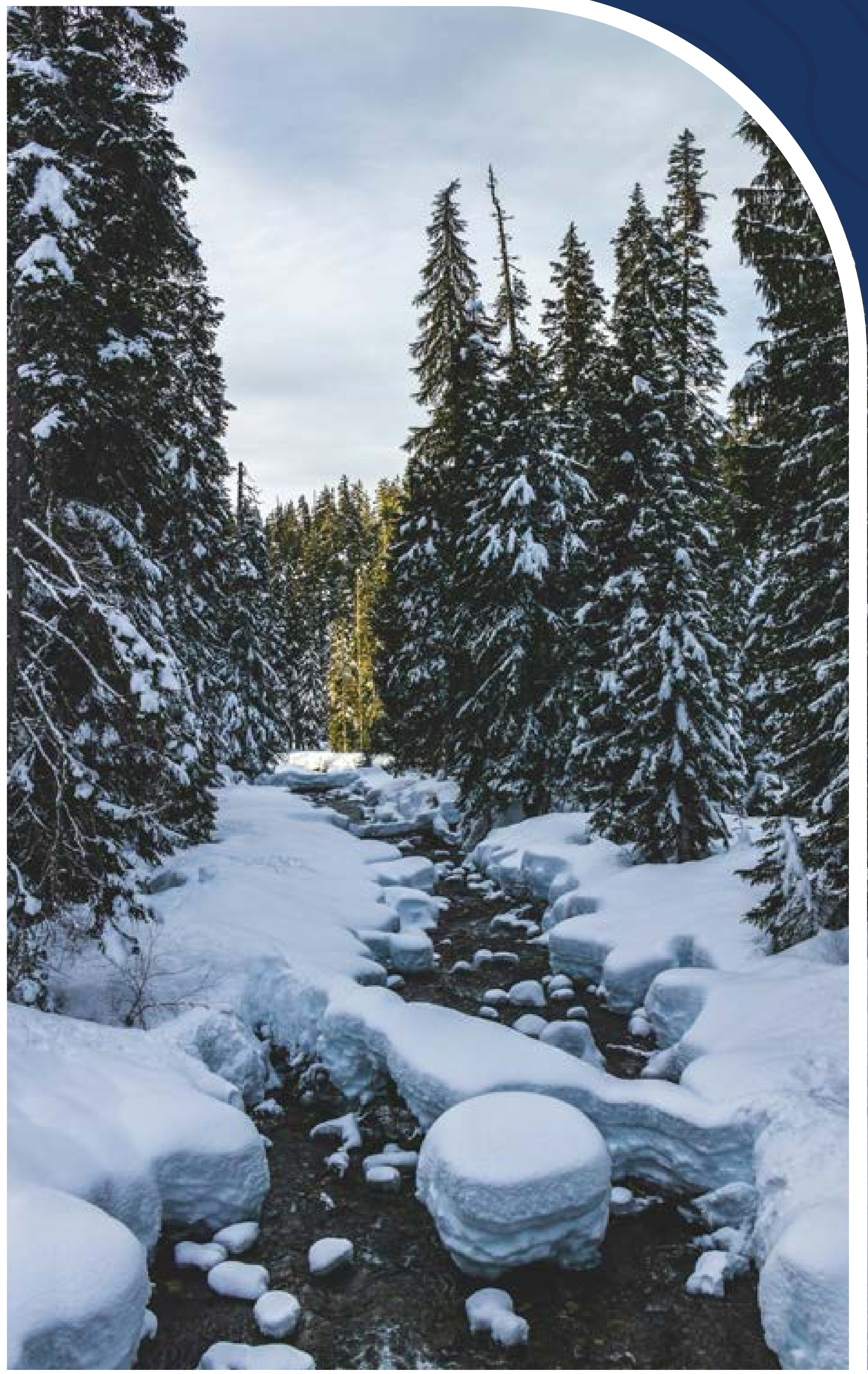

THE ERIC & WENDY SCHMIDT CENTER
Data Science & Environment

THE ERIC AND WENDY SCHMIDT CENTER FOR DATA SCIENCE & ENVIRONMENT

2024 ANNUAL REPORT

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FOREWORD

IT IS WITH GREAT PRIDE AND GRATITUDE that we share the 2024 Annual Report for The Eric and Wendy Schmidt Center for Data Science & Environment (Schmidt DSE). Now wrapping our second year of operation, we have assembled a talented and dedicated team and fostered meaningful collaborations with partners on campus and in places of influence across the globe. We are extremely proud of how our first positive results have helped address some of the planet's most urgent environmental challenges.

This report highlights many of our achievements over the last year. From creating solutions to combat global plastic pollution, to co-designing advances in Indigenous data sovereignty, and developing critical tools for wildfire recovery, agricultural sustainability, and water security, Schmidt DSE's impact is already making a mark locally, nationally, and worldwide.

These early successes have reaffirmed our conviction in the value of directing the full power of data science towards the right kinds of environmental problems. Furthermore, we are beginning to successfully demonstrate that the needs and knowledge of communities most affected by climate and planetary change must guide our actions.

This report also reflects our aspirations and visions for so much more that can be done. With momentum building and a growing team, we continue to push the boundaries of what's possible in our fields. We are committed to ensuring that our efforts produce tangible, lasting environmental solutions while fostering inclusivity and accessibility.

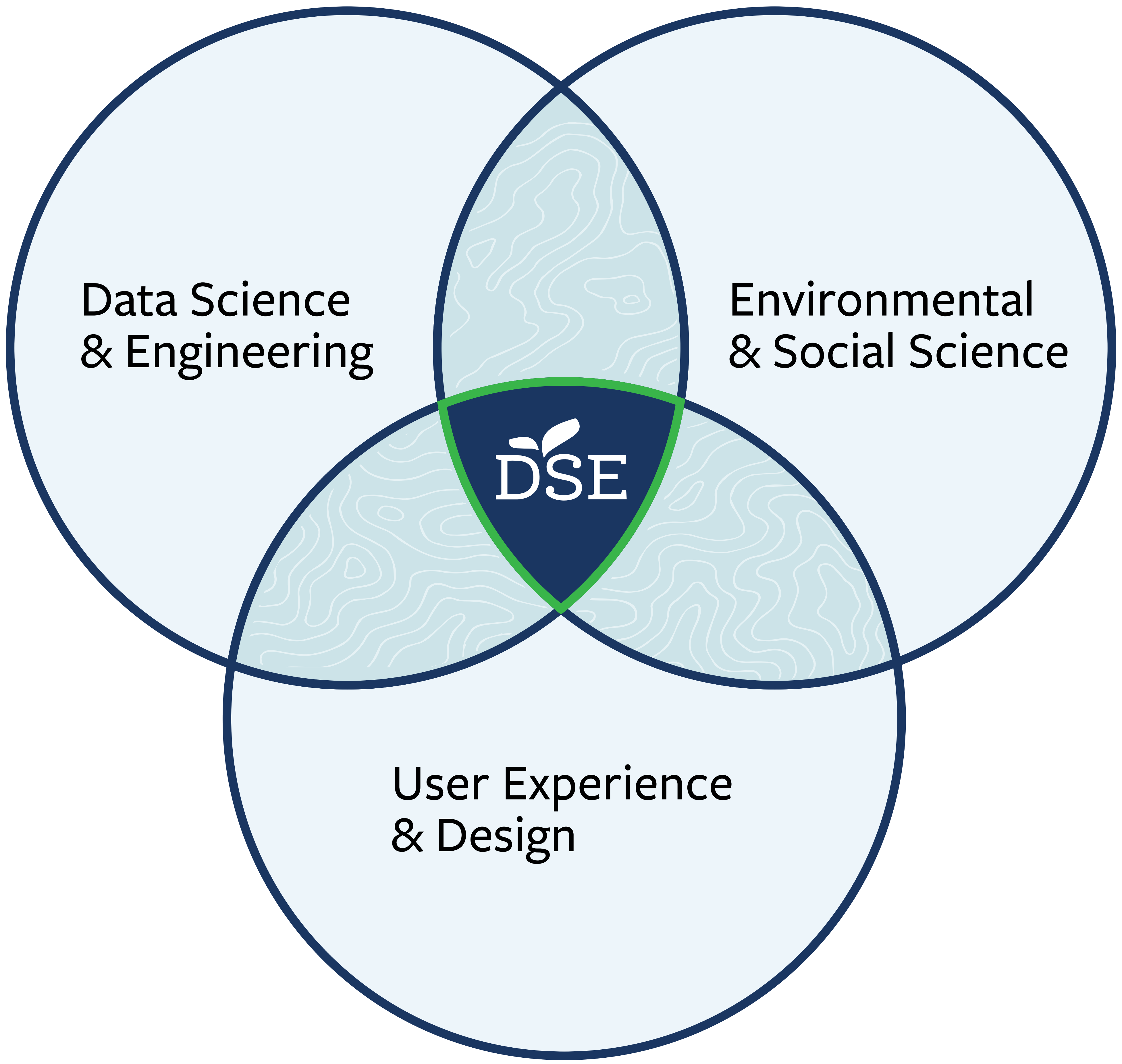
We hope that you are as energized by our early successes as we are and are as excited for the opportunities ahead. We are deeply grateful for your partnership and for your belief in the importance of this mission. Together, we look forward to forging a path toward a healthier, more sustainable, and more equitable future for all.

