

SECURE WATER FUTURE

Floodwaters connecting floodplains at the confluence of the Cosumnes and Mokelumne Rivers, California Delta. Using Principal Component Analysis (PCA), the colors indicate different features of the landscape. Importantly, blue colors signal areas of flood water inundation, providing both a visually pleasing image and a useful reference point to understand the flow of water, March 13, 2017. Image credit: Prof. Joshua Viers. Digital Image. Principal Components Analysis of 5 Band RapidEye Imagery.



Camping along the Green River in Utah during CASA ELE, 2023.

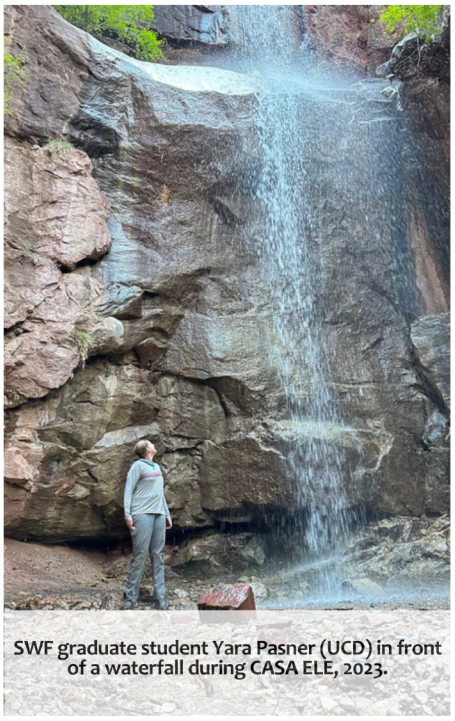
YEAR TWO REPORT (2022-2023)



SWF graduate student Humberto Flores Landeros (UCM) installing an Eddy Covariance Flux Tower at the UCM Experimental Smart Farm, 2023.



Group photo of the Secure Water Future team in Berkeley, CA, 2023.



SWF graduate student Yara Pasner (UCD) in front of a waterfall during CASA ELE, 2023.

Securing a climate resilient water future for agriculture and ecosystems through innovation in measurement, management, and markets

USDA-NIFA Award No. 2021-69012-35916
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Project Director: Dr. Joshua Viers, University of California, Merced

Partners: Utah State University; New Mexico State University; University of California, Davis; University of California, Berkeley; University of California Agriculture and Natural Resources; University of California, Los Angeles; Public Policy Institute of California; Environmental Defense Fund; Southwest Climate Hub.

This document summarizes Year Two (2022-2023) activities of the Secure Water Future (SWF) SAS CAP project. This report was compiled with support from Dr. Joshua Viers, Sarah Naumes, Kal Li, Wendy Haw, Luisse Alexie Calderon, Adam Crawford, and Jack Severson. We encourage you to follow our ongoing work at securewaterfuture.net.

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CASA ELE graduate student participants on a snow hydrology snowshoe hike in Utah, 2023.

CASA ELE graduate student participants Uduwarage Anushka Chathuranga Perera (NMSU), Naivy Rodal Morales (UCM), Yara Pasner (UCD), Saddy Pineda (USU), Aaron Watt (UCB), and Gabriela Sancho Juárez (USU) hiking along the Green River, 2023.





Tractor on the UCM Experimental Smart Farm displaying site plans, 2022.



Students at UCM during the start of the Water Hack Challenge, 2023.

Secure Water Future Project Director Joshua Viers, Ph.D. (UCM), showcasing the site plans for the UCM Experimental Smart Farm, 2022.





Tilling machine at the UCM Experimental Smart Farm, 2022.

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PROJECT LEADERSHIP CONTACTS



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Dr. Joshua Viers is a Professor of Water Resources Management in the School of Engineering at UC Merced. He also serves as the Associate Vice Chancellor for Interdisciplinary Research and Strategic Initiatives in the Office of Research and Economic Development (ORED) where he supports the Vice Chancellor for Research, Innovation, and Economic Development. He has previously held positions as the Associate Dean for Research for the School of Engineering and campus Director of the Center for Information Technology Research in the Interest of Society (CITRIS). Josh has led UC Merced's efforts to build an Experimental Smart Farm, develop a joint industry-university consortium on ag-food-tech research, and convene several universities in developing water accounting methods to secure a climate-resilient water future. He teaches environmental engineering with a focus on water resources management, geospatial analytics, ecosystem restoration, and sustainability.



SARAH NAUMES

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Sarah Naumes is the managing director of Secure Water Future. She brings her expertise in strategic project management and passion for fostering impactful research to the team. Since joining UC Merced in 2019, she has been instrumental in securing some of the university's most prestigious grants, including awards from the National Science Foundation (NSF), United States Department of Agriculture (USDA), Economic Development Administration (EDA), National Aeronautics and Space Administration (NASA), National Endowment for the Humanities (NEH), and other key state and federal agencies. With Secure Water Future, Sarah catalyzes translational team research into actionable outcomes. Balancing her efforts between research, community outreach, and team leadership, she employs a holistic strategy, collaborating closely with partners to guarantee the success of team projects from inception to conclusion.



Participants of Finding Common Water rafting on the Tuolumne River, 2022.

WHAT IS SECURE WATER FUTURE?



SWF graduate student Masoumeh Hashemi (USU) rafting on the Green River, Utah, during CASA ELE, 2023.

Secure Water Future is a collaborative of investigators from across the semi-arid western US aiming to improve agricultural and environmental water resilience. To achieve climate change adaptation in western agriculture and ecosystems, we need better information and flexible institutions for our most precious resource—water.

Currently funded by the US Department of Agriculture, the team combines the expertise of researchers, extension specialists, and educators working across California, New Mexico, and Utah with applicability to the western US and beyond.

Water-scarce regions in the western US need new management strategies to face climate change and drought, grow food for the country, and maintain ecosystem function. The pressure of increased human population and footprint, increased frequency and severity of drought, and reliance on dwindling water sources for agriculture, environment, and communities has resulted in a broken system with limited flexibility. With community advisor participation and guidance at every step, this project creates improved climate resilience and adaptation, understanding, and outcomes for data-driven decision-making among growers and water managers. The team includes experts in climate and water information, modeling, institutional design, multidisciplinary research, education, and actionable outreach.



White Sands National Park, New Mexico, 2023.



Sarah Null, Ph.D. (USU), and SWF graduate student Gabriela Sancho Juárez (USU) during CASA ELE, 2023.

The collaboration brings the findings of these experts together into localized use cases to serve as illustrations of the research adapted to local conditions and constraints. Through three use cases (San Joaquin Valley, CA; Mesilla Valley, NM; Cache Valley, UT) with differing water laws and similar orchard and row crop agricultural systems, snow-fed water systems, and conjunctive use infrastructure, we synthesize opportunities to increase flexibility and water security in the semi-arid western US.

As a solution, with comparatively low infrastructure costs and a short time to develop, iterate and deliver, this project investigates and develops data-driven decision-making tools and institutional design recommendations based on improved water measurement, management, and markets to achieve water security. Innovative water markets offer flexibility in management, especially when supported by timely, transparent, and accurate water use and information and scaled climate data in trading locations. Leveraging advances in the technologies around measurement, from sensors to instrumentation and information, and assembling existing data platforms around water and climate information facilitates participation in novel water management strategies and water markets. One output of the program is a dashboard for data-driven decision-making to support adaptation to climate change, projected climate extremes, especially multi-year droughts, from field to regional scales. Included in the dashboard will be water budget accounting including evapotranspiration – one of the most difficult components of the water budget to calculate – as well as new climate projections, and groundwater recharge scenarios.

By coupling hydro-economic and life-cycle assessment with water accounting and regional climate projections, the project goal is to evaluate and enable water trading for climate resilience in agricultural and ecological systems in the Southwestern US.

SELECTED ACCOMPLISHMENTS

Project Management

• Maintained project infrastructure to facilitate synergy across the four initial research teams and the education and Extension teams.
• Strengthened the internal reporting dashboard to track activity over the entire duration of the project.
• Strengthened SWF Womxn of Water (WOW), enhancing its programs and outreach.

Research

• Established a Team Science research team dedicated to fostering cross-disciplinary research on the operations of large, dispersed teams addressing climate change and its impacts.
• Held two in-person collaboration meetings to further facilitate team coherence.
• Hosted workshops and panels at the American Water Resources Association summer conference (AWRA 2023).
• Advanced the development of a water data decision dashboard.
• Published initial peer-reviewed papers on forecasting and crop-climate impacts.
• Convened water regulators and community advisors from California, New Mexico, and Utah to discuss water measurement and reporting needs for water markets.
• Submitted a collaborative paper that is under review about the current tools in measuring and validating water budgets at many scales

Education

• Launched the second year of the Climate Adaptation Science Academy Experiential Learning Expedition (CASA ELE) for affiliated graduate students.
• Hosted collaborative work sessions with graduate students (Shut Up and Write!) to enhance research efforts and strengthen our student network.
• Launched the UC Water Academy, a program designed to facilitate the next generation of water leaders, with mentors and graduate students from within the UC system.
• Executed a 72-hour hackathon (Water Hack Challenge) for undergraduate students in California.
• Held the second week-long summer camp about water and equity for local middle school students in Merced, California.

Extension

• Utilized information from our Year One public and community advisor survey to assess information needs, knowledge, and values as well as the potential barriers and benefits of water markets. The team is also using this information to help inform development of a water data decision dashboard.
• Collaborated with the UC ANR Water Webinar series.
• Held a game design summit to finalize the parameters of the Secure Water Future digital game. This was followed by four of our fellowship recipients collecting real water budget data for California, Utah, and New Mexico for game co-development.



Tuolumne River, 2022.

SWF TEAM STRUCTURE

Team Organization

There are over 80 members of the Secure Water Future team. These project affiliates represent various career stages, from full professors and vice presidents of organizations to undergraduate students. Members of the Secure Water Future team focus on issues relevant to California, Utah, and New Mexico, with applicability to the semi-arid western US.

