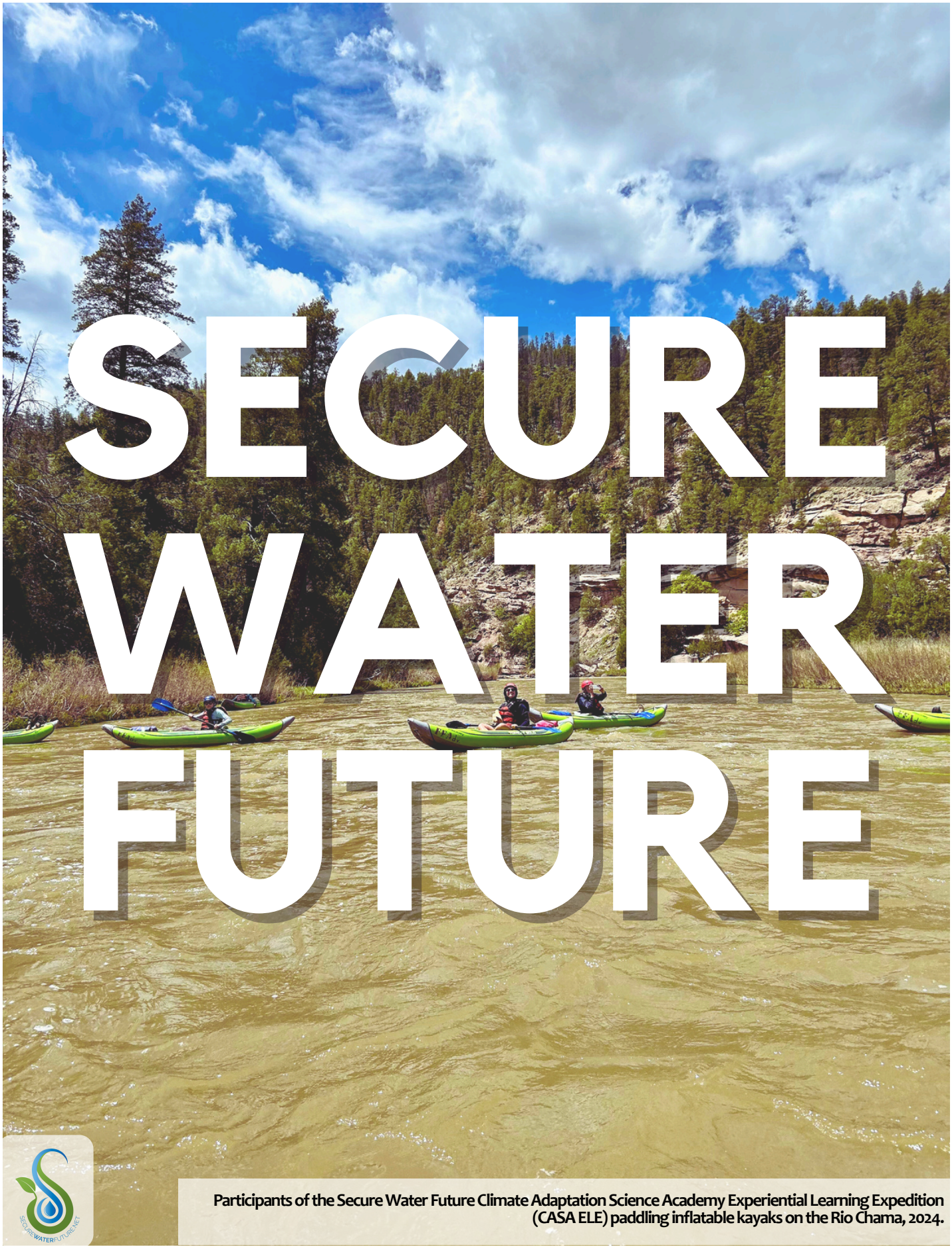
SECURE WATER FUTURE



Participants of the Secure Water Future Climate Adaptation Science Academy Experiential Learning Expedition (CASA ELE) paddling inflatable kayaks on the Rio Chama, 2024.



La Grange Hydroelectric Plant, Tuolumne River, 2024.

YEAR THREE REPORT (2023-2024)



Kaustuv Neupane (NMSU) packing up for the CASA ELE rafting trip, New Mexico, 2024.



Jacob Nesslage (UCM) & Lindsay Murdoch (UCD), Bosque del Apache, 2024.



Jack Severson (UCM) in Wisconsin for the USDA SAS CAP Project Managers Meeting, 2024.

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

USDA-NIFA Award No. 2021-69012-35916
USDA Award Date: September 1, 2021
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; USDA Southwest Climate Hub.

This document summarizes Year Three (2023-2024) Secure Water Future (SWF) SAS CAP project activities. This report was compiled with support from Jack Severson, Kal Li, Luisse Alexie Calderon, Wendy Haw, and Sarah Naumes. We encourage you to follow our ongoing work at securewaterfuture.net.

This work is supported by Agriculture and Food Research Initiative Competitive Grant no. 2021-69012-35916 from the USDA National Institute of Food and Agriculture.

Table of Contents

About SWF

Project Leadership Contacts 06
What is Secure Water Future? 08
Selected Accomplishments 10
Team Structure 11
Target Audience 12

Research Teams

Climate Integration 15
Markets 16
Management 17
Measurement 18

Conferences

OpenET Applications 21
American Geophysical Union 22

Extension

Mark Arax & Ellen Hanak: Fireside Discussion 26
State of the Tulare Basin 27
Conversation with E. Joaquin Esquivel 28
Digital Tools for Water Resources 29
Management Leadership Institute 30
Climate Adaptation Intern Program 31



Aqua Arcade Game Jam raffle winners, 2024.