The Eric and Wendy Schmidt Center for Data Science & Environment (Schmidt DSE) builds tangible, replicable, and inclusive solutions to environmental problems.

The powerful combination of modern data and environmental science offer transformative opportunities to create a healthy planet where people and nature thrive. At Schmidt DSE we:

- Leverage cutting-edge methodologies in data and environmental science to help address climate change, the biodiversity extinction crisis, and other urgent environmental challenges.
- Co-create solutions with decision makers and communities who are most knowledgeable about and most directly impacted by these problems.
- Work to ensure our findings are accessible to and usable by audiences with and without formal programming, data science, or other scientific backgrounds.

We help further the open science and open source movement by providing community-owned tools, data, and methodologies so that our collaborators can better understand, interrogate, and build upon this research. At the same time we adhere to data sovereignty and data privacy principles when working with Indigenous communities in particular.



At UC Berkeley, Schmidt DSE leverages world-class environmental and data science to help address pressing climate challenges at the local, national, and global scale.

We are proud to operate at the intersection of UC Berkeley's Rausser College of Natural Resources (RCNR) and the College of Computing, Data Science, and Society (CDSS). In September U.S. News and World Report announced what we know well: **CDSS is the #1 program in the country for undergraduate data science and graduate computer science, and #2 in undergraduate computer science. RCNR has been an academic leader in the natural and social sciences for over 50 years and is ranked 3rd for environmental science graduate programs nationwide.** A key ingredient in Schmidt DSE's success is drawing from these world class programs and helping to direct the power of students' future careers to solving the environment's most pressing challenges.

HOME AT UC BERKELEY

TRAINING THE NEXT GENERATION OF LEADERS

In 2024 we hosted **undergraduate internships** with 11 students from Rausser College, CDSS, the College of Environmental Design, and Economics. The students' software engineering and data documentation, visualization, and labeling skills were invaluable contributions to our projects in Indigenous Environmental Stewardship and biodiversity monitoring.

This year we are excited to welcome **McKalee Steen**, a UC Berkeley PhD candidate in the Environmental Science, Policy, and Management Department to our team. McKalee is a citizen of the Cherokee Nation of Oklahoma. At Schmidt DSE McKalee will use data science to analyze the social and ecological impacts of Indigenous environmental stewardship practices and will add to our research on Indigenous data sovereignty. This builds on Schmidt DSE's ongoing collaboration, engagement, and technical mentoring with McKalee over the last year and a half.

Three students from the School of Journalism are joining our team in Spring 2025 as part of **a new Masters fellowship program: Iris Qiu, Kelly Liu, and Neenma Ebeledike.** They bring extensive videography, photography, and data visualization skills and will develop visual storytelling assets to help disseminate our research to a wider audience.

←

BACK ROW
(left to right):
Rohit Raman, Evan Lingo, Camille Dayton, Danielle Louie, Dhruva Bhagwat.

FRONT ROW
(left to right):
Diana Tao, Ann Basil, Carolyn Zhuang, Nithya Appannagaari.

Not pictured:
Ethan Aquino and Max Taniguchi-King.

NEENMA EBELEDIKE

IRIS QIU

KELLY LIU

MCKALEE STEEN

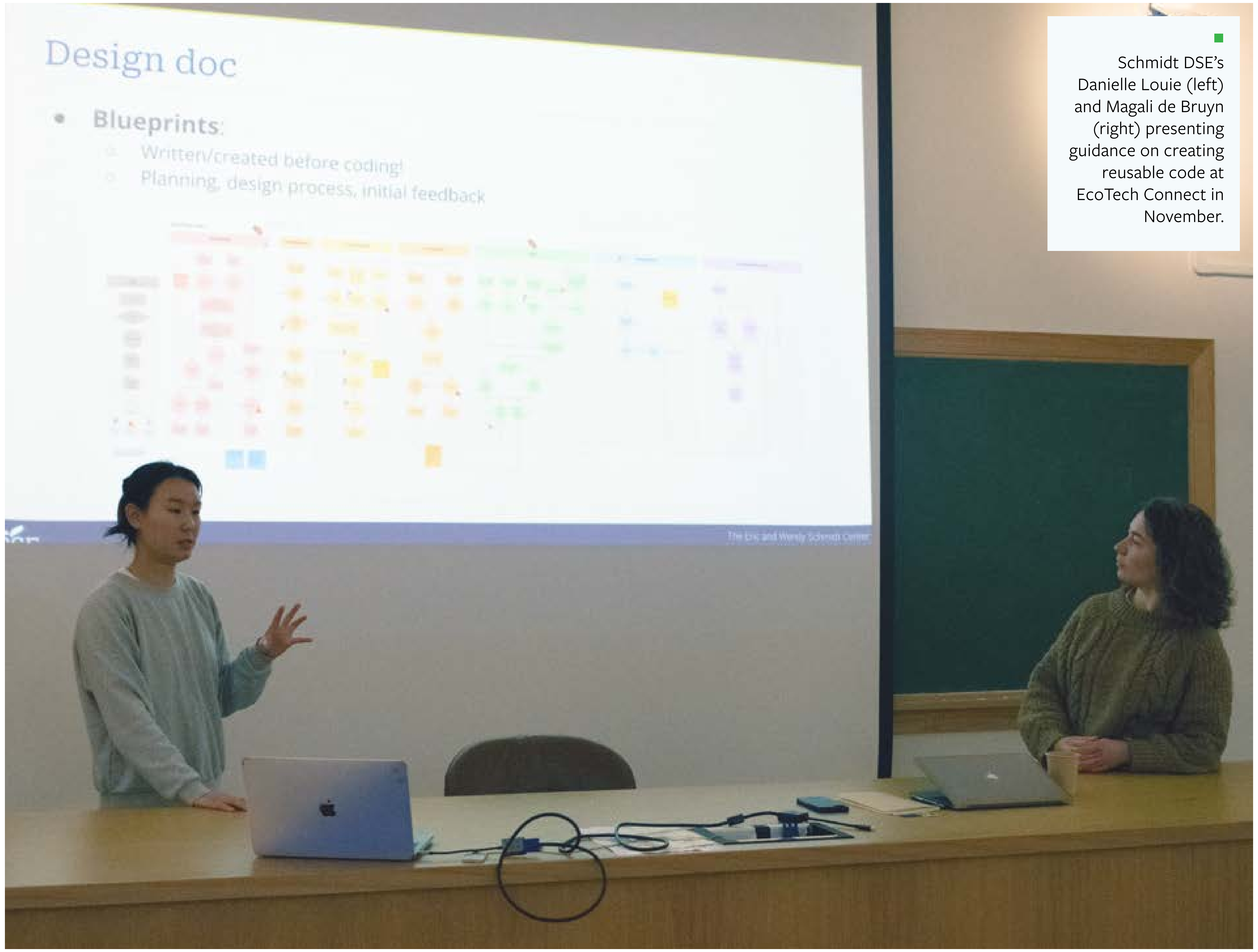
HOME AT UC BERKELEY

CAMPUS OFFERINGS

Last year we launched **EcoTech Connect:** an open discussion series on technical methods and coding best practices for environmental scientists. Our team presented our expertise and led six workshops throughout the fall with students on topics such as data visualization, mapping, and software development tools. Sam Pottinger, Senior Research Data Scientist/Software Engineer at Schmidt DSE, is also **teaching a new course open to all students called "Interactive Data Science and Visualization"** in Spring 2025. Through these kinds of outreach activities, we give back to campus from Schmidt DSE's deep expertise and provide new nodes of interaction with talent across the campus community.

NEW DATA SCIENCE CENTER ANTICIPATED THIS YEAR

We are thrilled that the Gateway, a new data hub on campus, is scheduled to open in the 2025-2026 academic year. The Gateway will foster interdisciplinary research and support more than 1,300 faculty, students, staff and researchers. The building will become the epicenter of campus data science and is located next door to Schmidt DSE. We look forward to working with the best data experts in computer and data science, engineering, biology, public health, economics, and more right in Schmidt DSE's backyard.



Schmidt DSE's Danielle Louie (left) and Magali de Bruyn (right) presenting guidance on creating reusable code at EcoTech Connect in November.

INNOVATION & IMPACT IN 2024

2024 was an extraordinary time for Schmidt DSE. We are proud to share that **our five initial projects progressed significantly** related to ending plastic pollution, scaling sustainable agriculture, co-designing Indigenous environmental stewardship, improving wildfire recovery, and addressing water scarcity during our second full year as an organization. With a bigger team and more efficient operations **we were also able to take on two new projects** that help advance global climate policy and collaborative land management. Excitingly, these efforts are already making a notable impact.

GLOBAL POLICY SOLUTIONS

Schmidt DSE is leading key projects in the US and internationally that provide decision-makers with necessary data, tools, and training to **address the climate and biodiversity crisis.**

END PLASTIC POLLUTION

Global plastic pollution is an urgent and growing concern given relentless production, consumption, and mismanagement of plastic materials. Our runaway global plastics system is accelerating climate change, causing catastrophic damage to ecosystems, and generating health risks for people and wildlife.