SWF Teams

There are seven distinct teams within Secure Water Future, each tackling different challenges and simultaneously working together: RT1-Climate Integration, RT2-Markets, RT3-Management, RT4-Measurement, Extension, Education, and Team Science.

Ad Hoc Groups

Secure Water Future ad hoc groups include Womxn of Water (SWF WOW), the year two SWF CASA ELE cohort (13 graduate students), and the UC Water Academy cohort (11 graduate students).

Newly Affiliated Faculty

Prof. Erin Hestir – UC Merced Civil & Environmental Engineering
Prof. Marc Beutel – UC Merced Management of Complex Systems

Leveraged Projects*

AgAID (Viers, Medellin, Abatzoglou, Bernacchi);
CDFA Drought and Flood Impact Study (Medellin, Escriva-Bou, Abatzoglou, Viers);
EPA EAR (Kiparsky, Dahlke, Green Nylen, Bruce, Bruno);
UCOP LACA (Harmon, Naughton, Viers);
EDA F3 (Viers, Bernacchi);
River Partners Grayson Restoration (Viers, Hestir);
NASA – Point Blue (Hestir, Viers);
Extension Sorghum Project (Hestir, Viers)

*These are projects that were cross-indexed with more than one co-investigator. Leveraged projects illustrate the network of intersecting work of collaborators.



CASA ELE graduate student participants Saddy Pineda (USU), Naivy Rodal Morales (UCM), Gabriela Sancho Juárez (USU), and Humberto Flores Landeros (UCM) on the Green River, 2023.



CASA ELE participants at The Soda Station in Wyoming en route to raft The Gates of Lodore on the Green River, 2023.



CASA ELE graduate student participants Julia Klejmont (NMSU) and Britta Schumacher (USU) taking a break along the Green River, 2023.

TARGET AUDIENCE

During this reporting period, Secure Water Future has focused on several distinct target audiences based on our overarching mission of fostering sustainable and flexible water security for diverse communities.



Participants of the Water Hack Challenge at UCM presenting to judges and other contestants, 2023.

Academics

We engaged with scholars and researchers in water resources, climate change, and agricultural sciences. Our research findings are designed to add value to the ongoing discourse in these academic circles, offering data-driven solutions and insights.

Policy Makers

We have collaborated with governmental officials to ensure that our work is accessible to those who are creating and implementing policies.

Students

As the next generation of thinkers, innovators, and leaders, students are pivotal to driving change. We have prioritized their inclusion, offering them hands-on learning opportunities, internships, and experiential educational programs.

Agricultural Community Advisors

Given the emphasis of our research on water utilization in agriculture, growers, irrigation districts, and water managers constitute a major segment of our audience. Our findings aim to equip them with tools and strategies to optimize water use while ensuring the sustainability of their agricultural practices.

Ecosystem Managers

Our research also resonates with those responsible for preserving and nurturing diverse ecosystems. They can benefit from our climate resilience strategies and insights into sustainable water resource management.

Communities in Specific Agroecological Systems

While our case studies primarily revolve around three locations – San Joaquin Valley, CA; Mesilla Valley, NM; and Cache Valley, UT – the implications of our work go beyond these specific regions. These sites represent water-stressed, snow-fed, conjunctive-use agroecological systems. By studying them, we aim to develop solutions that can be applied to similar regions globally, broadening our audience to agricultural producers and ecosystem managers.



The Secure Water Future team listening to Measurement research team lead Alfonso Torres-Rua, Ph.D. (USU), 2023.



Secure Water Future team in Berkeley, CA, 2023.

Participants of CASA ELE rafting on the Green River, Utah, 2023.



UC Water Academy participants on a hike, 2023.

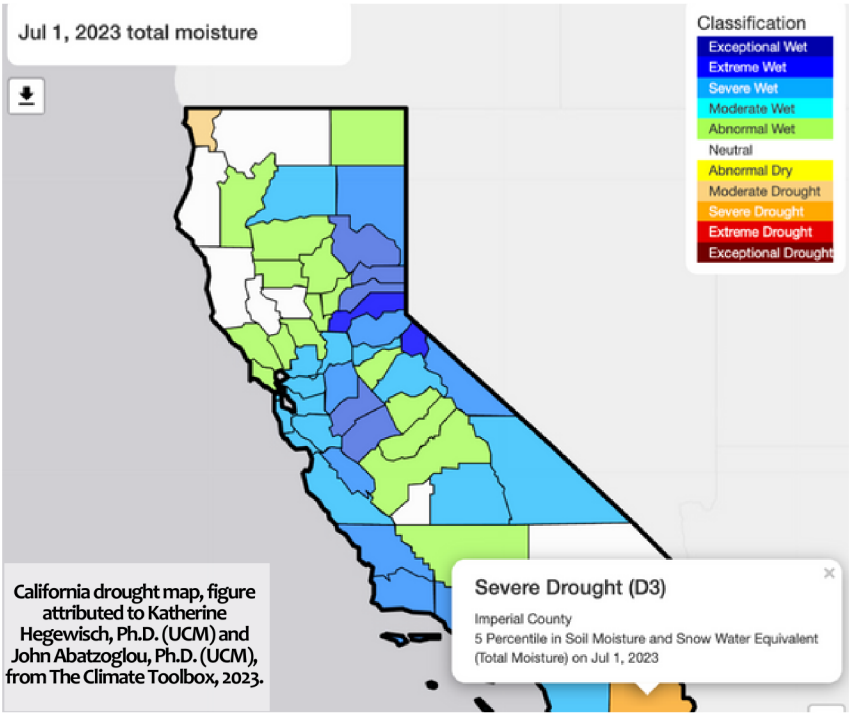
The Secure Water Future team's goal is to understand, enable, and envision water management strategies, empowered through data-enabled decision-making, for agricultural and ecological systems. The multidisciplinary team works with growers, irrigation districts, and ecosystem managers to adopt and adapt climate resilience strategies, train the next generation of multidisciplinary practitioners, and produce an online dashboard for data-driven decision-making.

RESEARCH

CLIMATE INTEGRATION



Climate Integration research team members John Abatzoglou Ph.D. (UCM) and Nick Santos (UCM), 2023.



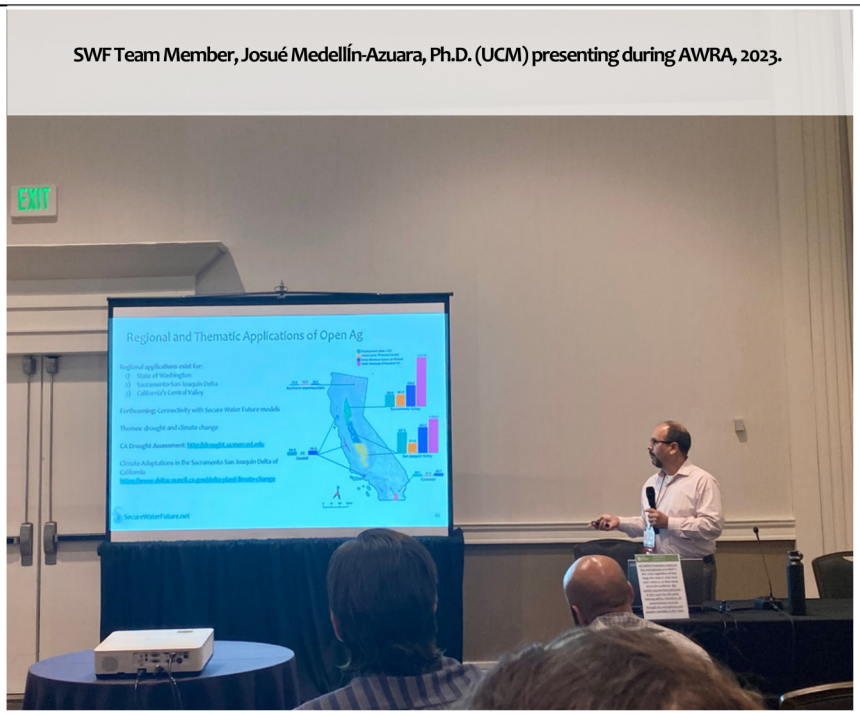
California drought map, figure attributed to Katherine Hegewisch, Ph.D. (UCM) and John Abatzoglou, Ph.D. (UCM), from The Climate Toolbox, 2023.

Our Climate Integration research team aims to improve the use of actionable information on current water use, seasonal forecasts, and climate projections to inform data-driven decisions made by stakeholders.

In year two, the team focused on (0) surveying existing water-centric decision support tools and accessible climate and water data feeds; (1) advancing the development of the water data decisions dashboard; (2) working on common climate science questions with the Groundwater USDA SAS CAP project; (3) integrating climate science with pressing research questions across other thrusts; and (4) publishing initial peer-reviewed papers on forecasting and crop-climate impacts.

In the next year, to improve the use of actionable information on current water use, seasonal forecasts, and climate projections to inform data-driven decisions made by stakeholders, the climate integration team will continue to make progress developing a water data decisions dashboard. Utilizing information captured in the multi-state needs assessment, the climate integration team is engaging in targeted semi-structured narrative interviews with key community advisors to further refine development. Simultaneously, the group continues to analyze existing tools and support the other research teams in a consultatory fashion.

MARKETS



SWF Team Member, Josué Medellín-Azuara, Ph.D. (UCM) presenting during AWRA, 2023.



Irrigation control gate in Cache Valley, Utah, during CASA ELE, 2023.

Our Markets research team aims to examine the institutional contexts and individual decisions that shape the potential for water markets to support agricultural, ecosystem, and community resilience while effectively managing impacts on third parties.