UC Merced Experimental Smart Farm.


Lunch and lectures on the Rio Chama, New Mexico, 2024.


Assistant Specialist Ben Lewis (UCM) kayaking on Lake Yosemite during the Super Soaker Water Academy, 2024.


Elephant Butte Reservoir, New Mexico, 2024.


Participants of the Aqua Arcade Game Jam, 2024.

Table of Contents

Outreach

Library Showcase 35
SWF Game Development 36
Water Manager Roundtable 37
Water Manager Field Day 38

Education

Aqua Arcade Game Jam 40
Jorge Cham Visit 43
CASA ELE 44
Super Soaker Water Academy 46
SWF: Women of Water (WOW) 47

The Team

Leadership 50
Advisory Board 54
Project Team 56

Appendices

Products with NIFA 57
Support Acknowledged
Other Products 65

PROJECT LEADERSHIP CONTACTS



JOSHUA VIERS, PH.D.

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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 was the Senior Director of Interdisciplinary Research and Strategic Initiatives at UC Merced and Managing Director of SWF until June 2024. She was pivotal in creating a culture of collaboration across various disciplines, significantly enhancing the university's research landscape. Sarah was instrumental in UC Merced's success in acquiring prestigious grants, including awards from NSF, USDA, EDA, NASA, NEH, and other critical state and federal agencies. As the Managing Director of Secure Water Future, a $10M USDA grant, she catalyzed translational team research into actionable outcomes for water security challenges. Balancing her efforts between research, community outreach, and team leadership, she collaborated closely with partners to guarantee the success of team projects from inception to conclusion.

Dr. Lauren Parker joined as SWF Managing Director effective October 1, 2024. She can be reached at leparker@ucmerced.edu.



SARAH NAUMES

Managing Director
snaumes@ucmerced.edu



Touring the La Grange Diversion Dam during the AgAID Water Meeting, 2024.

WHAT IS SECURE WATER FUTURE?

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.



SWF graduate student Shobha Khanna (UCM) rafting on the Rio Chama, New Mexico, during CASA ELE, 2024.

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 capacity, 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.



La Grange Dam, AgAID Water Meeting, 2024.



CASA ELE participant Marianne Cowherd (UCB) enjoys fresh asparagus during Don Bustos' farm tour, 2024.

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 but 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.

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 improvements in water markets, management, and measurement practices 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 measurement technologies, from sensors to instrumentation and information, and assembling existing water and climate information data platforms facilitates participation in novel water management strategies and water markets. One output of the program will be a dashboard for data-driven decision-making to support adaptation to climate change 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 assessments 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 primary research teams, as well as the Education and Extension teams.
- Strengthened the internal reporting dashboard to track activity over the entire duration of the project.
- Utilized a variety of resources and events to increase cohesion throughout the team.
- Strengthened SWF Womxn of Water cohort (WOW), enhancing its scope & outreach.

Research

- Held an in-person collaborative meeting to facilitate team cohesion.
- Contributed to the broader data repository for the project.
- 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.

Extension

- UC Merced and SWF hosted a conversation with Mark Arax, facilitated by Ellen Hanak: Historical Memory, Policy, and the Future of Water in the Central Valley.
- SWF co-hosted a conference in Tulare, CA, aimed to foster community collaboration, learning, and problem-solving.
- E. Joaquin Esquivel led a conversation on recent advances in water research at UC Merced.
- The Digital Tools for Water Resource Management workshop showcased resources for climate-informed decision-making for water users and managers.
- Refined and facilitated the Climate Adaptation Intern Program (CAIP), now in its second year.

Education

- Hosted author and comic, Jorge Cham, who gave a series of lectures to students from elementary to graduate levels in Merced, CA.
- Partnering with the UC Merced Game Development Club, Secure Water Future hosted a water-focused game jam, inspired by the previous year's Water Hack Challenge.
- Launched the third year of the Climate Adaptation Science Academy Experiential Learning Expedition (CASA ELE) for affiliated graduate students.
- Hosted the third Super Soaker Water Academy summer camp on water and equity for local middle school students in Merced, California.
- SWF WOW hosted regular Zoom coffee chats and organized events such as a networking dinner, mentorship hike, and camping trip.



Tuolumne River, AgAID Water Meeting, 2024.

SWF TEAM STRUCTURE

Team Organization

There are more than 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.

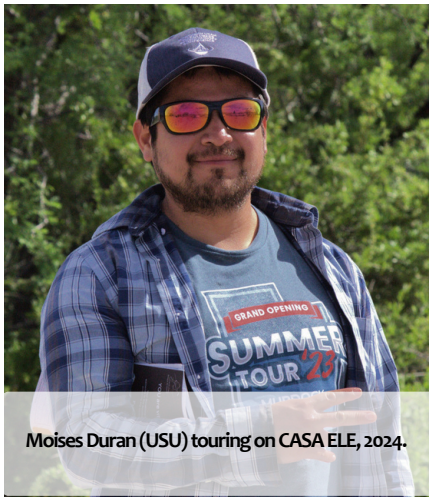
Ad Hoc Groups

Secure Water Future ad hoc groups include Womxn of Water (SWF WOW), the year three SWF CASA ELE cohort (16 graduate students), and the UC Water Academy cohort (13 graduate students).

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.



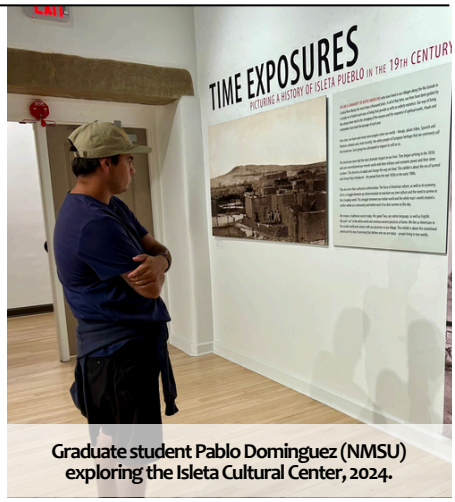
Moises Duran (USU) touring on CASA ELE, 2024.