WHERE WE ARE

The United Nations (UN) embarked on a global treaty negotiations process to help address these increasing challenges. Here, Schmidt DSE stepped in to offer our AI, data analysis, and data visualization expertise directly to the global community so that they could better understand (and ultimately advocate for) the most impactful science-based solutions for ending plastic pollution. Treaty negotiations are expected to conclude later this year.

HIGHLIGHTS

- Furthered global negotiations to end plastic pollution with a cutting-edge AI policy tool.
- Published a relevant paper in **Science** that has been downloaded over 20,000 times.
- Our model and research were featured in over 600 national and international news stories including in **the Guardian** and **the New York Times**.

END PLASTIC POLLUTION

OUR IMPACT

In 2024 Schmidt DSE and collaborators at the University of California Santa Barbara and the Benioff Ocean Science Laboratory harnessed cutting-edge methods in data science and AI to predict the global production, use, and fate of plastics through 2050. The results were sobering: without taking action, plastic pollution is set to double by 2050. But an optimistic key finding to emerge from this Schmidt DSE project was **that a package of four key policies—working together across the entire plastic life cycle—could nearly end plastic pollution.** By 2050 this policy package would reduce mismanaged plastic waste by up to 91% and cut associated greenhouse gases by one third. The model we built and delivered to delegations also enables policy makers to examine endless combinations of policies at different levels to inform their negotiation positions.

Over the course of this project Schmidt DSE and our collaborators sought to develop groundbreaking scientific models and research and to make our results more accessible to policymakers and the public. As a result we:

- Developed the Global Plastics AI Policy Tool: an interactive model that provides evidence-based, AI-powered projections of the future under various policy scenarios.
- Presented this tool at the 4th convening of the Intergovernmental Negotiating Committee (INC-4) in Ottawa, Canada. Our partners at UC Santa Barbara also met with negotiators at INC-5 in Busan, South Korea.
- Published a paper with our findings and policy recommendations in Science entitled "Pathways to reduce global plastic waste mismanagement and greenhouse gas emissions by 2050" (November 14, 2024). To date the paper has been downloaded over 20,000 times and was shared with every national delegate attending the UN negotiations.
- Created an interactive, web-based interactive simulation that helps depict plastic pollution rates under a strong treaty and if no action is taken (see images).
- Provided personalized briefings in bilateral meetings with dozens of different national delegations negotiating the treaty, which yielded positive dialogue about solutions in our science.
- Our science was featured in more than 600 US and global news stories, including the Associated Press, the Guardian, the New York Times, NBC, NPR, TIME, and the Washington Post.

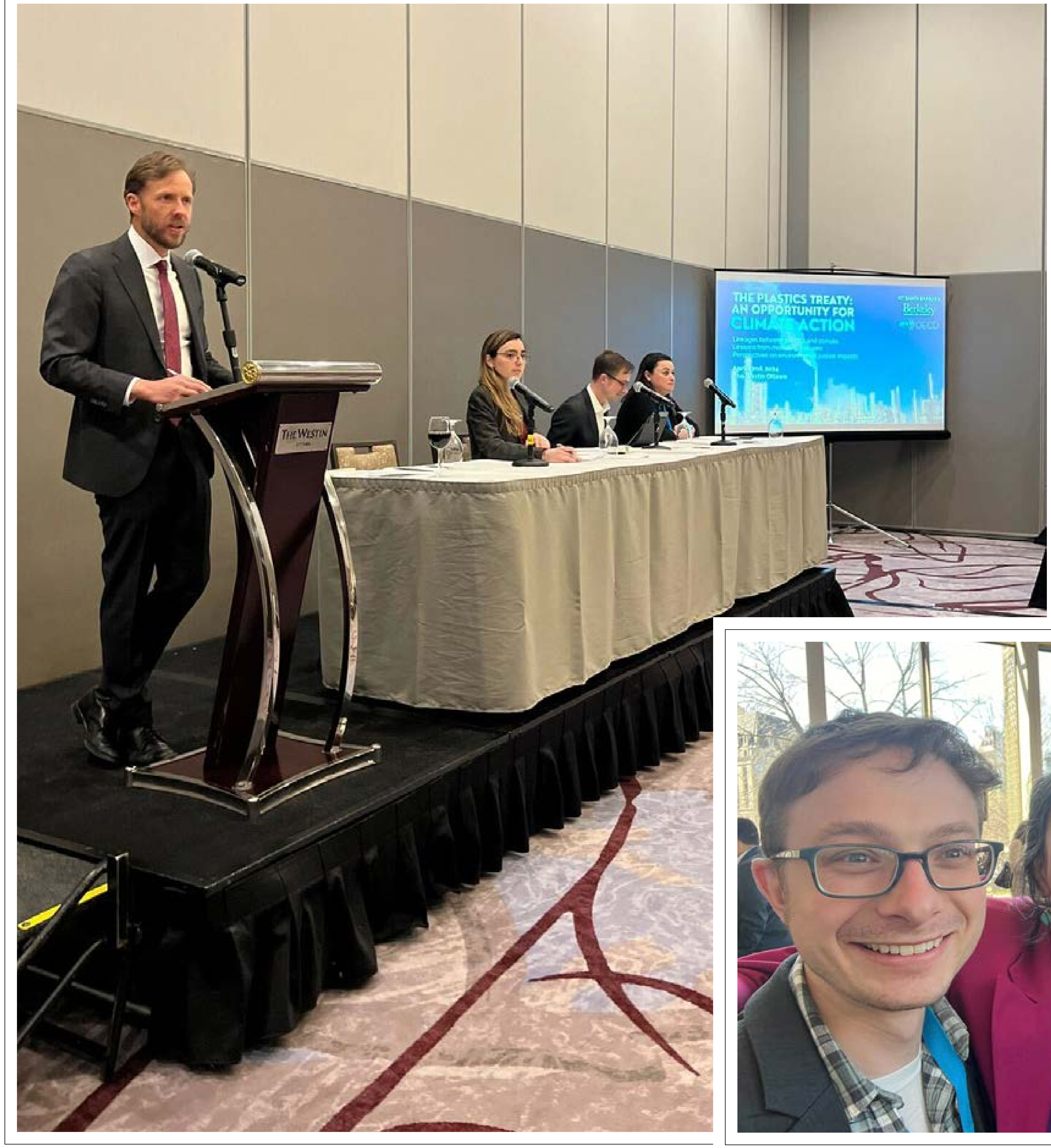
Our interactive simulation projects annual global plastic pollution that will be generated in 2050 under different scenarios, piled on top of Manhattan for scale. **TOP** If no action is taken, the annual plastic pollution generated in 2050 would be nearly double - growing to 121 million metric tons. **BOTTOM** Under a high ambition treaty, the annual plastic pollution generated in 2050 could be cut by more than 90% - dropping down to about 10 million metric tons.

END PLASTIC POLLUTION

FUTURE VISION

Schmidt DSE's vision is a world free of plastic pollution and our work is a testament to what's possible when we make data science open and transparent to help drive environmental change. Although the treaty was not finalized on the expected timeline last year, there were a number of positive outcomes that came out of the latest meeting in South Korea. **We were heartened, for example, to see 100+ countries rally behind a treaty draft that includes many of the provisions that surfaced in our research as key solutions for ending plastic pollution.** We are encouraged that some of the countries leading this coalition included nations with which we met to discuss our findings in depth. Much will be determined in this next round of negotiations expected in mid-2025. We will continue supporting partners—who are championing the most ambitious treaty outcomes—and ensuring our research continues to inform and strengthen the negotiations.

Schmidt DSE is also exploring ways to scale this work outside of the global treaty. For example, California Senate Bill 54 aims to reduce plastic pollution and is an opportunity for relevant policy engagement at the state level.



Schmidt DSE's Co-Director Douglas McCauley (left) and Sam Pottinger (third from left) presented the policy tool to national delegations, the Organisation for Economic Co-operation and Development (OECD), the environmental justice group Azul, and attendees at INC-4 in Ottawa in April.

Sam Pottinger (left) and UC Santa Barbara colleagues Nivedita Biyani (center) and Neil Nathan (right) at the INC-4 official side event, co-hosted by the University of California.

SCALE SUSTAINABLE AGRICULTURE

Feeding the world's population requires massive amounts of agricultural resources. These same resources are also substantially contributing to climate change and biodiversity loss. For example, some farmers employ pesticides, herbicides, and fertilizers to fight pests and weeds and provide plant nutrition. These and other industrial practices can have negative impacts including water pollution, soil erosion, increased greenhouse gas emissions, increased vulnerability to extreme climate events, and biodiversity loss. Even under careful management, areas with low crop diversity can harm soil and expose our food system to increasing risk as climate change continues.

Sustainable food production is essential to a future in which scientists anticipate less favorable growing conditions due to climate change. Specifically, science-based sustainable agricultural practices have been rigorously demonstrated to benefit farmers and the environment. New developments in data science present an exciting opportunity to remove some of the barriers to incentivize farmers to grow more nutritious food, increase climate resilience, reduce greenhouse gas emissions, and increase profits—all by taking tractable and scalable steps.