In Year Two, the team focused on: (1) collecting and analyzing data for and writing up a journal article that examines how economic models of water trading account for institutional, social, and environmental context; (2) convening water regulators and community advisors from California, New Mexico, and Utah to discuss water measurement and reporting needs for water markets and planning additional convenings on other topics; (3) exploring how water rights ownership evolved within and across sectors in the Mojave Desert following the introduction of a groundwater market, including the role water quality concerns have played in trading; and (4) beginning a literature review on the history and success of water markets for ecological sustainability.

In the next year, to examine the institutional contexts and individual decisions that shape the potential for water markets to support agricultural, ecosystem, and community resilience while effectively managing impacts on third parties, the markets team will hold additional convenings to better understand how institutional context affects the potential for water markets to enhance climate resilience for agriculture and ecosystems in our California, New Mexico, and Utah study areas. The markets team will further evaluate the potential for water markets by empirically evaluating market function (e.g., consolidation of permits among traders and interactions with groundwater quality) through a Mojave groundwater market case study.

MANAGEMENT



Nell Green Nylen, Ph.D. (UCB) & Josué Medellín-Azuara, Ph.D. (UCM) engaging in a discussion, 2023.



Secure Water Future team members collaborating over a meal in Berkeley, CA, 2023.

Our Management research team aims to assess long-term water resources variability in the southwestern United States using three key basins (San Joaquin Valley, CA; Great Salt Lake Basin, UT and Mesilla Valley, NM) as examples to determine dominant controls on water resources variability, and to evaluate environmental, management, and policy approaches for their sustainable management in future years.

In the next year, the management team is using a water balance approach to assess long-term changes in water availability and demands and ultimately identify approaches for compromise and multi-benefit water use in a changing climate. Water balances are a useful tool to quickly estimate natural runoff, account for depletions and streamflow, and estimate the effects of policy changes. We are evaluating novel water management strategies, including managed aquifer recharge, groundwater management, and water markets in California's San Joaquin Valley, New Mexico's Mesilla Valley, and Utah's Great Salt Lake Basin. We focus on water balances because they are effective tools for identifying promising solutions to secure water for beneficial uses with climate variability and an intuitive approach to communicate findings and results to broad audiences.

A complementary effort seeks to connect field-scale water budget measurements with the larger regional water balances to inform water and land use management strategies. Examples of field-studied management options include crop choice (e.g., comparing perennial crops like almonds and pecans to alfalfa and annual crops); irrigation technology (e.g., contrasting flood irrigation with drip or sprinkler systems); and land use (e.g., considering practices like fallowing or managed agricultural recharge). Scenarios with varied field land use aggregations will show the scaled-up water and agriculture implications of these different management alternatives.

MEASUREMENT



Participants of CASA ELE on a snow hydrology snowshoe hike in Utah, 2023.



Climate Integration research team lead John Abatzoglou, Ph.D. (UCM), 2022.

In Year Two, our Measurement research team conducted field research in Utah, New Mexico, and California. Each state has deployed or maintained equipment to improve water balance measurements, including eddy covariance flux towers in California and New Mexico from unique, under-studied land uses, which are especially relevant in the new socio-political landscape of the American southwest (fallowed fields, open bodies of water, and pasturelands).

Researchers are validating the USDA NASS Cropland Data Layer in New Mexico and Utah via remote sensing images from routine airplane flights and field surveys. This expansion from field to basin-scale increases our knowledge of types of crops (and therefore water use). But, just as important, it highlights the current level of precision and confidence in remote sensing versus ground-truthed tools used in agricultural water management. The Measurement Team has several comparison studies underway to address the growing interest in employing crop evapotranspiration data from the OpenET web platform in decision-making.

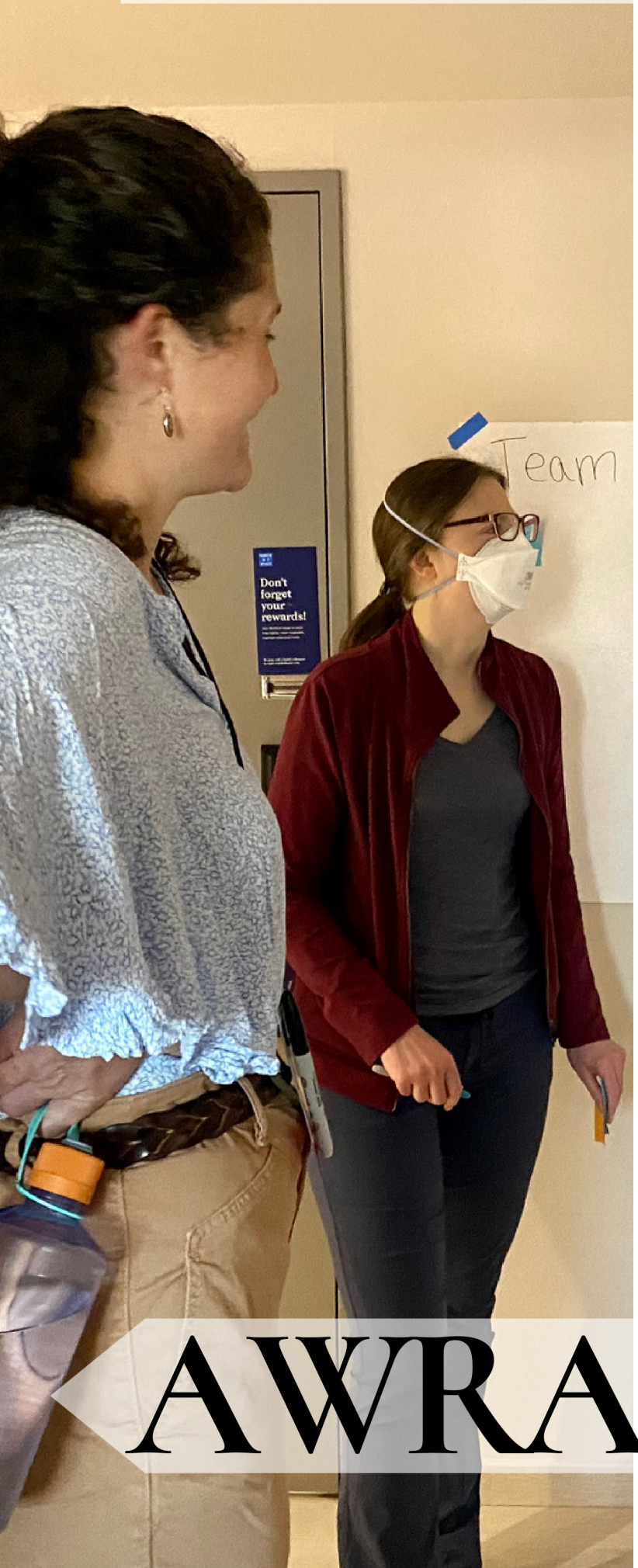
Graduate students in all three states are comparing OpenET estimates to field measurements. Research in New Mexico compares evapotranspiration field measurements to estimated evapotranspiration using locally calibrated crop coefficients derived from Harmonized Landsat Sentinel vegetation indices to use emerging datasets. Research in Utah is extending OpenET to water monitoring and conservation opportunities. From work in year two, we published a collaborative paper titled "A Decade of Data-driven Water Budgets: Synthesis and Bibliometric Review," highlighting the current tools for measuring and validating water budgets at many scales.

A major goal for the coming year is to increase the output of peer-reviewed publications. The measurement team has numerous publications currently in different stages of preparation including several comparisons of field measurements to OpenET. These comparisons inform decision-makers on the accuracy of OpenET for specific crops (e.g., alfalfa and pecan) in different regions in the arid western United States. Several measurement team members are working across research thrusts to improve team science and connections among research goals. The team will continue to collect and process field data from instrumentation installed in Year Two of the project.



Richard Heerema, Ph.D. (NMSU), and Masoumeh Hashemi (USU) at White Sands National Park, New Mexico, 2023.

Molly Bruce, J.D. (UCB) and Nell Green Nylen, Ph.D. (UCB) brainstorming during AWRA, 2023.



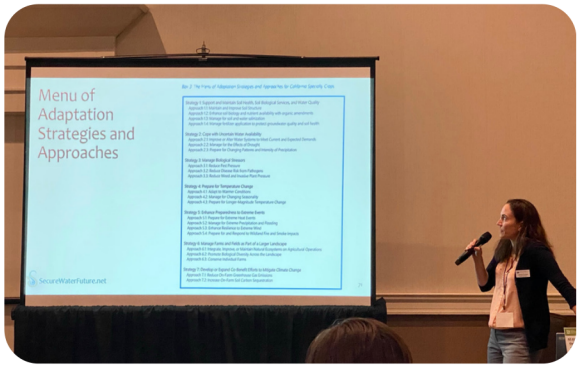


In July 2023, Secure Water Future was prominent at the American Water Resources Association (AWRA) summer conference, hosting a workshop and panels. This conference provided an invaluable opportunity for the team to review and align on project goals and deliverables and present work from the project's initial two years in a cohesive setting.

SELECTED AWRA PRESENTATIONS

Secure Water Future interns Adam Crawford (UCM) and Wendy Haw (UCM) presented their paper, "Enhancing University-Level Water Curriculum for Underrepresented Minority Students Through Outside-Of-Classroom Educational Opportunities: The Benefits of Hackathons and Water Games." This work originated from their involvement in the game development team and the facilitation of hackathon events at UC Merced.





Secure Water Future hosted the “Emerging Digital Tools for Effective Water Management in Water Scarce Regions” workshop at AWRA. Lauren Parker, Ph.D. of the USDA California Climate Hub, discussed emerging tools and best practices for effective water management. These tools included platforms for accessing and analyzing climate data, drought forecasts, agricultural evapotranspiration, and economic impacts of management decisions.

Andrew Ayres, Ph.D. of the Public Policy Institute of California (PPIC), presented “Defining and Trading Groundwater Rights in California’s Mojave Desert” during an AWRA panel about advances in water markets to achieve sustainability in water-scarce regions. Water scarcity in the Western US drives innovative responses to multiple demands, such as water trading and water banking. Using case studies, this panel discussed advances in water markets to improve flexibility, increase climate resilience, and address inequities.