The Rio Chama, New Mexico, 2024.


Participants of the SWF Super Soaker Water Academy (SSWA) on Lake Yosemite, 2024.

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.



Graduate student Pablo Dominguez (NMSU) exploring the Isleta Cultural Center, 2024.

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

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

Those responsible for preserving and nurturing diverse ecosystems 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 worldwide.


Participants of the AgAID Water Meeting in April, 2024.



La Grange Diversion Dam, AgAID Water Meeting, 2024.



CASA ELE participants at the American Dam, TEX-MEX border, 2024.



Aerial imagery of the UCM Vernal Pools and Grassland Reserve, 2024.

The Secure Water Future team's goal is to understand, enable, and envision data-enabled water management strategies for decision-making in 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 resources for data-driven decision-making.

RESEARCH

CLIMATE INTEGRATION



Dr. Salim Bawazir (NMSU) and graduate student Pablo Dominguez (NMSU) at Elephant Butte reservoir, 2024.



CASA ELE participants listening to Don Bustos discuss the acequia system and agriculture in northern New Mexico, 2024.

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.

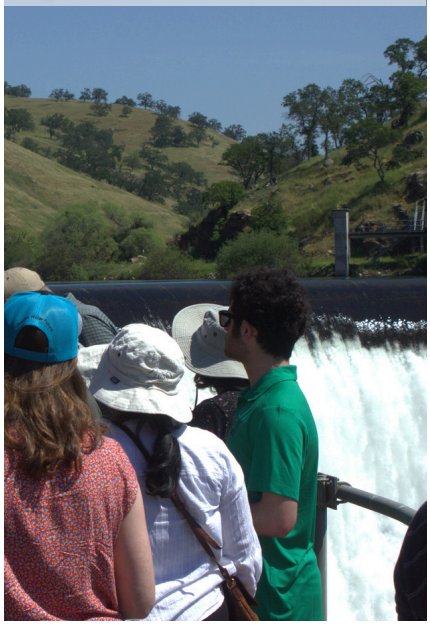
In Year Three, the Climate Integration research team consolidated their efforts on current water use, seasonal forecasts, and climate projections.

By using information captured in the multi-state needs assessment in Year One, the Climate Integration team continues to refine their water data decisions dashboard and engage in semi-structured narrative interviews with notable community advisors to pursue further development. Simultaneously, the group continues to analyze existing tools and support the other research teams in a consultatory and collaborative fashion.

MARKETS



Nageena Makhdoom (NMSU), Tejinder Singh (USU), Jamin Miller (NMSU), and Dr. Richard Heerema (NMSU) visiting an NMSU research site, CASA ELE, 2024.



La Grange Diversion Dam, AgAID Water Meeting, 2024.

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.

Throughout Year Three, the Markets Team joined efforts to better understand the intersection of water markets and climate resilience in agriculture and ecosystems across California, New Mexico, and Utah study areas. The team concentrated efforts on examining the institutional contexts and individual decisions that shape water market potential.

The Markets Team also assessed 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



Bosque del Apache, New Mexico, 2024.



Dr. Joshua Viers speaking at the SWF Library Showcase, UC Merced, 2024.

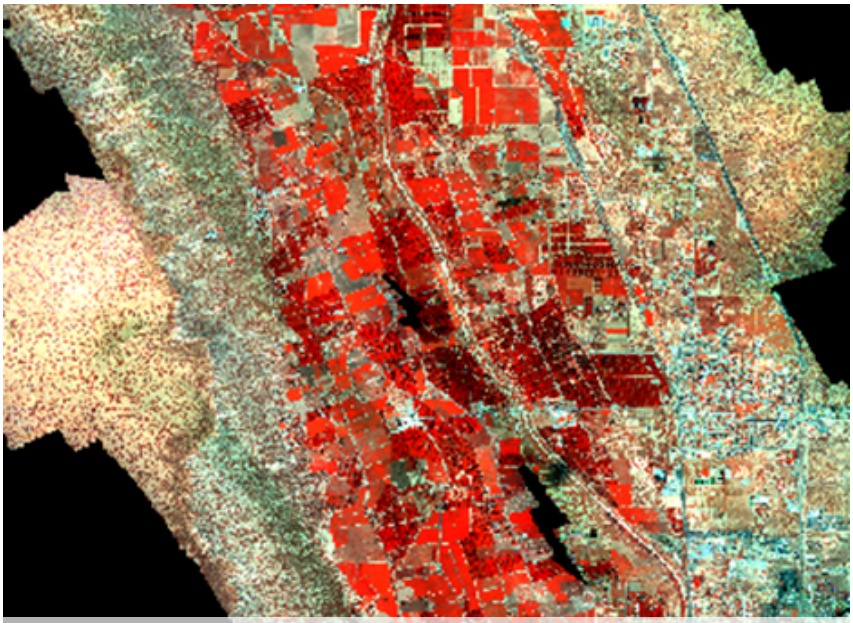
In Year Three, our Management research team continued to center their efforts on long-term water resources variability in the southwestern United States using three key basins, California's San Joaquin Valley, New Mexico's Mesilla Valley, and Utah's Great Salt Lake Basin. The focus was determining dominant controls on water resources variability to evaluate environmental, management, and policy approaches for sustainable management in future years.

Researchers used a water balance approach to assess long-term changes in water availability and water demand, identifying approaches for compromise and shared multi-benefit water use under a changing climate.