PHOTO COURTESY OF DR. YVONNE SOCOLAR

WHERE WE ARE

Sustainable agricultural practices include increasing crop diversity, crop rotation, and cover cropping. These practical shifts in behavior reduce greenhouse gas emissions, support habitat and species diversity, prevent soil erosion, improve water quality, and make farmlands more resilient to climate change. Despite these advantages, sustainable agriculture is not currently implemented at scale, often due to systemic regulatory issues and financial hurdles. To help lower these barriers and enable farmers with freedom to prepare for a changing future, Schmidt DSE is developing open source tools for crop insurance and agricultural finance agents to directly quantify and better understand sustainable agriculture's benefits, so that they can in turn support farmers choosing to implement these practices at scale.

HIGHLIGHTS

- Created an AI tool for determining climate impacts to crop yield and yield stability.
- Uncovered compelling federal policy opportunities to incentivize sustainable agriculture.
- Developed a public database for studying crop yield, stability, and other key agricultural applications.

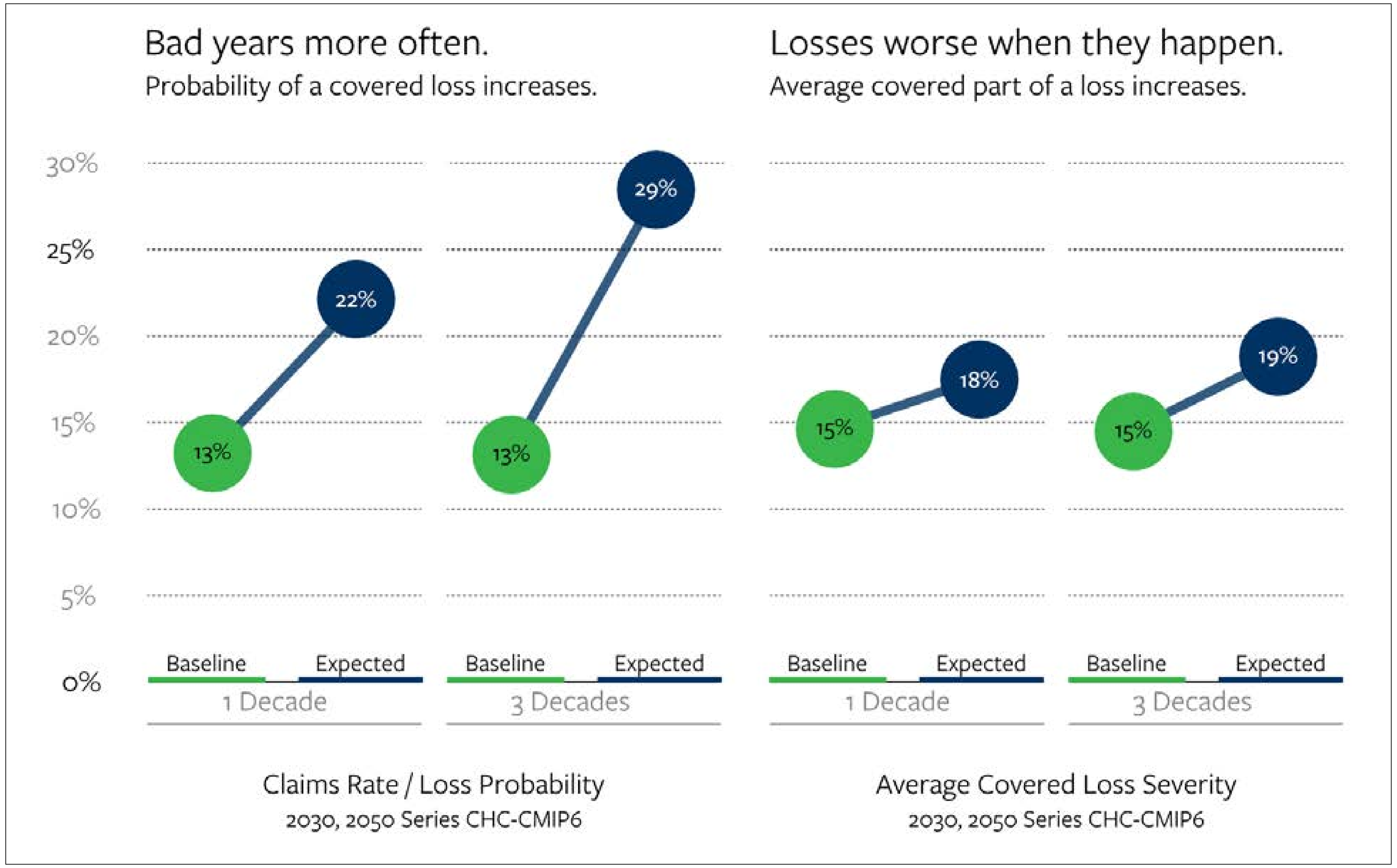
OUR IMPACT

In 2024 Schmidt DSE built AI novel methodology for understanding climate impacts to agricultural production. We are exploring opportunities with the Berkeley Food Institute to translate this new science into policy.

The tool uses artificial intelligence that simulates many thousands of possible agricultural outcomes under climate change for the next three decades. In our model, hundreds of computers work together to use neural networks to understand impacts on corn crop yields and corresponding government-subsidized crop insurance in this time frame. Federal crop insurance is a critical safeguard to our country's food system: it's both essential to confronting climate change and under threat by worsening growing conditions. Altogether, insurance costs have already increased 500% since the early 2000s. **We find that farmers' and insurance companies' financial stabilities are further threatened as crop losses become increasingly frequent and devastating from climate change.** Without action, the claims rate of the examined crop insurance program will unsustainably double by 2050.

Our simulations also uncover how subtle policy changes related to federal crop insurance could significantly mitigate these losses by rewarding stability-promoting practices. For example, we have uncovered specific instrument designs that, through 508h, could holistically recognize the benefit of regenerative systems in a practice-agnostic way.

Additionally, we have identified specific adjustments to the Farm Bill that could further enable the United States Department of Agriculture's Risk Management Agency (which manages the federal crop insurance program) to respond to changing growing conditions. These changes would empower RMA to optionally recognize benefits that farmers leveraging climate-resilient practices (like sustainable agriculture) already provide to the US food system, removing a current insurance disincentive for preparing for continued climate change.



We depict our projections under expected further global warming (intermediate warming scenario - IPCC SSP245) versus a "baseline," which assumes today's growing conditions continue into the future unchanged (data from Pottinger et al 2024 preprint).