Finding Common Water participants on the Tuolumne River, 2022.

EXTENSION



Extension team lead, Safeeq Khan, Ph.D. (UCM), 2022.

Extension provides educational resources and assistance to individuals and communities in various fields. To develop and implement a multifaceted Extension and outreach program that looks at the changing knowledge, behavior, and attitudes toward securing a climate-resilient water future for agriculture and ecosystems, the Extension team is planning upcoming field days and assisting with regional conferences with thought partners.

GAME DEVELOPMENT

WHAT IS BEING DEVELOPED?

Based on working sessions during 2022-2023, culminating in the Game Design Summit on April 18-19 in Las Cruces, the team has laid out plans for the SWF water game and is moving forward with design and production. This game is intended to enhance the cross-disciplinary understanding of water scarcity among game designers, artists, animators, and researchers.

Four of the 2023 SWF graduate student summer fellowship recipients assisted with collecting real water budget data for California, Utah, and New Mexico for co-developing our digital game.

The New Mexico State University Learning Games Lab leads game production with research support from across the project.

Amy Muise (NMSU) at White Sands National Park, New Mexico, 2023.





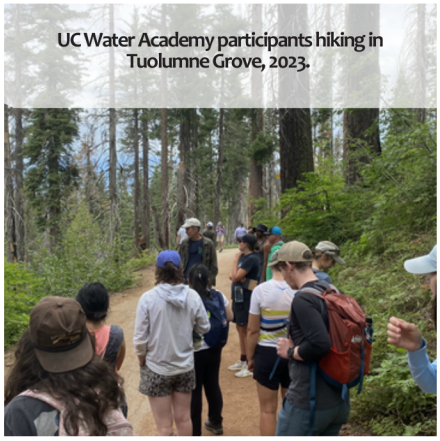
SWF team members brainstorming at the Game Design Summit, 2023.

THE SWF GAME WILL

- Increase conceptual understanding of water use in agriculture and the interconnectedness of surface water, groundwater, and precipitation/climate.
- Acknowledge the importance of economic, ecological, and social factors.
- Recognize that many users share aquifers; each user's impacts influence individuals' short- and long-term success.
- Budget water for unknown events or catastrophes and use a water budget to prepare for and mitigate those.
- Recognize, at a higher conceptual level, that water trading strategies can enable farmers to trade water with each other when needed.
- Recognize that technology can increase water use efficiency.
- Include markers for long-term success vs. short-term success.

Middle school students learning about water quality and testing techniques on Lake Yosemite, 2022.





UC Water Academy participants hiking in Tuolumne Grove, 2023.

“You can’t learn about water without getting wet.”

The Secure Water Future educational catalogue coalesces around the basic premise that “You can’t learn about water without getting wet.” We invite K-12, college, and graduate students to dive into our programming. Through experiential learning exercises, we illustrate the impacts of uncertainty due to climate change and the potential for technological and management solutions to improve our collective future water security.

EDUCATION

DIGITAL AGATHON*

Participants collaborating during the AgAID AgAthon, 2023.



AIMS

The Digital AgAthon targeted undergraduate and graduate students interested in artificial intelligence and developing solutions for agriculture using computer vision, geospatial data, or cloud computing platforms. Students were expected to work in teams to solve one of three challenge prompts.



AgAID AgAthon fourth place Water Challenge winners Tejas Bhartiya (UCM), Gabriel Lee (UCM), Paul Stratton (UCM), Shrivaikunth Krishnakumar (UCM), and Carolyn Cui (UCM), 2023.

ABOUT THE AGAID AGATHON

AgAID is a USDA and NSF-funded AI institute. The AgAID Institute hosted its second iteration of the Digital AgAthon during the weekend of January 27 - 29, 2023. The 2023 Digital AgAthon was a hybrid event that was hosted virtually over Microsoft Teams and in-person at selected locations.

Secure Water Future aided in organizing the hackathon and facilitated one of the in-person locations at the University of California, Merced. AgAID and Secure Water Future continue to work together to facilitate stronger outcomes for both teams.

AgAid AgAthon participants at UCM, 2023.



OUTCOME

This hackathon was a three-day event with in-person gatherings at WSU, UC Merced, and OSU and a fully remote option.

Participants could participate in either the Labor Challenge or the Water Challenge.

*The AI Research Institutes program is supported by NSF and USDA-NIFA under the AI Institute: Agricultural AI for Transforming Workforce and Decision Support (AgAID) award No. 2021-67021-35344.

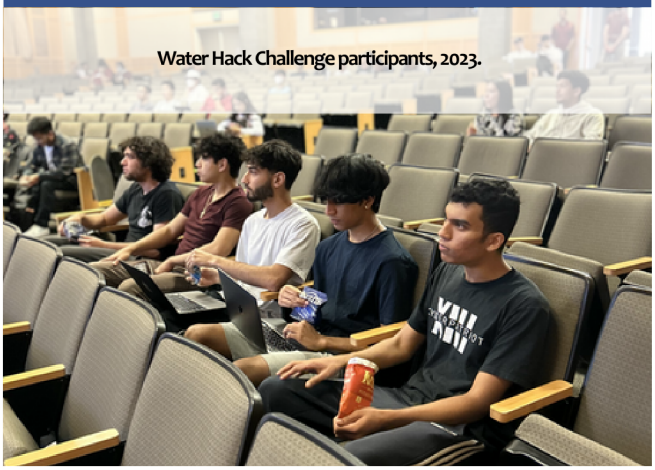
WATER HACK CHALLENGE



Water Hack Challenge participants, 2023.

GOALS

The goal of this hackathon was for students to better understand water resources in the Central Valley of California, how to communicate scientific data, and how water and data intersect. Students could work individually or in teams of up to five people. Collaboration was encouraged.

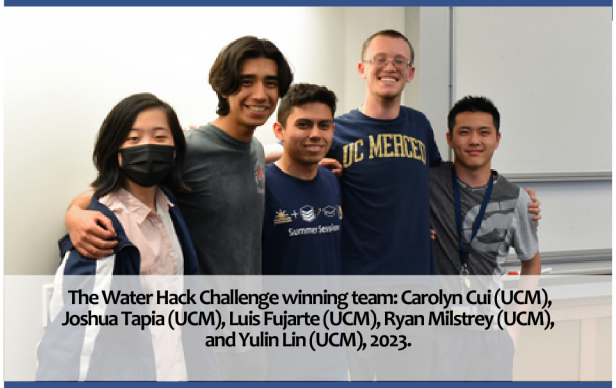


Water Hack Challenge participants, 2023.

THE CHALLENGE

Secure Water Future held its first hackathon at UC Merced during the weekend of April 21 – 23, 2023. The Water Hack Challenge (WHC) was an innovative space for students to explore data-driven solutions to water issues. The event was open to undergraduate and graduate students belonging to California colleges and universities.

The three challenges from which students could select were based on the phases of the water cycle: Liquid-Flood, Solid-Snow, and Gas-Evapotranspiration. The Liquid-Flood Challenge prompted participants to create a model to determine the flood risk in Merced, California, or produce a visual representation that aids users in understanding the certainty and trajectory of change in climate models.

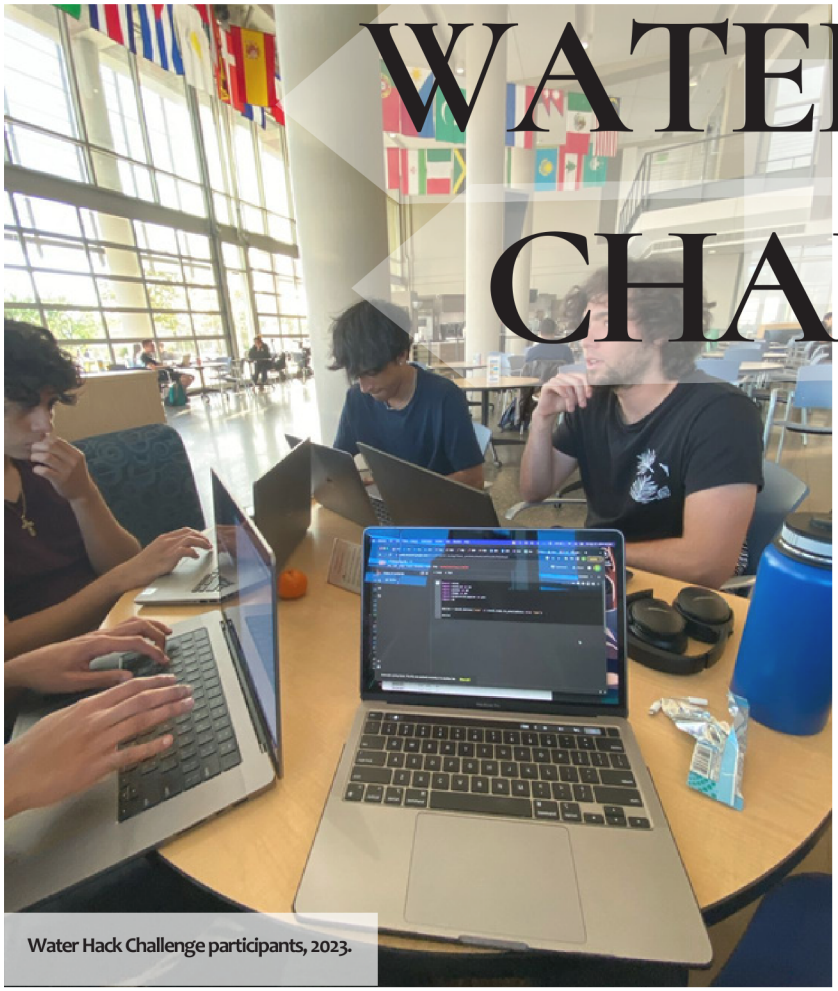


The Water Hack Challenge winning team: Carolyn Cui (UCM), Joshua Tapia (UCM), Luis Fujarte (UCM), Ryan Milstrey (UCM), and Yulin Lin (UCM), 2023.