A complementary effort of Year Three was evaluating novel water management strategies (e.g. aquifer recharge and water banking) to secure water for beneficial uses during prolonged drought conditions. By analyzing different water budget components in the aforementioned basins, the team gained a better understanding of management and water resources available to troubleshoot through drought conditions.

Additional factors that impact total water supply resources, such as climate change, were also investigated. Analyzing the variability of meteorological patterns and examining historical trends in agricultural water demand in relation to hydroclimate, drought, population, and land use in these three regions support the identification of approaches for compromise and multi-benefit water use in a changing climate.

MEASUREMENT



Aerial imagery of the Mesilla Valley, New Mexico, 2024.



Anderson Safre (USU) and Dr. Richard Heerema (NMSU) at an Elephant Butte dam measurement station, 2024.

In Year Three, our measurement research team continued conducting research in Utah, New Mexico, and California. Each state's team has progressed in research and field activities on monitoring water use and water conservation and markets. The measurement team has several manuscripts in peer review and several comparison studies underway to address the growing interest in employing crop evapotranspiration data from the OpenET web platform into decision making.

Graduate students in all three states are participating in field and analysis work, from comparing OpenET estimates to field measurements, to conducting water balance approaches to determine water conservation. Research in New Mexico is expanding into additional sites to monitor pistachio orchards during multiple seasons. Research in California continues advancing the UCM Experimental Smart Farm and the AgMar Experimental Sites for aquifer recharge studies. Research in Utah is demonstrating the value of remote sensing products like OpenET to identify water market and conservation opportunities. The team also conducted activities engaging the agricultural community and water agencies; these activities saw great initial reception. In addition, the team is conducting crop life cycle assessment studies in alfalfa and other crops across the three participating states. All members in the measurement team are also interacting and collaborating regularly.

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 that explore 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 semi-arid western US. 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.

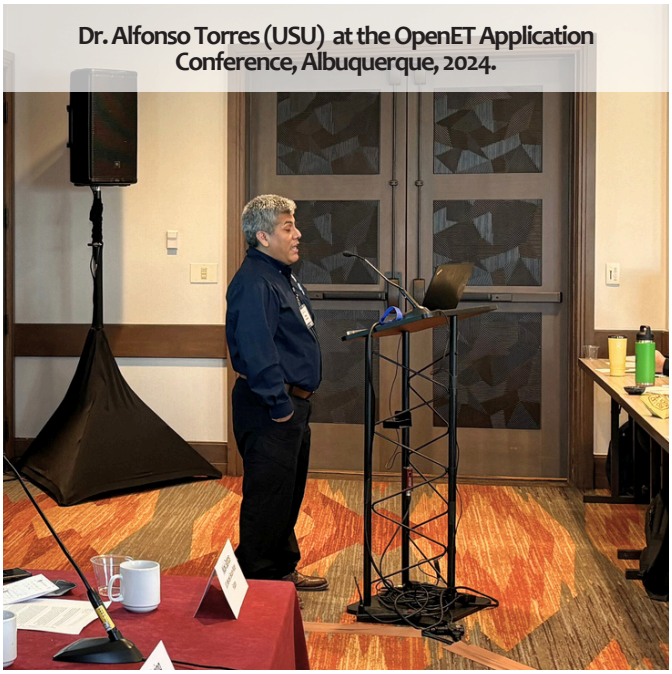


Yelenka Nunez Bolano (UCM) rafting on the Rio Chama during CASA ELE, New Mexico, 2024.

Bob Sabie (NMSU), Dr. Emily Waring (UCM), and Nick Santos (UCM) at the OpenET Application Conference, 2024.



Dr. Alfonso Torres (USU) at the OpenET Application Conference, Albuquerque, 2024.



Secure Water Future had a strong presence at numerous conferences throughout Year Three, including AGU, OpenET Applications, and SAS CAPs. Additionally, the team hosted several workshops and panels. These events offered invaluable opportunities to highlight project deliverables and present work from the initiative's first three years in a comprehensive and engaging manner.

CONFERENCES

OPENET APPLICATIONS CONFERENCE

Bob Sabie presenting at the OpenET Applications conference in Santa Ana Pueblo, New Mexico, 2024.



ABOUT THE EVENT

The OpenET Conference was a major event where Secure Water Future researchers and team leads from UCM (Nick Santos, Dr. Emily Waring, Jack Severson), USU (Dr. Alfonso Torres-Rua), and NMSU (Bob Sabie) presented different research topics and challenges, allowing interaction and discussion with other scientists about the use and application of OpenET and remote sensing solutions for water management and markets.

NETWORKS REACHED

The SWF presentation benefited the broad user group of OpenET by providing independent validation of OpenET in two different major crops in New Mexico.

The conference was primarily made up of OpenET users, stakeholders, contributors, water professionals, and data scientists.

The in-person audience was estimated to be over 100 people. The presentation from SWF was recorded and is available on YouTube.

Full attendance at the SWF session for the OpenET Applications conference, New Mexico, 2024.



AMERICAN GEOPHYSICAL UNION

Sarah Naumes (UCM) presenting "Empowering Future Climate and Water Leaders: Outcomes of the Secure Water Future Experiential Learning Program" at AGU, 2023.



ABOUT THE CONFERENCE

The American Geosphysical Union (AGU) meeting is an international gathering focused on Earth and space sciences, featuring a variety of talks and panels that cover a broad spectrum of topics related to these fields and their intersection with society. Scientists, educators, policymakers, journalists, and communicators attend AGU to deepen their understanding of our planet and environment. AGU fosters pathways to discovery, raises awareness for addressing climate change, promotes collaborations that lead to solutions, and advances the fields and professions of science towards a new era of justice, equity, diversity, inclusion, and belonging.