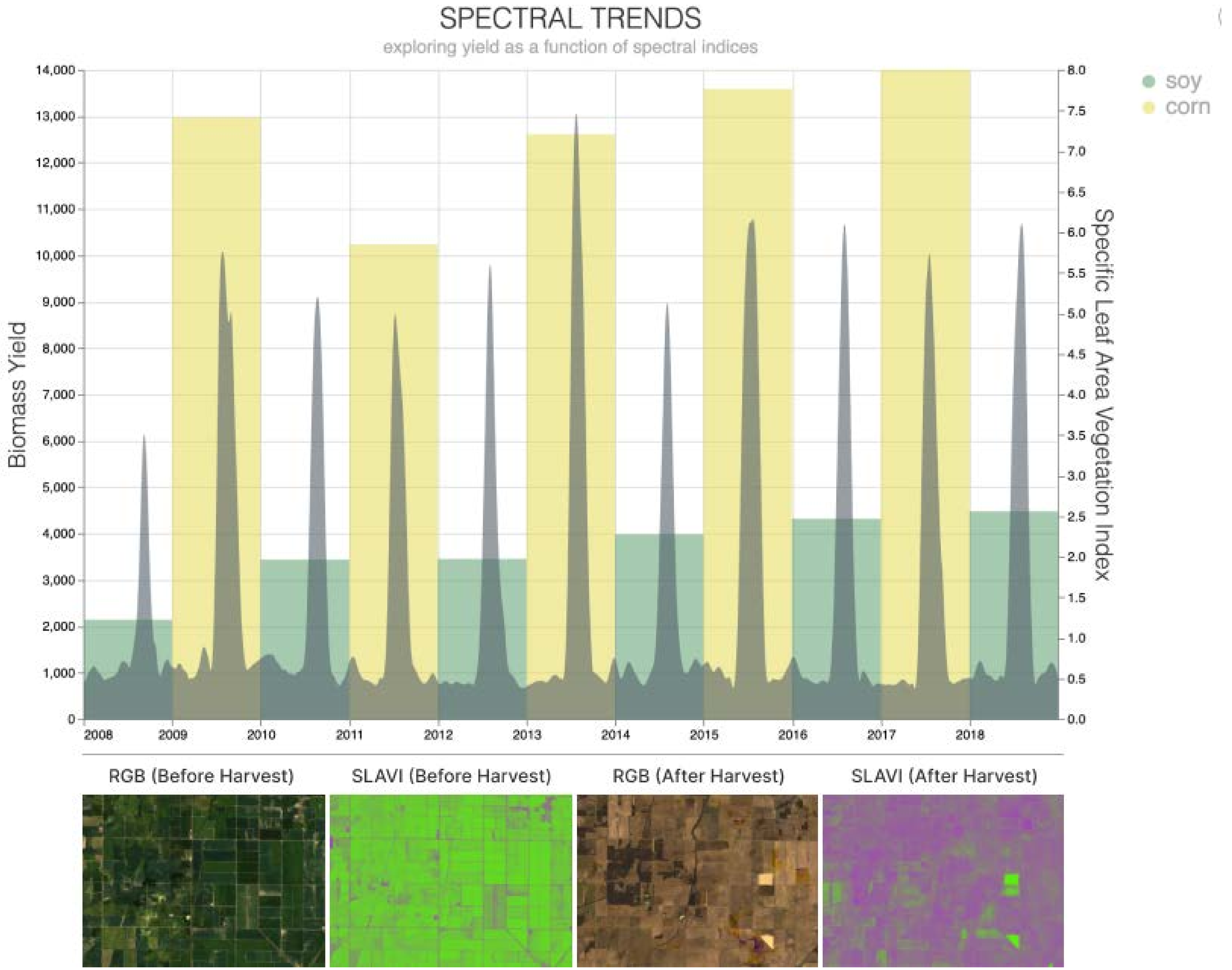
OUR IMPACT *(continued)*

Alongside climate risk modeling, we are using data from NASA's Landsat satellites to develop a public database tracking over 14,000 points in corn and soy fields in the midwestern United States. The database contains daily values for 36 different vegetation indices from the year 2000 to present, along with a number of derivative metrics that are useful for detecting crop planting and harvesting. The data will be useful for myriad agriculture applications, including the study and monitoring of yield, yield-stability, soil health, cover-cropping, and other sustainable agricultural practices.

Schmidt DSE is now beginning to explore this data with a particular focus on yield-stability and cover-cropping (our collaborators at the US Department of Agriculture are particularly interested in the latter). Because this database is public, our hope is that the data will help empower and accelerate research and action in the agricultural field more broadly. Moreover, we are releasing an open-source codebase so that researchers can quickly generate new databases for their own locations and metrics of interest. A detailed project description can be found here.

FUTURE VISION

In collaboration with the University of Arkansas, Berkeley Food Institute, and other UC Berkeley partners we are exploring policy opportunities for our research. We also look forward to further refining and distributing the spectral indices database to key stakeholders.



Schmidt DSE's Spectral Trends Database monitors over 14,000 corn and soy fields in the midwestern United States from 2000 to present day. The above chart overlays biomass yield and the "Specific Leaf Area Vegetation Index" (SLAVI) for a field from 2000 to 2012. SLAVI is one of 36 vegetation indices tracked by our system. The bottom row shows True-Color and SLAVI Landsat imagery from both before (the spikes in the chart) and after harvest.

REDUCE THE WORST GREENHOUSE GASES

NEW

The landmark United Nations (UN)'s Montreal Protocol is one of the most successful global environmental treaties in history. It helped to sidestep a potential catastrophe to the ozone layer by regulating ozone depleting substances, which were also potent sources of greenhouse gases. The Montreal Protocol was adopted in 1987 and codified into US law in 1988. It enjoys universal ratification by all UN member states. Since the adoption of the Kigali Amendment in 2016, the treaty's focus is on regulating the production and consumption of hydrofluorocarbons (HFCs), which are very detrimental greenhouse gases. The UN's Multilateral Fund has committed more than $4 billion to date (with an additional $1 billion added recently) to support implementation of the Montreal Protocol. There is an exciting opportunity to use data science to more tactically guide funding implementation. The benefits of this approach are twofold: we can fight climate change and reinforce our long-term commitment to preserving the integrity of the ozone layer.

WHERE WE ARE

Upon invitation from the Multilateral Fund, Schmidt DSE is co-creating interactive scientific tools to help inform governments across the globe as they design potential greenhouse gas-reducing projects. In order to achieve the Montreal Protocol's climate goals, world leaders need more powerful analytical tools to assess HFC consumption trends and understand the need for different policy interventions. Our interactive mathematical model can help demonstrate impacts, trade-offs, and considerations in real time as nations contemplate increasingly complex policy opportunities. In turn, this can help optimize the Multilateral Fund's investments, including aiding countries in the planning and execution of phasing out HFCs, to improve other environmental co-benefits overall.

HIGHLIGHTS

- New in 2024.
- Developed policy simulation toolkit for users in 144 nations to optionally assist global climate policy analysis and implementation.
- Led comprehensive, two-day workshop with United Nations staff on tool usage and development.

REDUCE THE WORST GREENHOUSE GASES NEW

OUR IMPACT

Schmidt DSE's expertise in policy design simulation (similar to our work on the global treaty to end plastic pollution) can help support the Montreal Protocol in this exciting phase. In 2024 we continued developing the policy simulation toolkit that will enable users in 144 nations to compare and combine analyses of policies under consideration. **The interactive, accessible platform will also help support decision making so that more resources are directed to creating real, lasting environmental and social outcomes.** Moving forward, the tool will incorporate any additional proposed policy types explored in partnership with our UN colleagues. We are aiming to test this toolkit directly with national-level environmental regulators in early 2025.

Last October Magali de Bruyn, Data Scientist/Research Software Engineer and Sam Pottinger, Senior Research Data Scientist/Software Engineer led a two-day workshop on tool design and development with Multilateral Fund staff members in Montreal. This was a critical opportunity for our team to collect input on design and functionality from key users.

FUTURE VISION

We have the opportunity to help fundamentally accelerate key global efforts to mitigate climate change. Amid changing national and international political environments, the Montreal Protocol is one of the strongest international agreements aiming to reduce greenhouse gas emissions. Moreover, the Montreal Protocol has received lasting support including from the US (unlike the Paris Agreement and other similar treaties). However, compliance with the Montreal Protocol partly hinges on successful, robust analysis—especially those that maximize the impact of ongoing investments from the Multilateral Fund. We look forward to rolling out this groundbreaking opportunity that will empower nations to design, select, and implement successful climate policies to reduce some of the world's most potent greenhouse gases.

Schmidt DSE team members Magali (right) and Sam (left) visited the United Nations offices in Montreal last fall to present and collect feedback on our prototype model and forge stronger ties with members at the UN, including at the Convention on Biological Diversity (CBD).

"The Schmidt DSE team is absolutely fantastic, inspirational, impactful, and visionary. At their workshop in Montreal we were able to clarify our team's vision for a tool that will have a real impact on the work we do. This was a rewarding experience because we were able to understand how a digital, open-access tool can empower users to design the Multilateral Fund's policies and activities that will protect the ozone layer, mitigate climate change, and maximize social outcomes."

TINA BIRMPILI
Chief Officer, Multilateral Fund for the Implementation of the Montreal Protocol

PATHWAYS TO COLLABORATIVE LAND MANAGEMENT

Schmidt DSE is collaborating with Indigenous and local communities, local officials, and national agencies on land management opportunities that **leverage traditional ecological knowledge and innovative data science.**

CO-DESIGN INDIGENOUS ENVIRONMENTAL STEWARDSHIP

Since time immemorial, Indigenous peoples and local communities have successfully stewarded ecosystems in accordance with their knowledge, innovations, and practices. At the same time, we are facing a dual climate and biodiversity crisis. In the last fifty years, for example, global vertebrate wildlife populations have dropped by about 73%. If we are to significantly address and reverse this devastating loss, we must support effective practices for promoting biodiversity that center leadership from Indigenous peoples and traditional ecological knowledge.

WHERE WE ARE

Schmidt DSE is part of a growing worldwide effort to co-design environmental goals, tools, and practices with Indigenous communities. Co-design helps ensure that environmental stewardship is grounded in multiple ways of knowing (including traditional ecological knowledge and western science) and that Indigenous sovereignty and rights to land management are honored in these efforts.

We are working with the Karuk Tribe's Wildlife Team in Northern California to develop an AI-powered visualization tool and broader data platform. This effort supports the Wildlife Team to parse and analyze wildlife data collected on their ancestral lands. Importantly, the platform, tool, and the data passed through it are fully owned and solely accessible by the Wildlife Team so that it maintains sovereignty and privacy over their data. This partnership has been very significant in building our understanding of the space and practical considerations around Indigenous digital sovereignty. Last year Schmidt DSE also significantly grew relationships with additional Indigenous and non-Indigenous collaborators who are working to advance Indigenous data sovereignty in environmental stewardship worldwide.

2024 HIGHLIGHTS

- Co-designed AI visualization tool and data platform for wildlife data analysis with the Karuk Tribe's Wildlife Team in northern California.
- Developed an AI tool to help identify culturally-significant animal sounds.
- Visited Karuk territory to train and collaborate with their Wildlife Program on data science tools and research.
- Led a side event at the global biodiversity conference COP16.
- Prepared three relevant academic papers and one white paper.
- Hired two postdoctoral researchers to lead these efforts.