OUTCOME

Throughout the course of this hackathon, participants acquired valuable insights as they collaborated in teams to address challenges related to significant water issues. The weekend-long event propelled students to step out of their comfort zone to design and develop a solution for an unfamiliar subject.

HOSTING THE WATER HACK CHALLENGE



Water Hack Challenge participants, 2023.

Secure Water Future student intern Wendy Haw took the lead in hosting the Water Hack Challenge. Here, she recounts her experience:



SWF intern, Wendy Haw.

"Hailing from the University of California, Merced; Merced College; California State University, Fresno; California State University, Sacramento; California State University, Stanislaus; University of California, Irvine; and University of California, Berkeley, 76 students from across the Central Valley and beyond participated in the WHC. During the hackathon, participants had the opportunity to attend six workshops to expand their technical and collaboration skills. These workshops were led by Merced College and UC Merced undergraduates and allowed hackathon participants to learn about teamwork skills, Git, Firebase, app development, ReactJS, and UI/UX. Participants could use the skills that they learned from these workshops and incorporate them into their projects. Additionally, seven mentors, including faculty from Merced College and individuals associated with SWF at UC Merced, provided their expertise in technical skills, water domain knowledge, and collaboration skills to the WHC participants. Given the success of the Water Hack Challenge, we plan to organize future project-based events for students in the Central Valley community."

CASA ELE

WHAT IS CASA ELE?

Over a week in May, 13 graduate students from partner institutions traveled by van and raft with faculty and water management mentors to experience first-hand the semi-arid Western US and its water, agricultural, and natural resources infrastructure and processes for decision-making. This experiential trip included meeting the people who affect and are affected by water and agricultural management choices.

Our Experiential Learning Expedition is based on successful educational models, including the UC Water Academy and USU Climate Adaptation Science program, and spans the regional water management cycle.

Group photo of CASA ELE participants and mentors, 2023.



OUTCOME

Through the program, graduate students cultivated a greater understanding of western water problems and solutions, developed connections to their research, and built written products to share their experiences with the broader population through scientific communication materials.

CASA ELE participants Naivy Rodal Morales (UCM), Saddy Pineda (USU), and Humberto Flores Landeros (UCM) cooking a meal, 2023.



TOPICS COVERED

In 2023, the engagement covered:

- Hydroclimatic conditions and likely futures;
- Surface water, including headwaters and monitoring stations, reservoirs, and rivers;
- Agricultural management;
- Environmental water management;
- Reconciling agriculture and ecosystems: current and alternative land uses and multi-benefit land use;
- Regulated vs. unregulated river systems.



Sarah Naumes (UCM) and Josh Viers, Ph.D. (UCM) in Utah during CASA ELE, 2023.

CASA ELE EXPERIENCE



Adam Crawford (UCM) on snowshoes during CASA ELE, 2023.

Secure Water Future intern Adam Crawford participated in CASA ELE and recounts his experience here:

"While the CASA ELE trip is designed to inform the next generation of water professionals about water, the genuine bonding among participants truly shines. I went with limited expectations of what I would take from this trip; I walked out not only with a greater understanding of water and the numerous issues that surround it, but also a greater appreciation for the people that compose this project and are tackling these issues.

"This journey enabled me to engage in meaningful conversations with people from diverse states, introducing me to colleagues working in the same building as me whom I had previously never known." - Adam Crawford

Over the course of the 2023 CASA ELE trip, participants spent more than 15 hours driving around Utah and Colorado. From our hotel rooms in Salt Lake City to a farm in Corinne, and after several more stops, we ended up at the Gates of Lodore entrance in northwest Colorado. During the hours we spent driving, we developed connections that would not have happened otherwise.

During these car journeys, conversations ranged from personal stories about backgrounds, aspirations, and favorite musicians to technical discussions about water rights, the nuanced differences between energy sources, and everything in between. These conversations continued onto the river where, once again, we were mixed up to further facilitate getting to know everyone on the trip. My CASA ELE journey was unconventional—I, an undergraduate student, unexpectedly found myself on a trip intended for graduate students. A last-minute cancellation opened a spot, and having been a SWF intern for almost a year, I received a message asking about my interest in rafting. After some back-and-forth, I hesitated but eventually accepted. In hindsight, saying "yes" was a great decision."

SUPER SOAKER WATER ACADEMY



Middle school students kayaking on Lake Yosemite during SSWA, 2023.

GOALS

By the end of the week, students develop a heightened awareness of the relationship between water, agriculture, climate change, and the need for technological enhancements. Water-based activities, including kayaking, complement this program.



UCM VICELab Manager, Ben Lewis (UCM), explaining equipment to a group of SSWA participants, 2023.

WHAT IS SSWA?

Augmenting grade 6 and 7 curricula, the Super Soaker Water Academy (SSWA) weeklong program engages middle school students from the Central Valley of California in interactive educational programming about water. Starting with the water cycle, students understand how and where water is stored and utilized in the heavily populated and agriculturally dominant state of California. Capitalizing on this understanding, students then developed a conceptual sense of how water access intersects with users' various economic and social needs.

A group of SSWA students in Lake Yosemite after collecting water samples, 2023.



OUTCOME

Our survey of participants indicated that those who joined our week-long Super Soaker Water Academy gained scientific knowledge including comprehension of such concepts as evapotranspiration, the water cycle, and water contamination. One participant stated, “I feel like an adult already. [...] I'm really excited, really thankful to have this experience so I'm ready and prepared when I'm older and come to college later.”

UC WATER ACADEMY



Participants and mentors of the UC Water Academy in Tuolumne Meadows, 2023.

OUTCOME

Through lectures, discussions, and hands-on activities, students gained practical skills and developed a deep understanding of the complex interactions between fire, water, and land management. The course equips students with the knowledge and tools necessary to address these critical issues in their future careers.

UC Water Academy participants and mentors, 2023.



WHAT IS UCWA?

In 2023, UCWA was a four-day experiential learning expedition focused on the intersection of wildfire, fire ecology, watershed science, aquatic ecology, and natural resources management in the Tuolumne River Watershed. The course provided a unique opportunity for 11 graduate students to engage with experts in the field, learn about the history and impacts of wildfires in the watershed, explore the diverse aquatic ecosystem of the watershed, and understand the challenges and opportunities for managing and adapting to climate change.



Ted Grantham, Ph.D. (UCB) showing UC Water Academy participants how to measure stream flow on the Tuolumne River, 2023.

LESSONS LEARNED

1. Including a lead graduate student provides valuable mentorship
2. A combined thematic (i.e., wildfire + water) requires additional programming and concept introduction activities
3. Diversifying future water leaders necessitates diversifying current water mentors.



UC Water Academy participants in front of a redwood tree, 2023.

Group photo of the Secure Water Future team in Berkeley, CA, 2023.



Erin Hestir, Ph.D. (UCM) discussing the application of remote sensing to post-fire water quality measurement following the Rim Fire of 2013 with UC Water Academy participants, 2023.

The Secure Water Future team includes collaborators from the University of California, Merced, University of California, Davis, University of California, Los Angeles, University of California, Berkeley, New Mexico State University, Utah State University, PPIC, EDF, UC ANR, and USDA.

The Team

LEADERSHIP



JOSHUA VIERS

Dr. Joshua Viers is a Professor of Water Resources Management in the School of Engineering at UC Merced. He also serves as the Associate Vice Chancellor for Interdisciplinary Research and Strategic Initiatives in the Office of Research and Economic Development (ORED) where he supports the Vice Chancellor for Research, Innovation, and Economic Development. Josh has led UC Merced's efforts to build an Experimental Smart Farm, develop a joint industry-university consortium on ag-food-tech research, and convene several universities in developing water accounting methods to secure a climate-resilient water future.

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SARAH NAUMES

Sarah Naumes is the managing director of Secure Water Future. She brings her expertise in strategic project management and passion for fostering impactful research to the team. Since joining UC Merced in 2019, she has been instrumental in securing some of the university's most prestigious grants, including awards from the National Science Foundation (NSF), United States Department of Agriculture (USDA), Economic Development Administration (EDA), National Aeronautics and Space Administration (NASA), National Endowment for the Humanities (NEH), and other key state and federal agencies. With Secure Water Future, Sarah catalyzes translational team research into actionable outcomes.

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JOHN ABATZOGLOU

Dr. John Abatzoglou is an Associate Professor in Management of Complex Systems at UC Merced. John received his bachelor's degree in Atmospheric Science from UC Davis and doctorate in Earth Systems Science from UC Irvine. John's academic interests are primarily focused around climate science and impacts in the American West. John's Climatology Lab works on a diverse set of research questions spanning climate science and meteorology as well as their impacts on systems including water resources, wildfire, and agriculture.

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ANDREW AYRES

Dr. Andrew Ayres is a Research Fellow at the Public Policy Institute of California. Andrew's main areas of research include environmental and natural resource economics, institutional economics, applied econometrics, and water economics and policy. Andrew's current work examines legal and economic institutions for the management of groundwater resources, with a focus on water marketing and managing impacts from fallowed lands.

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ELLEN BRUNO

Dr. Ellen Bruno is an Assistant Cooperative Extension Specialist at UC Berkeley in the Department of Agricultural & Resource Economics. Ellen's research and extension program addresses economic questions at the intersection of agriculture and the environment. Much of Ellen's current work considers the potential and effectiveness of water-related policies, which includes understanding how farmers respond to changes in water prices. Ellen received her Ph.D. in Agricultural and Resource Economics from UC Davis and her B.S. degree in Management Science from UC San Diego.

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LEADERSHIP



HELEN DAHLKE

Dr. Helen Dahlke is a Professor in Integrated Hydrologic Sciences at the University of California, Davis. Helen obtained a Ph.D. degree in Environmental Engineering from Cornell University. Helen's current research interests include surface water - groundwater interaction, water resources management, vadose zone transport processes, and applications of DNA nanotechnology in hydrology. One of Helen's main research efforts focuses on testing the feasibility of using agricultural fields as recharge sites for groundwater banking.