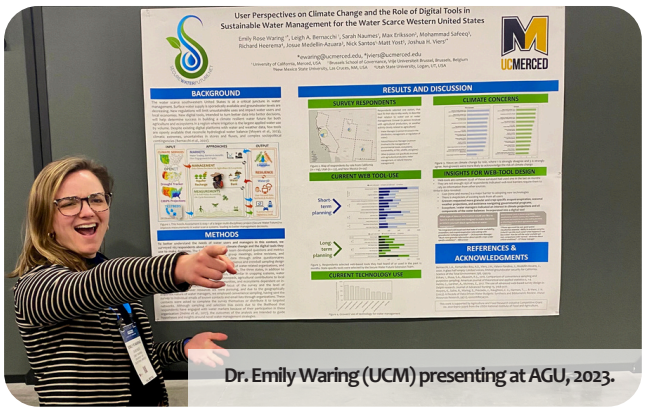
IMPACTS

The Secure Water Future team's presence was known throughout the AGU conference, with numerous posters, conference papers, and research papers presented to an extensive audience in the scientific community. Topics covered included sustainable irrigation, multi-benefit riparian and floodplain restoration, team science, groundwater recharge, and water markets. In addition to this, many collaborators and team members from around the world attended the conference, providing a stimulating venue for collaboration and fostering partnerships to come.

SELECTED AGU PRESENTATIONS

User Perspectives on Climate Change and the Role of Digital Tools in Sustainable Water Management for the Water Scarce Western United States.

Emily Waring, Leigh Bernacchi, Safeeq Khan, Max Erikkson, Sarah Naumes, Nick Santos, Matt Yost, Richard Heerema, Joshua Viers



Dr. Emily Waring (UCM) presenting at AGU, 2023.


Dr. Joshua Viers (UCM) & Nick Santos (UCM) presenting at AGU, 2023.

Harnessing Decentralized Team Science to Secure a Climate Resilient Water Future

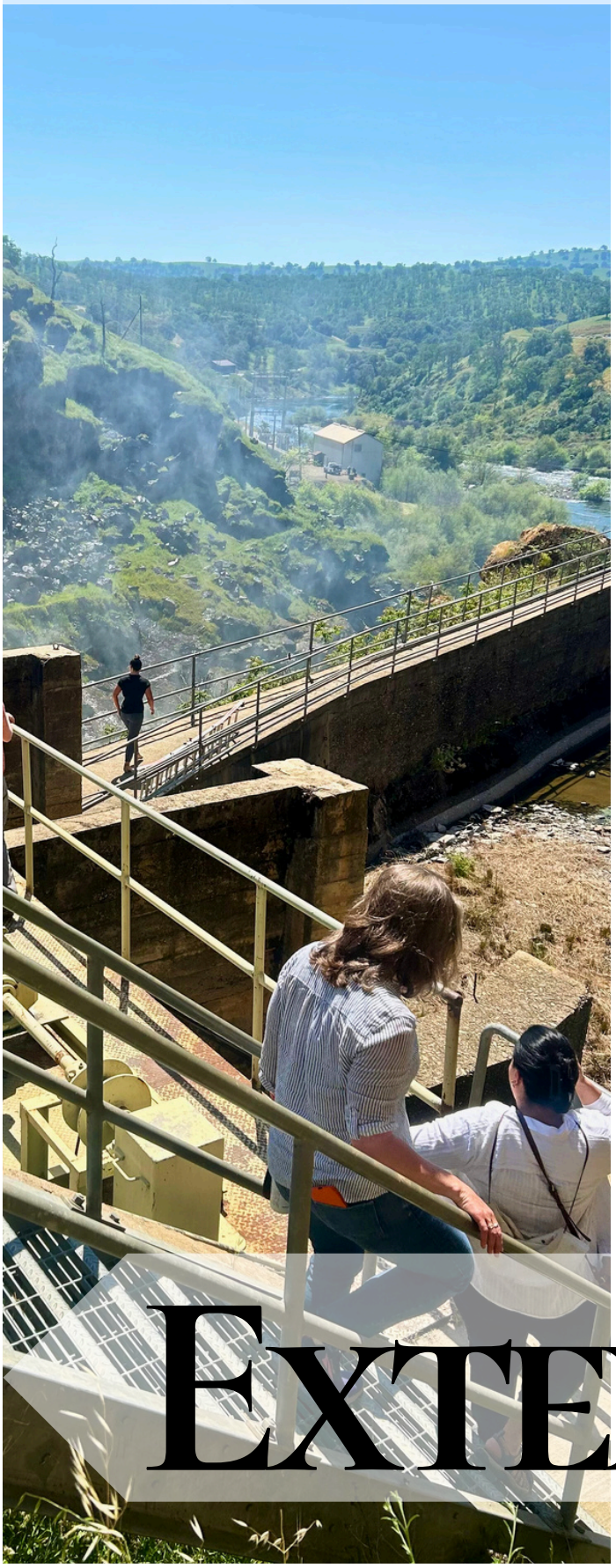
Nick Santos, Lauren Parker, Emily Rose Waring, Leigh Bernacchi, Kelley Moyers, David Meyer, Joshua Viers

Empowering Future Climate and Water Leaders: Outcomes of the Secure Water Future Experiential Learning Program

Joshua Viers, Sarah Naumes, Sarah Null, Richard Heerema, Sam Fernald


SWF team collaborating at AGU, 2023.

Touring the La Grange Diversion Dam during the AgAID Water Meeting, 2024.





Display of the MVPGR and SWF reception at the Kolligan Library, 2024.

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

EXTENSION

EXTENSION



Along the Rio Grande, New Mexico, 2024.



Merced Vernal Pools and Grassland Reserve's (MVPGR) 10th year anniversary, hosted at UC Merced, 2024.