CO-DESIGN INDIGENOUS ENVIRONMENTAL STEWARDSHIP

OUR IMPACT

In 2024 we made significant advancements with the Karuk Wildlife Team. **Our first tools in development help sort and make sense of camera trap data.** We are preparing to develop and deploy computer vision in this pipeline for AI-facilitated monitoring. We hired postdoctoral researcher Felipe Montealegre-Mora and undergraduate interns Danielle Louie, Max Taniguchi-King, and Nithya Appannagaari to support this effort. We are leveraging UC Berkeley's open-source software Jupyter Notebooks, as well as past research from the Department of Environmental Science, Policy, and Management to help with their biodiversity monitoring work.

Another tool we are helping develop uses AI models to identify animal sounds, with a special focus on culturally significant, non-avian species (such as wolf). **This project drives technological innovation and underscores the critical integration of cultural priorities in biodiversity conservation.** We used over 10,000 audio clips collected from field data to retrain 4 distinct classes of machine learning models, improving our ability to detect several species of insects, frogs, and mammals in California. We also developed a small open source application that will make it easier for researchers and communities to label local sound data and create custom models to improve species detection. Schmidt DSE postdoctoral researcher Amy Van Scoyoc leads this work along with undergraduate interns Ann Basil, Camille Dayton, Diana Tao, Ethan Bailey Aquino, and Rohit Raman. This effort is part of a collaboration with the State of California and UC Berkeley's Geospatial Innovation Facility.

Last summer our staff visited the Karuk Wildlife Team in Orleans, CA to install data collection and analysis software and train their team on usage. As part of our visit we were honored to learn cultural history and traditional ecological knowledge from tribal members, witness traditional practices including cultural burns and meals, and participate in a river float.

OUR IMPACT *(continued)*

In 2024 we also led relevant national and global workshops to help disseminate our work and best practices in this field. **Notably, we organized and led a side event at the United Nations Biodiversity Conference (COP16)—the largest biodiversity conference to date—which included 190 participating countries in Cali, Colombia in October.** Schmidt DSE's Magali de Bruyn partnered with Hindou Oumarou Ibrahim, President of the Association for Indigenous Women and Peoples of Chad, who moderated our event on the intersection of environmental stewardship, traditional ecological knowledge, data science and AI, and Indigenous data sovereignty. This helped deepen our understanding of the field and laid groundwork for our Indigenous digital sovereignty and environmental stewardship work internationally.

Finally, we are preparing three academic papers with the Karuk Wildlife Team that provide technical findings on wildlife monitoring and establish the Tribe as environmental data science and conservation experts. **One paper offers groundbreaking analysis on how the Wildlife Team's traditional knowledge, research, and citizen science efforts support elk restoration and presents a potential model for Indigenous-led conservation efforts worldwide.** This paper will be submitted for peer review in early 2025. We are also producing a white paper with guidance on technical implementation of Indigenous digital sovereignty with Indigenous academic partners. This white paper was developed with Schmidt Futures Fellow Annie Snyder.

Magali (third from right) and the directors of la Red de Adolescentes y Jóvenes Indígenas de Amazonas (the Network of Indigenous Youth and Young Adults of the Amazon) at COP16.

Schmidt DSE's Magali de Bruyn (center) and Hindou Oumarou Ibrahim (right) organized a successful side event on AI and Indigenous biodiversity monitoring and stewardship.

CO-DESIGN INDIGENOUS ENVIRONMENTAL STEWARDSHIP

FUTURE VISION

We are continuing to co-design the tools and data analysis workflows with the Karuk Wildlife Team, as well as continuing the process of installing the data platform on their servers. We will provide ongoing training and co-working sessions so that their team can fully utilize and refine the tooling. We look forward to continuing our collaboration.

In 2025 we will continue building connections with Indigenous communities in the Amazon and internationally. We are also excited to further support the work of the International Indigenous Forum on Biodiversity, which is active in the United Nations. Finally, we are hoping to convene academics, community organizers, and youth together in a working group on the technical implementation of Indigenous digital sovereignty for environmental stewardship and AI development.

"Our collaboration with Schmidt DSE is deeply meaningful because their team respects and uplifts the needs, traditional ecological knowledge, and cultural practices of our communities. Their approach prioritizes Indigenous-led research and decision-making, ensuring we retain control over our data and knowledge while avoiding the harmful patterns of extractive research. Unlike approaches that exploit Indigenous cultures without offering genuine benefit to those communities, Schmidt DSE works to build trust and promote equitable resource sharing. Together, we aim to amplify Indigenous leadership and voices, recognizing the value of thousands of years of harmonious living within our ancestral ecosystems and the interconnectedness we have with all living beings. By fostering respect, trust, and equitable partnerships we can chart a path toward a more balanced and sustainable relationship with the natural world for the benefit of all."

KARUK WILDLIFE TEAM

IMPROVE WILDFIRE RECOVERY IN NATIONAL PARKS AND BEYOND

Public lands management agencies oversee hundreds of millions of acres of lands nationwide that serve as critical habitat refuge and act as vital carbon sinks. Wildfires are some of the greatest threats to the health of species and ecosystems that depend on these places. Agencies like the National Park Service (NPS) face grave challenges in addressing wildfires from climate change to underfunding. While fire prevention and preparedness typically receive more attention, fewer efforts are dedicated to recovery: specifically, how to manage landscapes in time-sensitive periods after a fire.

WHERE WE ARE

Schmidt DSE is partnering with NPS to develop a first-of-its-kind suite of tools to help land managers make quick and informed decisions that support post-fire recovery in drylands and arid ecosystems. Data science offers a unique opportunity to improve tracking, management, and restoration of burned areas. In this project we are using both observed and modeled data in order to help scale recovery efforts in the face of an ever-changing climate and across the immense diversity of US landscapes. As a testament to the value of this collaboration, the NPS has directly invested in Schmidt DSE's research on this project.

HIGHLIGHTS

- Pilot testing tool in Joshua Tree National Park and the Mojave National Reserve that allows land managers to rapidly assess and respond to wildfires.
- The National Park Service is funding three new positions at Schmidt DSE in recognition of our contributions to this project.
- Hired a data visualization expert to support this effort.

IMPROVE WILDFIRE RECOVERY IN NATIONAL PARKS AND BEYOND

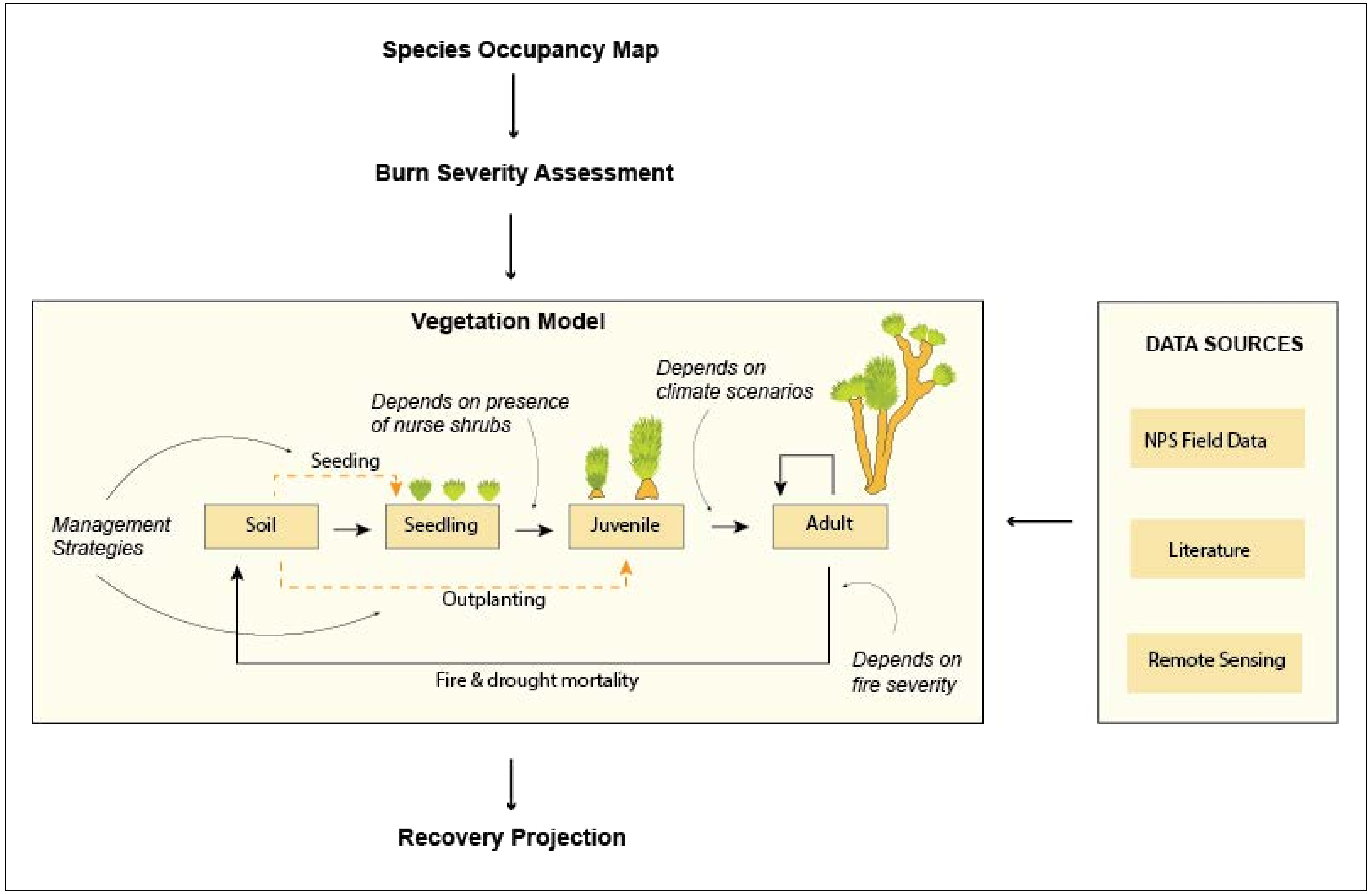
OUR IMPACT

We are pilot testing a tool in Joshua Tree National Park and the nearby Mojave National Preserve with NPS and the Bureau of Land Management (BLM). The tool uses satellite imagery to rapidly assess fire boundaries and appropriately tunes the severity assessment for the local desert ecosystem. **This allows for land managers to receive real-time information and make quicker management decisions.** In the future and with additional development, the tool will:

- Include desert-specific data so that land managers can better predict long term impacts on wildlife and plants. Eventually we hope to expand the tool to other types of ecosystems too (e.g. chaparral and sagebrush habitats).
- Factor in landscape complexities such as varying vegetation, temperatures, and topography and link recovery dynamics to future climate change scenarios.
- Incorporate observed data collected by NPS and other management entities, with satellite data and vegetation modelsThis will help extend the tool's capabilities beyond severity mapping to include recovery predictions.
- Communicate wildfire severity in other types of landscapes that are newly fire-prone.

We significantly expanded our partnerships with collaborators in NPS and other agencies working on wildfire recovery. For example, we:

- Presented the tool at an NPS conference in San Francisco last April.
- Met with stakeholders at the Mojave Region Native Plant Restoration Workshop to explore vegetative succession data sets developed by collaborators in the tool pilot region.
- Built relationships with staff at USGS and BLM, state agencies, and with Tribal communities to help ensure the tool is useful beyond NPS-managed lands.



Workflow for a dynamic post-fire recovery model for Joshua Trees (*Yucca brevifolia*). Model structure and parameterization is based on diverse data sources, including field monitoring data, literature data, and remote sensing. The model is patch-based, i.e., divides the landscape into units to capture spatial heterogeneity. Transition probabilities (arrows) describe the likelihood of each patch to move from one state to another, either without intervention (black) or under specific management strategies (color), and are conditioned by species interactions, present and future climate, and fire characteristics. When fully implemented, the tool will identify priority areas for conservation action and fire management.

IMPROVE WILDFIRE RECOVERY IN NATIONAL PARKS AND BEYOND

OUR IMPACT *(continued)*

NPS is committed to our collaboration and as a result has awarded funding to Schmidt DSE for two postdoctoral research positions and a data analyst. We are thrilled to bring on Lucia Layritz and Maya Zomer who have extensive expertise on fire recovery and fire ecology. Lucia's previous research has focused on investigating how climate change will impact ecosystem regeneration abilities in the future and she brings expertise in vegetation and climate (scenario) modeling. Maya's previous research focused on the interactions between fire, climate, and plant traits and brings expertise in the ecophysiology of plant regeneration. We hired a data visualization expert, Amanda Anderson-You, who will be instrumental in ensuring the tool is accessible and useful for land managers. This year we will hire an additional data analyst with aforementioned funding from NPS.

FUTURE VISION

While our pilot project is focused on Joshua Trees in Joshua Tree National Park, we are designing and engineering flexible modeling tools that can scale across ecosystems. This may include include chaparral shrublands in California's Santa Monica Recreation Area and Channel Island National Park, sagebrush habitat in Idaho's Craters of the Moon National Monument & Preserve and City of Rocks National Reserve, and in Whitebark pine forest habitats at Oregon's Crater Lake and California's Lassen Volcanic National Parks. Each of these ecosystems face novel management challenges under the effects of climate change. Ultimately, we aim for the tool to cover a large latitudinal gradient of ecosystems that vary in both water limitation and proneness to fire (and are expected to continue changing due to climate instability). We also hope to expand the tool usage for more public agencies and Tribal nations.

Schmidt DSE staff Nick (left) and Maya (right), with Jay Goodwin (center), Vegetation Branch Chief at Joshua Tree National Park, visited historic wildfire locations in the park to understand fire impacts on Joshua Tree populations.

"Historically, fire severity and fire risk tools have not worked well in desert ecosystems because these tools are usually developed for forests, where plant productivity, biomass, and density are much higher. Schmidt DSE's work is very helpful to fire and resource managers working in the desert because it's specifically tailored to those landscapes."

JAY GOODWIN

Former Vegetation Branch Chief at Joshua Tree National Park

ADDRESS CLIMATE-CAUSED WATER SCARCITY

Snow plays a critical role in storing and supplying fresh water to billions of people worldwide. In California alone snowmelt is responsible for about 33% of the state's annual water supply. Nationwide this number jumps to between 60-70%. Globally, about 1.5 billion people depend on snowmelt-fed water systems and many are in climate-vulnerable regions. This includes communities in the Himalayas, Andes, and other mountain ranges. However, the amount of snow varies significantly from year to year. This variability is ever-increasing with climate change and can have disastrous impacts. For example, severe flooding is common in seasons with significant, rapid snowmelt. Conversely, too little snowmelt is disastrous for crops and threatens drinking water sources.

One of the biggest challenges in snow science right now is identifying accessible methods for measuring the volume of water in snow in real-time. While current measurement methods are accurate, the most accurate methods require large amounts of capital to acquire measurements (i.e. flying LiDAR planes, satellite remote sensing, or using SNOTEL data). Moreover, the same methods are vastly time-consuming and largely unhelpful for making real-time water management decisions.

WHERE WE ARE

Schmidt DSE is working to address these challenges in water security by developing an AI-powered data product that will provide free, life-saving snow and water data to global water managers, scientists, and the general public. This has the potential to significantly improve the reliability of snowmelt forecasting and help communities better prepare for extreme climate events including floods and droughts. The tool will leverage freely-available global satellite datasets and be accessible via a web-based platform. Presently we are working to document and optimize the data pipelines used in California's Sierra Nevada region. We are focusing on this region initially because a significant portion of the state's snowpack originates here and because it is a data-rich environment, which allows us to prototype first-generation tools with higher levels of confidence and accuracy. Based on this work we hope to build and scale tools for other snowmelt-fed geographies in the future.

HIGHLIGHTS

- Developing an AI-powered data product that will provide free data to water managers, scientists, and the public.
- Creating a suite of recommendations to help optimize pipelines and data usage for staff at the California Department of Water Resources.

ADDRESS CLIMATE-CAUSED WATER SCARCITY

OUR IMPACT

In 2024 we were thrilled to bring on Prapthi Agarwala, a Schmidt Futures Fellow, who designed a process to collect stakeholder input so that we can tailor the tool to meet the needs of key users. Prapthi has led interviews with the state's Department of Water Resources as well as local water managers, academics, and private companies in the Sierra Nevada with shared interests in snowmelt monitoring. Early analyses of these interviews demonstrates that despite a wealth of data, decision making processes that work to incorporate those data are often inefficient. **Our recommendations will focus on optimizing pipelines and data usage for consistent, data-driven decision making within and across watersheds.**

We also developed relationships with fellow researchers at the UC Berkeley Central Sierra Snow Lab in California, the International Centre for Integrated Mountain Development (ICIMOD) in the Himalayas, and the Nepal Development Research Institute (NDRI). These three groups provide local data that will be used to validate our global model. At the same time, we are working to determine whether free, globally-available datasets like satellite imagery provide enough information to be useful for local prediction.

FUTURE VISION

We aim to release our initial research, tools, and recommendations for snowmelt monitoring to staff at the Department of Water Resources in 2025. We also look forward to additional interviews with stakeholders internationally as we work to scale this project beyond California.

OPEN AND DEMOCRATIZE METHODS FOR GEOSPATIAL DATA ANALYSIS

NEW

Geospatial data forms the foundation of environmental research but accessing and effectively using its necessary software, skills, and datasets is often a challenge. Furthermore, there is significant change afoot in how geospatial data is processed and shared, with cloud-native analysis workflows becoming increasingly common and sometimes necessary. On top of this, the high costs of software licenses, cloud computing, and data access create substantial barriers that limit the impact and effectiveness of this work. The future of geospatial data analysis demands removing these barriers to improve access and inclusion in the environmental and data science fields more broadly. Imagine a future in which a climate scientist, an ecologist, and a city planner can seamlessly collaborate through the cloud and explore land management strategies that combine diverse data. This data could include climate projections with species evolution models and land usage boundaries from Nairobi to New York City. Schmidt DSE believes this future is possible and has launched a brand new initiative called GeoJupyter to meet this unique opportunity.