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ALVAR ESCRIVA-BOU

Dr. Alvar Escriva-Bou is an assistant professor with the Civil and Environmental Engineering Department and the Institute of the Environment and Sustainability at the University of California, Los Angeles. His research uses systems approaches to explore integrated water, energy, food and environmental resources management. Specifically, he focuses on the integration of the human dimension in these socio-environmental systems, linking engineering and economic models to assess drought impacts, improve urban and agricultural resilience, or analyze policy outcomes and tradeoffs.

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SAM FERNALD

Dr. Sam Fernald is the Director of the New Mexico Water Resources Research Institute (NM WRRI). He leads NM WRRI in its mission to develop and disseminate knowledge that will assist the state, region, and nation in solving water resources problems. NM WRRI supports university faculty research, provides training opportunities for students, and transfers research findings to the academic community, water managers, and the general public. Sam is the past president of the National Institutes for Water Resources (NIWR) which advocates for the 54 water institutes in the nation.

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SAFEEQ KHAN

Dr. Safeeq Khan is a Cooperative Extension specialist in water and watershed sciences at the University of California Division of Agriculture and Natural Resources (UC ANR) and an Adjunct Professor in the Department of Civil & Environmental Engineering at UC Merced. Safeeq's research broadly focuses on understanding interactions between climate, regolith, and terrestrial ecosystem in the Earth's critical zone. Safeeq's research relies heavily on field experiments and data-driven numerical models as research tools to inform land and water management.

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JOSUÉ MEDELLÍN-AZUARA

Dr. Josué Medellín-Azuara is an Associate Professor in Civil and Environmental Engineering at UC Merced. Josué is also an Associate Director for the UC Davis Center for Watershed Sciences and the UC Agricultural Issues Center, and an Adjunct Research Fellow at the Public Policy Institute of California. Josué is the principal investigator for the economic impact assessments of recent California droughts on agriculture and communities.

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LEADERSHIP



DAVID MEYER

Dr. David Meyer has helped design and implement evaluations for organizations of all sizes, including the United Nations, the National Science Foundation, the US Department of Agriculture, as well as state and local government agencies. David spent 10 years in the private sector providing strategic planning, team assessments, and performance measurement for companies ranging from Fortune 100 companies to start-up ventures. David's Ph.D. is in organizational psychology and human resources development and he has research interests in technology transfer, mixed-motive business teams, and interdisciplinary research groups.

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MIKE MYATT

Mike Myatt oversees EDF's California Water program as senior director, climate resilient water systems. The California Water program focuses on advancing incentive-based approaches that ensure adequate water for ecosystems, improve agriculture's resilience to climate change and address the needs of disadvantaged communities. Mike leads EDF's initiatives to advance groundwater sustainability policies and practices across the Central Valley. Mike collaborates with nonprofit partners, state and federal agencies, community-based organizations, landowners, and local community advisors to ensure that diverse perspectives are included in all phases of his work.

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SARAH NULL

Dr. Sarah Null is a professor of watershed sciences at Utah State University. Sarah's research includes environmental water management, improving aquatic habitat objectives in water resources systems models, evaluating tradeoffs between human and environmental water uses with uncertainty and identifying climate adaptations for water systems. Sarah's work focuses on California and the American West. She holds a Ph.D. and master's degree in geography from UC Davis and a bachelor's degree in economics from UCLA.

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NICK SANTOS

Nick Santos is a programmer, geographic information system (GIS) specialist, instructor, web developer, and environmentalist specializing in decision support applications. At the Center for Information Technology Research in the Interest of Society (CITRIS) at UC Merced, Nick develops models, software, databases, and applications to help analyze and understand California agriculture as well as environmental impacts and indicators. Nick is also the instructor for Coursera's five-course specialization in GIS.

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ALFONSO TORRES-RUA

Dr. Alfonso Torres-Rua is a Utah State University researcher focused on remote sensing applications for water measurement, conservation, and education in agriculture, urban, and environmental landscapes. Alfonso's lab team aims to develop knowledge, methodologies, and tools to address water scarcity and climate change questions in arid regions.

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ADVISORY BOARD



ERIC AVERETT

Eric Averett is CEO of Atlas Water and has been an adjunct professor at Taft College and Bakersfield College for 20 years. Before joining Atlas Water, he was general manager of the Rosedale–Rio Bravo Water Storage District for over 14 years. He has been involved in evaluating and resolving water supply and quality challenges facing Kern County since 1991. He sits on the board of directors of the Kern County Water Agency. Eric graduated from California State University, Bakersfield with a degree in environmental resource management.



NATHAN DAUGS

Nathan Daugs is the manager of the Cache Water District in Utah. He is a graduate of Utah State University with a degree in Animal Science. He previously worked as planner and technician for the Utah Department of Agriculture and Food and Utah Association of Conservation Districts, where he worked with landowners implementing water and environmental enhancement projects. Nathan is committed to ensuring sustainable economies and ecosystems through proper water management.



EREK FUCHS

Dr. Erek Fuchs specializes in quantitative hydrology with interests that include connectivity physics and groundwater resilience in conjunctive use of irrigated agricultural systems. He was born in New Mexico and raised on a small ranch near Capitan. He completed his academic degrees in Range and Watershed Science (BS), Range Hydrology (MS), and Water Science and Management (Ph.D.) with an emphasis in Quantitative Hydrology and Agricultural Water Resources at New Mexico State University.



MARK MATSUMOTO

Dr. Mark Matsumoto joined the University of California, Merced on September 1, 2015 where he was previously the Dean of the School of Engineering. He was previously Associate Dean for Research and Graduate Education and Professor of Chemical and Environmental Engineering at UC Riverside. Dr. Matsumoto's career research focus is environmental engineering treatment processes, particularly those associated hazardous waste sites, groundwater remediation, and water reuse applications.



RIC ORTEGA

Ric Ortega has served as General Manager and Director of Governmental and Legislative Affairs of the Grassland Water and Resource Conservation District since August of 2011. Born and raised in the small town of Dos Palos, Ric grew an affinity to the outdoors from an early age. Ric carries Bachelor of Science in Animal Science, Ecology and Systematic Biology from Cal Poly, San Luis Obispo and a Master of Science in Wetland Ecology from UC Davis.

ADVISORY BOARD



BLANE SANCHEZ

Blane Sanchez, from Isleta Pueblo, served as the first New Mexico tribal member on the NM Interstate Stream Commission over the last 16½ years, ending in July 2023. A background in farming and ranching influenced by his grandfather led him to obtain an undergraduate degree from New Mexico State University in agriculture (range science). His 30-plus years of professional work and experience includes the areas of natural resources management, water quality standards, environmental protection, facilitation, tribal and state water policy, water utilities administration, and exposure to water research.



JOAN SNYDER

Joan Snyder is a retired investment banker whose decades-long career on Wall Street involved asset management, securities research, and, as an Executive Director of Merrill Lynch International, client responsibilities for Asia. She is a sixth-generation member of a CA farming family and managed her own New York farm for thirty-five years. With a primary residency in Vermont, she maintains a consulting practice in finance for agtech and regenerative ag projects.



ASHLEY SWEARENGIN

Ashley Swearengin is president and CEO of the Central Valley Community Foundation, a charitable foundation serving the six counties of Central California and providing over $100 million in funding to over 650 community benefit organizations over the last decade. Prior to joining CVCF, she served as Mayor of the City of Fresno from 2009 through 2016. As mayor, she implemented substantial changes to improve the delivery of city services, revitalize the downtown and urban core, promote business and job growth, address chronic homelessness, and stabilize the city's financial position.



ANN WILLIS

Dr. Ann Willis is the California Regional Director for American Rivers where she leads the conservation program to conserve and protect rivers through science-guided projects, policies, and collaborations. Her journey to river conservation began on the Middle Fork Salmon River, where she was introduced to whitewater rafting after graduating college. Her experience of belonging on that trip has guided each of her choices as she's followed her passion for rivers and the communities that depend on them.

PROJECT TEAM

The Secure Water Future project team encompasses faculty, postdocs, graduate students, undergraduate students, and staff from universities and non-profit partners. This list includes affiliated team members from September 1, 2022, to August 31, 2023.

Faculty & Research Collaborators

John Abatzoglou, Ph.D. (UCM)
Chelsea Arnold, Ph.D. (UCM)
Andrew Ayres, Ph.D. (PPIC)
Khaled Bali, Ph.D. (UC ANR)
Salim Bawazir, Ph.D. (NMSU)
Leigh Bernacchi, Ph.D. (UCM)
Molly Bruce, J.D. (UCB)
Ellen Bruno, Ph.D. (UCB)
Henry Cathey (NMSU)
Barbara Chamberlin, Ph.D. (NMSU)
Helen Dahlke, Ph.D. (UCD)
Dave DuBois, Ph.D. (NMSU)
Alvar Escriva-Bou, Ph.D. (UCLA)
Sam Fernald, Ph.D. (NMSU)
Teamrat Ghezzehei, Ph.D. (UCM)
Nell Green Nylen, Ph.D. (UCB)
Robyn Grimm, Ph.D. (EDF)
Ellen Hanak, Ph.D. (PPIC)
Tom Harmon, Ph.D. (UCM)
Richard Heerema, Ph.D. (NMSU)
Scott Hotaling, Ph.D. (USU)
Safeeq Khan, Ph.D. (UCM)
Mike Kiparsky, Ph.D. (UCB)
Giorgos Kourakos, Ph.D. (UCD)
Ahmed Mashaly, Ph.D. (NMSU)
Josué Medellín-Azuara, Ph.D. (UCM)
Kelley Moyers, Ph.D. (UCM)
Amy Muise (NMSU)
Mike Myatt (EDF)
Colleen Naughton, Ph.D. (UCM)
Sarah Null, Ph.D. (USU)
Mariana Rivera-Torres (EDF)
David Rosenberg, Ph.D. (USU)
Bob Sabie (NMSU)
Nick Santos (UCM)
Caiti Steele, Ph.D. (USDA Southwest Climate Hub)
Gregory Torell, Ph.D. (NMSU)
Alfonso Torres-Rua, Ph.D. (USU)
Josh Viers, Ph.D. (UCM)
Emily Waring, Ph.D. (UCM)
Matt Yost, Ph.D. (USU)