In Year Three, our Extension team continued its mission to develop and extend curricular content to various audiences, reflecting Secure Water Future's research focus. Dr. Safeeq Khan, Extension team lead, stated, "Our Extension team aims to develop and extend curricular content to various audiences reflecting Secure Water Future's research. In Year Three, the Extension thrust organized and facilitated multiple events and programs designed to disseminate SWF's research findings and encourage collaboration amongst institutional teams and local communities in the region."

Building on the successes of previous years, the team continued its engagement with the California climate stewardship program, hosted the annual Tulare Basin workshop, and maintained the Climate Adaptation Intern Program (CAIP) at Utah State University. The Extension team also organized the 2024 Rural Communities Water Managers Leadership Institute, in partnership with Self-Help Enterprises, and planned outreach events with community members, including sessions with guest speakers.

A CONVERSATION WITH MARK ARAX, FACILITATED BY ELLEN HANAK: HISTORICAL MEMORY, POLICY, AND THE FUTURE OF WATER IN THE CENTRAL VALLEY

THE CONVERSATION

The UC Merced Library and Secure Water Future co-hosted a pivotal event focused on water policy in California, exploring its historical context and future prospects.

Acclaimed author Mark Arax read from his book "The Dreamt Land: Chasing Water and Dust Across California," and Dr. Ellen Hanak, Vice President and Director of the PPIC Water Policy Center and a senior fellow at the Public Policy Institute of California, explored the critical role of historical memory in shaping water policies and its impact on the future of this vital resource.



Dr. Ellen Hanak engaging in dialogue with Mark Arax and the audience, 2023.



Author Mark Arax speaking to the audience at UC Merced, 2023.

WHAT WAS THE IMPACT OF THE DIALOGUE?

Over the course of the event, guest speaker Mark Arax highlighted the critical importance of water, particularly in California's Central Valley. Dr. Ellen Hanak emphasized the need for innovative policies and sustainable practices to ensure a resilient future. Their enriching dialogue brought together and enlightened many in the local community, underscoring the significance of water management.

STATE OF THE TULARE BASIN

ABOUT THE HOSTS

The Tulare Basin Watershed Network (TBWN) is a coalition of leaders and practitioners from the agriculture and food industry, water management, ecological and conservation groups, and socio-economic interests. They range from local, regional, state, and federal agencies and organizations and seek to protect and enhance the Tulare Basin watersheds and resources.

UC ANR is a statewide network of University of California researchers and educators dedicated to the creation, development, and application of knowledge in agricultural, natural, and human resources.

SWF is a collaborative of investigators from across the semi-arid western US aiming to improve agricultural and environmental water resilience. We have combined efforts to co-host this critical conference.

Attendees of State of the Tulare Basin, 2023.





Showcase of a presentation at State of the Tulare Basin, 2023.

WHAT IS STATE OF THE TULARE BASIN?

In support of SWF extension and outreach efforts, we hosted a conference in Tulare, CA with 74 attendees featuring 18 speakers from different backgrounds united with the community in learning, awareness, and problem solving and with a goal to inspire further collaboration and communication among community advisors within the region.

The 2023 State of the Basin conference theme was “Managing Hydroclimatic Extremes.” The event provided a forum to increase awareness on the rich history of the basin and discussed challenges and opportunities brought about by the recent droughts and floods. The conference had a high impact on the attendees on understanding the importance for building social, economic, and environmental resilience in the region.

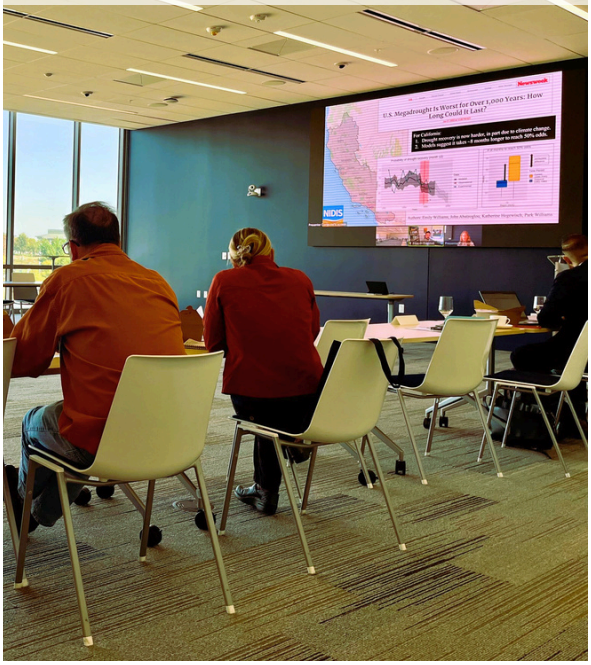
A CONVERSATION WITH E. JOAQUIN ESQUIVEL ABOUT RECENT ADVANCES IN WATER RESEARCH

WHO IS E. JOAQUIN ESQUIVEL?

E. Joaquin Esquivel was appointed to the State Water Resources Control Board by Governor Jerry Brown in March 2017 and designated by Governor Gavin Newsom as Chair in February 2019. Previously, he served as Assistant Secretary for federal water policy at the California Natural Resources Agency in the Governor's Washington, D.C. office, where he facilitated the development of policy priorities between the agency, the Governor's Office, the California Congressional delegation, and federal stakeholder agencies.

Chair Esquivel was born and raised in California's Coachella Valley. He holds a B.A. from the University of California, Santa Barbara in English.

The panel engaging in a presentation over Zoom during the round table discussion with E. Joaquin Esquivel, 2023.





Dr. Joshua Viers presenting on climate change, hydropower, and environmental flows during a panel discussion, 2023.