WHERE WE ARE

We are leveraging the Jupyter ecosystem, which encompasses open-source software maintained by a global community that empowers collaboration, accessibility, and innovation in data science and research. Its interactive tools such as Jupyter Notebooks enable users to explore, visualize, and share insights while promoting data reproducibility and transparency. Nearly 10 million Jupyter notebooks have been made public by GitHub users and Nature deemed Jupyter one of 10 computer codes that transformed science. Schmidt DSE's Co-Director Fernando Pérez co-founded Project Jupyter and is instrumental to the emerging GeoJupyter effort. We are also grateful to our collaborators at the UC Berkeley Geospatial Innovation Facility for lending their relevant expertise in teaching and research.

HIGHLIGHTS

- New in 2024.
- A collaborative effort, building on a close partnership with European Open Source developers (QuantStack in Paris, Simula in Oslo) and funded by the European Space Agency.
- Prototyping new open source tools for geospatial data analysis that leverage the open-source Jupyter ecosystem to vastly improve collaboration, efficiency, accessibility and reproducibility in geospatial data analysis.
- Conducting user interviews to better understand current pain points, needs, and future vision from a variety of users in education, research, industry, and others.
- Hired a new staff member to support development and collaborations with leading experts in geospatial research and software engineering.

OPEN AND DEMOCRATIZE METHODS FOR GEOSPATIAL DATA ANALYSIS

NEW

OUR IMPACT

Although we are in the very early stages of this project our collaborators at Quantstack, with seed funding separately provided by the European Space Agency (ESA) have already developed a prototype and Schmidt DSE will support development. This prototype leverages both the Jupyter ecosystem and the open source QGIS software, and is being openly developed in the JupyterGIS repository. It currently provides essential capabilities including:

- **Interactive Geospatial Mapping:** Visualizes geospatial data in JupyterLab, which enables more detailed, interactive, and confident geospatial analysis.
- **Collaborative Editing:** Allows multiple users to interact with data simultaneously, while ensuring that users retain full control over their data.

Schmidt DSE hired Matt Fisher, Research Software Engineer, to help lead this project. This role serves two purposes: first, to provide software engineering expertise and second, to support community building and help bring together leading experts working at the intersection of geospatial data and software engineering.

Currently, our team is prioritizing convening members of the geospatial research community and gathering feedback on our work. To date we have brought together over 20 leading geospatial researchers and open source software engineers who are eager to help build our vision. We have met regularly over the past year to share insights and develop strategy going forward, and have begun interviewing users to identify leading features to prioritize. Finally, we are developing roadmaps for contributions and collaboration from the Open Source Community. For more information please visit our website.

FUTURE VISION

Schmidt DSE will continue refining and enhancing prototypes to ensure it meets the specific needs of geospatial programmers and scientists in 2025. Upcoming community events in the works include a workshop at the Community Surface Dynamics Modeling System (CSDMS) annual meeting and a multi-day, hybrid hackathon in May 2025.

Moreover, we are excited to be among the first users of GeoJupyter and plan to integrate it into additional Schmidt DSE projects. For example, GeoJupyter will be important to a project led by Schmidt DSE postdoctoral researcher Kristin Davis in collaboration with UC Berkeley’s Stone Center for Environmental Stewardship. Kristin is studying how urban development affects wildlife migratory patterns in the greater Yellowstone area of Wyoming and aims to leverage geospatial mapping to support urban planning efforts, including optimizing building siting and fencing designs to better accommodate wildlife movement. This will help improve usability, incorporate feedback, and expand GeoJupyter’s functionality so that the prototype aligns with the community's evolving requirements.

THE TEAM

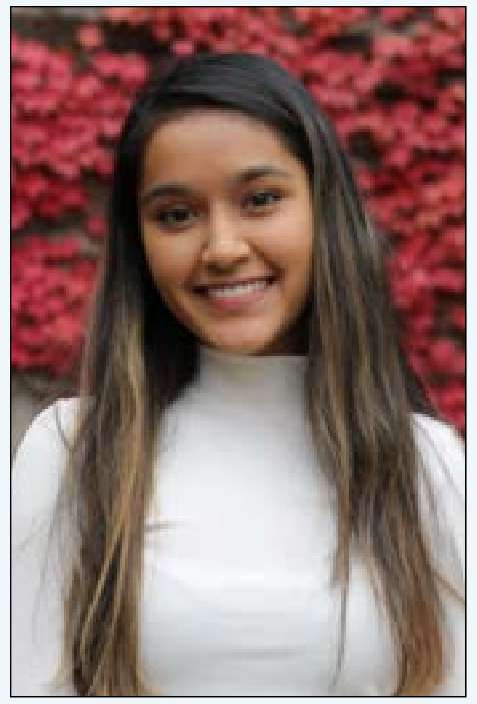
SCHMIDT DSE has grown to 32 contributors including faculty advisors, postdoctoral researchers, program staff, and undergraduate interns. We are dedicated data scientists, software engineers, program managers, communicators, and designers who love the work that we do! One of the most exciting testaments to Schmidt DSE's early successes is that several collaborators have committed additional funding to our work together. This significant validation in our research increases our potential impact and our own direct investments in the work that we do.

First row (from left): Suzanne Spencer, Annie Snyder, Ciera Martinez, Maya Weltman-Fahs, Sam Pottinger, Kristin Davis, Amy Van Scoyoc, and Fernando Pérez. Second row (from left): Carl Boettiger, Prapthi Agarwala, Kevin Koy, Doug McCauley, Nick Gondek, Maya Zomer, Lucia Layritz, Danielle Louie, Felipe Montealegre-Mora, Justin Brashares, and Matt Fisher. Third row: Brookie Guzder-Williams. Not pictured: Amanda Anderson-You, Ann Basil, Camille Dayton, Carolyn Zhuang, Dhruva Bhagwat, Diana Tao, Ethan Aquino, Evan Lingo, Nithya Appannagaari, Max Taniguchi-King, Magali de Bruyn, and Rohit Raman.

SPOTLIGHT — SCHMIDT FUTURES FELLOWS

We have the honor of hosting two fellows from the Technologists for Global Transformation program at Schmidt Futures: Prapthi Agarwala and Annie Snyder. Both Prapthi and Annie's contributions have been fundamental to advancing our mission and amplifying our impact.

PRAPTHI AGARWALA



At Schmidt DSE Prapthi designed a strategy to collect input on managing snowmelt-fed water supplies in the Sierra Nevada. Her analytical and communications skills have ensured a successful stakeholder interview process, and she will synthesize findings and make recommendations for optimizing water management decision making. Subsequently, Prapthi will help guide this project as it scales globally.

ANNIE SNYDER

Annie was instrumental in developing the first draft of Schmidt DSE's white paper: "AI and Indigenous Data Sovereignty: Responsible Use for Biodiversity Monitoring." She helped lead our communications strategy for COP16 in Cali, Colombia, including writing and designing materials and coordinating our team's side event. Annie is also part of the planning committee that will host a forthcoming workshop on campus called "Digital Sovereignty with Data Vulnerable Communities."

MORE 2024 ACCOMPLISHMENTS

Our talented staff members achieved additional successes including three paper publications and the development of an international workshop on AI. Brookie Guzder-Williams, Senior Data Scientist, published "Measuring Change in Urban Land Consumption: A Global Analysis" in MDPI. Ciera Martinez, Senior Program Manager, published "The importance of habitat type and historical fire regimes in arthropod community response following large-scale wildfires" in Global Change Biology. Sam Pottinger, Senior Research Data Scientist/Software Engineer, led an AI Ethics workshop last summer on campus in partnership with three universities in the US and Australia.

VALUES AT SCHMIDT DSE

Accessibility

Schmidt DSE is part of the "**open science**" movement that seeks to make scientific research more accessible, transparent, and collaborative. Accessibility is too-often undervalued and is critical to fostering open science that works for and includes everyone. As proponents of open science we create and support open software, tools, data, and knowledge for data management and analysis. When possible we pursue work that allows for open licensing. Notably, accessibility is one of the four **FAIR principles** (findability, accessibility, interoperability, and reuse of digital assets) that underlie open science work.

Transparency

Transparency is critical in our processes and products so that others can reproduce our work. Moreover, transparency helps ensure that those involved in our projects can better understand and interrogate our decision making. While it may not be possible or practical to document each decision that has been made in our work, we are committed to communicating all information possible that can help shed light on our methods.

Data Sovereignty

In many cases data should be open and freely accessible to everyone, but in others we may protect privacy to avoid causing harm. In the environmental and data science fields, harm occurs when cultural data is misrepresented or inappropriately shared without consent from Indigenous groups. Particularly when collaborating with Indigenous groups, we may not make our work accessible to the public; rather it may be fully owned and maintained by the Indigenous group(s) themselves. We abide by appropriate laws and rules when working with data including the **CARE principles for Indigenous data governance** (collective benefit, authority to control, responsibility, and ethics). More broadly, we also avoid exposing sensitive information on locations of endangered species and other geographic data, or sharing personal data without consent.

GRATITUDE

We are deeply grateful to the talented colleagues, collaborators, and supporters who were instrumental in our collective achievements in 2024. We see an immense opportunity to continue developing cutting-edge data science, deepening our partnerships, increasing the accessibility of our work, and expanding our positive impact with more tangible environmental solutions generated worldwide. We look forward to staying in touch as we tackle the exciting opportunities and challenges on the horizon this year and beyond.

Thank You!

CONTACT US:
dse@berkeley.edu