Graduate Students

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Spencer Cole (UCM)*
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Humberto Flores Landeros (UCM)
Greg Goodrum (USU)
Lucy Hackett (UCB)
Masoumeh Hashemi (USU)
Tasnim Kamal Shamma (NMSU)
Shobha Khanna (UCM)
Julia Klejmont (NMSU)
Liying Li (UCM)
Raji Lukkoor (UCM)
Jamin Miller (NMSU)
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Naivy Rodal Morales (UCM)
Jose M. Rodriguez-Flores (UCM)*
Liam Sabiston (NMSU)*
Gabriela Sancho Juárez (USU)
Garrison Schlauch (UCB)
Britta Schumacher (USU)
Berhanu Sinshaw (UCM)
Zada Tawalbeh (NMSU)
Touyee Thao (UCM)*
Kira Waldman (UCD)
Arthur Wardle (UCB)
Aaron Watt (UCB)

*Degree completed

Undergraduate Students

Alexie Calderon (UCM)
Matthew Carr-Wallace (UCM)
Lily Chavez (NMSU)
Adam Crawford (UCM)*
Diane Martinez-Gomez (UCM)
Wendy Haw (UCM)

*Degree completed

Staff

Isaiah Apodaca (NMSU)
Abby Bushman (USU)
Ben Lewis (UCM)
Kal Li (UCM)
Sarah Naumes (UCM)

External Evaluator

David Meyer, Ph.D. (BSU)



SWF collaborators at White Sands National Park in New Mexico, 2023.

Yosemite National Park, CA, 2023.



UC Water Academy participants and mentors, 2023.

These appendices feature publications and presentations with the NIFA Acknowledgement and other major SWF products.

PRODUCTS

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Abatzoglou, J. (2022, November 19). The science of climate change and its impacts on California deserts. Presented at the Anza-Borrego Desert Natural History Association, Borrego Springs, California.

Abatzoglou, J., McEvoy, D., Nauslar, N., Hegewisch, K., & Huntington, J. (2023, March 1). Downscaled subseasonal fire danger forecast skill across the contiguous United States. Atmospheric Science Letters, e1165. https://doi.org/10.1002/asl.1165

Abatzoglou, J., Faciancani Dourado, G., Rheinheimer D., & Viers, J. (2023, May 1). Climate whiplash in California: too much to bear, too little to handle? Presented at EGU23, the 25th EGU General Assembly, held 23-28 April, 2023 in Vienna, Austria and Online. https://ui.adsabs.harvard.edu/abs/2023EGUGA..2510605F/abstract

Ayres, A. (2023, July 18). Defining and trading groundwater rights in California's Mojave Desert. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734378

Bruce, M. (2023, July 18). Influence of institutional context on water markets in the Southwest: Takeaways from a convening on water measurement and reporting. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734378.

Bruce, M., Sherman, L., Bruno, E., Kiparsky, M., & Fisher, A. (2023, January 10). Recharge net metering (ReNeM) is a novel, cost-effective management strategy to incentivize groundwater recharge. Research Square. https://doi.org/10.21203/rs.3.rs-2419554/v1

Calderwood, A., Rodriguez, A., Foglia, L., & Dahlke, H. (2022, December 15). Setting bounds on levee setback distance to optimize high conductivity pathway use for groundwater recharge. Presented at the AGU Fall Meeting, Chicago, Illinois. https://ui.adsabs.harvard.edu/abs/2022AGUFM.H46F..04C/abstract

Clifton, B., Ghezzehei, T., Fremier, A., & Viers, J. (2022, December). Assessing natural flow regime driven floodplain evolution following hydrologic reconnection along the Cosumnes River, California, USA. Presented at the AGU Fall Meeting, Chicago, Illinois. https://ui.adsabs.harvard.edu/abs/2022AGUFM.H13F..08C/abstract

Cole, S. (2023). Agricultural implications of implementing California's sustainable groundwater management act in the Greater Kings River basin. [Master's thesis, University of California, Merced]. ProQuest Dissertations and Theses Global.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Dahlke, H. (2023, July 18). Estimating long-term changes in groundwater recharge: A comparison of plot estimates to regional outputs from groundwater models. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732587

Dourado, G., Rallings, A., & Viers, J. (2023, March 17). Overcoming persistent challenges in putting environmental flow policy into practice: A systematic review and bibliometric analysis. Environmental Research Letters, 18 https://doi.org/10.1088/1748-9326/acc196

Eppig, M., Lloyd, B., Krcmarik, A., & Sabiston, L. (2023, July 17). Water wise: Strategies for drought-resilient real estate. Presented at the American Water Resources Association 2023 Summer Conference. Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732269

Escriva-Bou, A. (2023, July 10). Developing Drought Indicators for Assessing Multi-Sectoral Impacts in Complex Water Systems. Poster presented at the Pantha Rei symposium, Potsdam, Germany. https://events.gfz-potsdam.de/panta-rhei

Escriva-Bou, A., Dettinger, M., Mount, J., & Rosser, A. (2023, April 25). Developing Drought Indicators for Assessing Multi-Sectoral Impacts Using a Systems Approach. Paper presented at the EGU General Assembly 2023, Vienna, Austria. https://doi.org/10.5194/egusphere-egu23-16758

Escriva-Bou, A., Hanak, E., Cole, S., & Medellín-Azuara, J. (2023, February 1) The future of agriculture in the San Joaquin valley. Public Policy Institute of California. https://www.ppic.org/publication/policy-brief-the-future-of-agriculture-in-the-san-joaquin-valley/

Espinoza, V., Bernacchi, L., Eriksson, M., Schiller, A., Hayden, A., & Viers, J. (2023, February 7). From fallow ground to common ground: Perspectives on future land uses in the San Joaquin Valley under sustainable groundwater management. Journal of Environmental Management, 333, 117226. https://doi.org/10.1016/j.jenvman.2023.117226

Espinoza, V., Booth, L., & Viers, J. (2023, April 18). Land use misclassification results in water use, economic value, and GHG emission discrepancies in California's high-intensity agriculture region. Sustainability, 15(8), 6829. https://doi.org/10.3390/su15086829

Fernald, S. & Heerema, R. (2023, March 6). How can we manage irrigation for the benefit of both farm and aquifer? Presented at the Western Pecan Growers Association Conference and Tradeshow, Las Cruces, New Mexico.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Goodrum, G. (2023, July 17). Optimizing water management for water supply and fish habitat in the Bear River Basin. Presented at the American Water Resources Association 2023 Summer Conference. Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732270

Haw, W., & Crawford, A. (2023, July 18). Enhancing university-level water curriculum for underrepresented minority students through outside-of-classroom educational opportunities: The benefits of hackathons and water games. Presented at the American Water ResourcesAssociation 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734156

Heerema, R. (2023, June 6). Irrigation systems. Webinar presented to the Western Pecan Growers Association. https://westernpecan.org/irrigation-systems/

Heerema, R. (2023, March 1). Deep percolation--one of irrigation water's forgotten fates. Pecan South, 56(1), 20-25. https://www.pecansouthmagazine.com/magazine/issue/2023-03/

Hegewisch, K. (2023, July 19). The Climate Toolbox. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734493

Hotaling, S. (2023, June 1). Mountain rock glaciers: an overlooked, climate-resilient water source for Utah? Training presented at the Utah Division of Water Resources. Salt Lake City, Utah.

Khan, S. (2022, October 8). Management of water and watersheds: Learning from the past. Presented to the Self-Help Enterprises Leadership Institute, Visalia, California.

Khan, S. (2023, July 18). Assimilating remotely sensed data into SWAT model for predicting crop evapotranspiration. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732587

Khan, S. (2023, July 18). Whole catchment instrumentation? The Southern Sierra experience in stereo. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734391

Khan, S. (2023, March 1). Development of a near-realtime water information system for California. UC Berkeley Workshop on measurements & monitoring, Berkeley, California.

Khan, S. (2023, May 20). Management of water and watersheds: Learning from the past. Presented to the Self-Help Enterprises Leadership Institute, Visalia, CA.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Kirupairaja, T., Bawazir, S., Solis, J., Perera, A., Fernald, A., & Sabie, R. (2023, May 15). Hydrologic process on fallow farmland in the Mesilla Valley, New Mexico. Presented at the Climate Smart Agriculture Student Symposium at University of Texas Arlington, Arlington, Texas.

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Null, S., & Sancho-Juárez, G. (2023, July 18). A review of water markets for ecological protection. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734378

Null, S. (2023, July 18). Water balances to manage environmental water. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732587

Null, S.E., Goodrum, G., Gray, C., Morrisett, C., Pineda, S., Sancho-Juárez, G., & Turney, E. (2023, July 17). Reservoir storage variability through time in the American West. Presented by Saddy Pineda at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734493

Nylen, N. (2023, May 22). The role of regulatory relationships in wastewater innovation. Legal Planet. https://legal-planet.org/2023/05/23/the-role-of-regulatory-relationships-in-wastewater-innovation/

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Nylen, N., Owen, D., Harder, J., Kiparsky, M., & Hanemann, M. (2023, April 24). To manage water scarcity, California needs a framework for fair and effective water right curtailment. Legal Planet. https://legal-planet.org/2023/04/24/managing-water-scarcity/

Osorio-Diaz, K. & Torres-Rua, A. (2023, July 19). Integration of geographic information systemsand remote sensing products to address water balance and irrigation management in Utah's water canal companies. Presented at the American Water Resources Association 2023 Summe

Parker, L., Hegewisch, K., Medellin-Azuara, J., Amidi-Abraham, G., Santos, N., & Burns, J. (2023, July 19). Emerging digital tools for effective water management in water scarce regions.Workshop at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734515

Pasner, Y. (2023, July 17). Vertical hydraulic head gradients in numerical groundwater flow modeling. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732569

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Perera, A., Bawazir, S., Solis, J., Fernald, A., Sabie, R. (2023, May 15). Using sensitive 3-D Eddy Covariance system to estimate evapotranspiration of young pecan orchard. Presented at the Climate Smart Agriculture Student Symposium at University of Texas Arlington, Arlington, TX, United States.