WHAT TRANSPIRED IN THE DIALOGUE?

A round table discussion was held on Friday, November 3rd, 2023, featuring distinguished guests from Secure Water Future and the University of California, Merced. These experts were invited to share their latest water-related research findings with E. Joaquin Esquivel.

The event provided an excellent platform for in-depth discussions and exchanges of ideas on pressing water issues, allowing the attendees to delve into innovative solutions and advancements in the field. The collaboration between these organizations and researchers emphasized the importance of addressing water sustainability and management, fostering a productive dialogue on future strategies and research directions.





Visiting the UC Merced Vernal Pools & Grassland Reserve, Digital Tools for Water Resource Management Workshop, 2024.

WHAT WAS THE FOCUS OF THE WORKSHOP?

On January 29, SWF hosted an Extension event titled "Digital Tools for Water Resource Management" at the Merced County Cooperative Extension office in Merced, California.

This event served approximately 20 agricultural and water professionals and showcased several resources that can be used to support climate-informed decision-making.

Workshop participants were introduced to tools including OpenET for gathering near real-time crop water usage, the Groundwater Accounting Platform for water balance and trading, OpenAg for assessing climate impacts on agriculture, the Climate Toolbox for gathering historical drought data, and the Water Data Decisions Dashboard. Workshop participants benefited from a start-to-finish example and in-depth tutorials informing the stages of their decision-making to manage water resources more effectively in the West.

After the workshop, participants attended a guided tour of the UC Merced Experimental Smart Farm and the Merced Vernal Pool and Grassland Reserve.

WHO ENCOMPASSES THE CALIFORNIA WATER LEADERSHIP INSTITUTE?

On April 19, 2024 members of the Secure Water Future team introduced our project to a group of more than 20 community members and participants as a part of a UC Merced extension event with Self-Help Enterprises (SHE). In addition to presenting the SWF project to the participants, the SWF team assisted in facilitating the day's events, including presentations on the current and future climate in the Central Valley, hands-on activities focusing on the application of technology within communities, and a tour of the Merced Vernal Pool Grassland Reserve.

OUTCOMES FROM THE CALIFORNIA WATER LEADERSHIP INSTITUTE

This event brought together leaders from various communities in the Central Valley to open the discussion on integrating climate research into disadvantaged communities. The resulting experiences allowed participants to expand their understandings of the research being conducted on campus, as well as how the findings relate to their communities in the San Joaquin Valley.



Visiting UC Merced's Vernal Pools & Grassland Reserve during the Self-Help Enterprises (SHE) extension event, 2024.

CLIMATE ADAPTATION INTERN PROGRAM

CAIP interns work on their products as part of a weekly program meeting, 2024.



WHAT IS CAIP?

Launched in 2023, CAIP is a semester-long, cohort-style program hosted by Utah State University where undergraduate interns receive a competitive hourly wage to work with experts and program leadership to create fact sheets, decision tools, or other resources that correspond to climate adaptation needs in Utah and the surrounding region. Over 13 weeks, interns are trained in the basics of climate change as well as how to research climate adaptation topics and communicate their findings in formats that are most useful for their audience.

GOALS

CAIP has three primary goals:

1. Provide Utahns (e.g., elected officials, state agencies, residents) with high-quality information to better understand climate change in Utah and effective adaptation measures that can be implemented.

2. Prepare the next generation of climate adaptation experts in Utah through the training of undergraduates.

3. Evaluate the efficacy of a semester-long Extension program to train undergraduates in climate adaptation.





Scott Hotaling & Kendall Becker
Co-Founders of the Climate Adaptation Intern Program (CAIP)

CLIMATE ADAPTATION INTERN PROGRAM



Overview

In January 2024, the Climate Adaptation Intern Program (CAIP) was created within USU Extension to meet Utah's growing need for climate adaptation planning. In a cohort-style program, Dr. Scott Hotaling, an Assistant Professor in the Department of Watershed Sciences and USU's Climate Resiliency Extension Specialist, and D Becker, the CAIP Coordinator, train USU students from a variety of disciplines in climate adaptation planning to create fact sheets, decision tools, websites, and oth specific to the unique needs of Utah and the surrounding region. We primarily work with undergraduates but welcome interested graduate students from any discip

The goal of the CAIP is to provide Utah's leaders, state agencies, businesses, and residents with the resources and information they need to make intentional chang economic, social, health, and environmental burdens of climate change. Concurrent goals of the program are to train the next generation of climate adaptation expe connect interns to Extension as a career, and evaluate the efficacy of a semester-long program that engages students with climate adaptation issues.