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Tawalbeh, Z., & Bawazir, S. (2023, July 17). Assessing satellite-derived OpenET platform evapotranspiration for operational irrigation management of mature pecan orchard in the New Mexico Mesilla Valley. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732551

Tawalbeh, Z., & Bawazir, S. (2022, October 21). Comparison of mature pecan orchard OpenET estimates with ground measured values. New Mexico Section ASABE at Southwestern Cotton Ginning Research Lab, Las Cruces, New Mexico.

Torres-Rua, A. (2023, July 18). Why we need high-resolution data from UAVs for water balance methods. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734391

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Viers, J. (2022, October 26). Understanding, enabling, and envisioning water management strategies empowered through research. Presented at the 67th Annual New Mexico Water Conference, Las Cruces, New Mexico. https://nmwrri.nmsu.edu/events/events.html

Viers, J. (2023, July 18). Closing the data gap on consumptive water use in a rapidly changing hydroclimate to better sustain agriculture and ecosystems. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734391

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Waring, E. (2023, July 17). Information sources and flexibility among water decision-makers under climate change. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1732581

Yost, M. (2023, July 18). Closed loop alfalfa monitoring to improve irrigation efficiency. Presented at the American Water Resources Association 2023 Summer Conference, Denver, Colorado. https://events.rdmobile.com/Sessions/Details/1734391

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APPENDIX II: OTHER PRODUCTS

Research Instrumentation

- To establish a water budget for the pistachio site at La Mesa, Las Cruces, NM, we engaged in a field setup of soil moisture probes in four pistachio fields with eight sensors in each location up to 240 cm deep. This benefits researchers and community advisors working in this field.
- We installed telemetry devices at three sites in New Mexico to ensure data continuity for one irrigation season. This benefits researchers and community advisors working in this field.
    - To benefit agriculture research, we also created telemetry connection instructions.
- In New Mexico, we purchased a compact weather station and radio telemetry setup to ensure a sustainable data collection process. This will benefit researchers and the local community.
- We installed the UC Merced Experimental Smart Farm weather station and eddy covariance flux tower. This benefits any researchers engaged in ET measurements and monitoring.

Workshops and Outreach

- We hosted a ggplot2 workshop on data visualization for SWF-affiliated and adjacent graduate students. This benefited 17 graduate students and staff at affiliated institutions. The workshop was hosted by Britta Schumacher, who is a full-time data scientist working for the US Census Bureau's International Programs Center and a Ph.D. student working under Dr. Matt Yost at Utah State University.
- We hosted a workshop at UC Berkeley with approximately 60 attendees called “SGMA in 2023: Advancing an Agenda to Meet Emerging Needs." This convening aimed to strengthen partnerships between the research community and groundwater community advisors on social and economic issues of groundwater management. We invited a group of academic economists, policy experts, interdisciplinary researchers, extension agents, managers and regulators at the local and state levels, environmentalists, farmers, community advocates, and others with on-the-ground experience. Participants co-developed an agenda for ongoing and future collaboration to best leverage applied research for impact on this important issue. This benefited both groundwater community advisors and applied researchers.
    - As an output from the workshop at UC Berkeley titled "SGMA in 2023: Advancing an Agenda to Meet Emerging Needs," we wrote a blog about water management in San Diego, California. This benefited both groundwater community advisors and applied researchers.
- Our team collaborated in onboarding the Merced Subbasin Groundwater Sustainability Agency (MSGSA) as a pilot partner for the Groundwater Accounting Platform by facilitating a landowner workshop. There were over 20 participants. This benefited the Merced Subbasin GSA, the California Water Data Consortium, the Environmental Defense Fund, and MSGSA landowners.
- We hosted a half-day virtual convening on water measurement and reporting needs for water markets. Our goals were to foster (1) learning across geographies and (2) knowledge transfer between approximately 25 convening participants (with a range of community advisor and expert perspectives from California, New Mexico, and Utah) and 12 SWF researchers. Convening participants learned from one another and SWF researchers learned from convening participants.
- Through a Mojave market analysis, we hosted an outreach meeting with the Mojave Water Agency.
- We assisted Sustainable Conservation in hosting a Soil-Water Expert Convening at UC Merced with over 50 collaborators from across California.

Workshops and Outreach Continued

- We hosted UC Water Academy policy pitch presentations open to community advisors across California, New Mexico, and Utah. The 11 graduate students from the UC Water Academy presented. We specifically targeted an audience of water managers to provide context about the impacts of wildfire on water.
- Our Extension lead co-hosted the UC ANR Water Webinar Series and SWF collaborators presented to the broad target audience. For additional details, see: https://ciwr.ucanr.edu/News_and_Events/WaterWebinar/
- We hosted a table at FIRA 2022 in Fresno, California, which spanned three days and included over 500 domestic and international participants from the agricultural sector.

Educational and Student Support Programming

- We hosted an event serving a group of 50 underserved students from the Boys and Girls Club of Merced County, which implemented a groundwater contamination activity to show students how contamination in one well can spread to others along an aquifer. The ages of students ranged from 5-14 years. This benefitted both the students who could effectively learn about groundwater and those preparing for SWF activities and larger-scale programming like our Super Soaker Water Academy (SSWA). The activity had a high educational impact, with even the youngest students understanding how groundwater near one well can be polluted and then contaminate other areas, an issue commonly seen in many areas of the Central Valley of California. SWF planners also benefited, as the event served as an additional testing environment for continued usage of the groundwater contamination activity. SWF outreach efforts also benefitted from this since students could learn about other programs at UC Merced.
- Through our Super Soaker Water Academy (SSWA), 25 middle school students participated in educational water activities, including a kayaking field trip to Lake Yosemite for water testing methods, drone programming and navigation, and the creation of ArcGIS StoryMaps of Central Valley water sources and other topics. This event benefitted students from a Central Valley school, enabling them to learn more about water challenges in the region. Students were taught about STEM pathways into higher education and technology. Many students had no previous access to the technology and concepts used in SSWA activities.
- Secure Water Future held its first hackathon at UC Merced during the weekend of April 21 – 23, 2023. The Water Hack Challenge (WHC) was an innovative space for students to explore data-driven solutions to water issues. The event was open to Central Valley undergraduate and graduate students. Hailing from the University of California, Merced; Merced College; California State University, Fresno; California State University, Sacramento; California State University, Stanislaus; University of California, Irvine; and University of California, Berkeley, 76 students from across the Central Valley and beyond participated in the WHC.

APPENDIX II: OTHER PRODUCTS

Educational and Student Support Programming Continued

- Over a week in May, 13 graduate students from partner institutions participated in the Climate Adaptation Science Academy Experiential Learning Expedition (CASA ELE) and traveled by van and raft with faculty and water management mentors to experience first-hand the semi-arid Western US and its water, agricultural, and natural resources infrastructure and processes for decision-making. This experiential trip included meeting the people who affect and are affected by water and agricultural management choices.
- We have hosted weekly concentrated work sessions in person at UC Merced and online for SWF-affiliated and adjacent graduate students and postdoctoral scholars. This program has benefitted graduate students and postdoctoral scholars in facilitating the successful completion of work and enhancing our community across California, New Mexico, and Utah.

Additional Funding

- We helped develop a successful $298,224 grant proposal titled “Adaptation pathways for agricultural land repurposing in the San Joaquin Valley and their impacts on heat and air quality extremes on vulnerable communities.” This will benefit vulnerable communities in the San Joaquin Valley and individuals working in agriculture.
- We helped develop a successful $500,000 grant proposal titled “Balancing ecological and energy needs in California’s water resources through FlowPywr: A decision support system for integrating hydropower operations and environmental flows under climate change.” This will advance strategies for managing California’s hydropower resources for optimal contribution to grid operations.
- We helped develop a successful $59,941 grant proposal to the Utah Public Lands Initiative titled "Are Utah's aquatic insects in decline? Insights from the National Aquatic Monitoring Center's unprecedented 41-year record."
- We helped develop a successful grant proposal with matching funding from the Utah Division of Water Resources totaling approximately $30,000. The Institute for Land, Water, and Air Impact Grant was titled "Clarifying the potential for Utah's mountain rock glaciers to buffer streamflows and support biodiversity as statewide snowpack declines.”
- We helped develop a successful $65.1 million grant proposal to the Economic Development Administration (EDA) to accelerate the integration of technology and skills in the Central Valley region’s agriculture industry—improving productivity and job quality for existing farmworkers while driving a more resilient and sustainable food system. The coalition unites partners such as University of California, Merced, the California Farmworkers Foundation, industry leadership like the California Fresh Fruit Association, regional philanthropy, and local government around a vision for a more innovative, equitable, and resilient agricultural industry in one of the country’s most important food-producing regions.

APPENDIX II: OTHER PRODUCTS

Game and Water3D Production

- We launched a basic informational Water3D website. The application is in production. This will provide support for growers who plan to use Water3D for modeling in the coming years.
- We purchased a Water3D server. This will benefit researchers and growers when we deploy it next year.
- We hosted a SWF game design summit wherein designers, artists, animators, and researchers convened to scope the production of our game. This game is intended to enhance the cross-disciplinary understanding of water scarcity among game designers, artists, animators, and researchers.





The Green River in Utah, 2023.