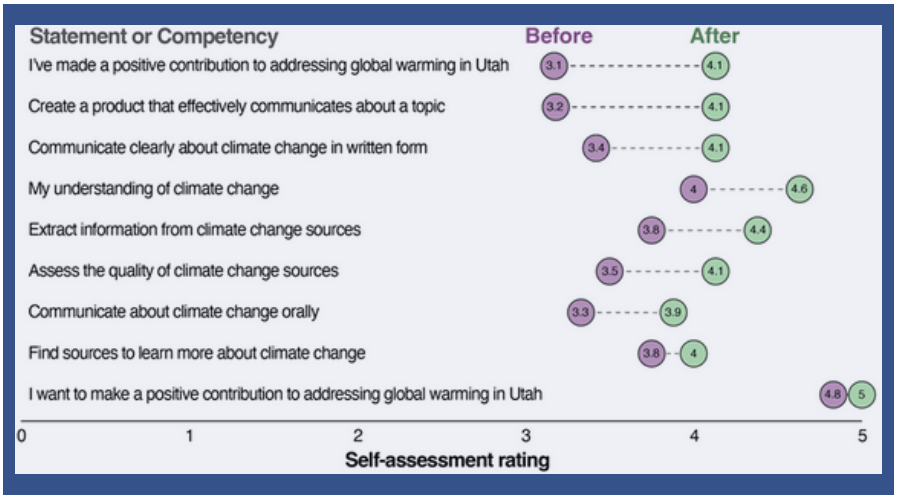


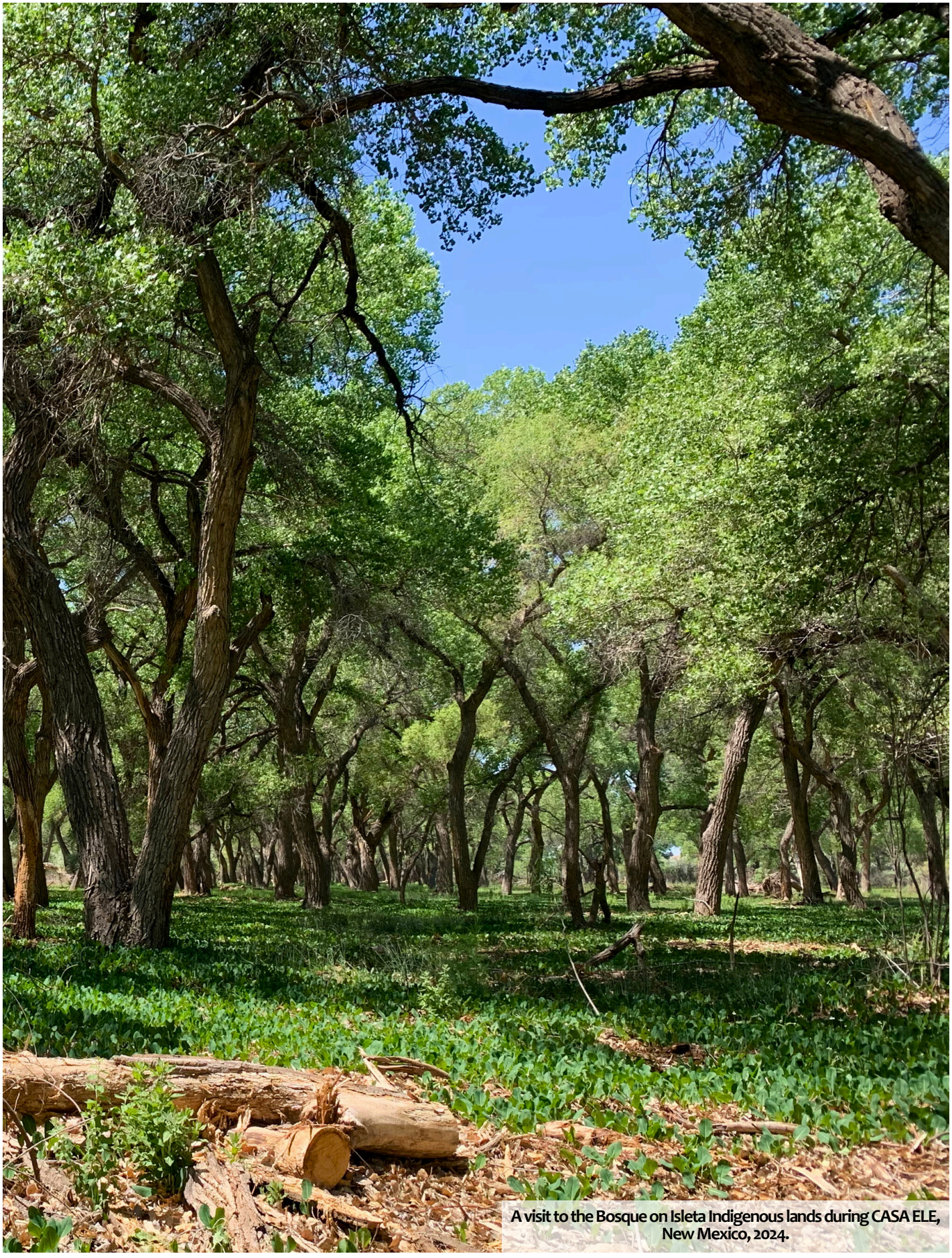
FUTURE PLANS

We successfully completed the first CAIP cohort in Spring 2024, with 10 interns finishing the program. To date, we have published two fact sheets and a lesson plan, with an additional seven fact sheets currently in progress. These materials cover a wide range of topics, including water-wise landscaping and the potential for artificial carbon sequestration in Utah.

In the coming year, we will focus on publishing the remaining products from the 1st CAIP cohort, while also training our 2nd and 3rd cohorts. We are exploring the possibility of expanding CAIP to other institutions within SWF and are preparing a manuscript about the program for peer-reviewed publication. Looking beyond the next year, we are securing the necessary resources to ensure that CAIP continues to thrive even after the SWF project comes to a close.

Results of an IRB-approved pre- and post-intern survey of CAIP participants show how interns ranked themselves on a scale of zero (low) to five (high) for a range of statements or competencies relating to their climate change knowledge, motivation, and communication abilities. Results are ordered by largest to smallest increase.





A visit to the Bosque on Isleta Indigenous lands during CASA ELE, New Mexico, 2024.



Bosque del Apache National Wildlife Refuge, 2024.



Shareen Farha (NMSU) on tour at Don Bustos' farm, CASA ELE, 2024.

Outreach involves intentional efforts to deliver information, resources, and essential services to individuals who might not otherwise have access. This includes actively engaging with communities to raise awareness, share knowledge, and offer support. Outreach is vital for bridging access gaps and ensuring that all community members benefit from available resources and services. Through outreach, SWF aims to raise awareness, disseminate knowledge, and provide support to community members in their efforts to secure a climate-resilient future

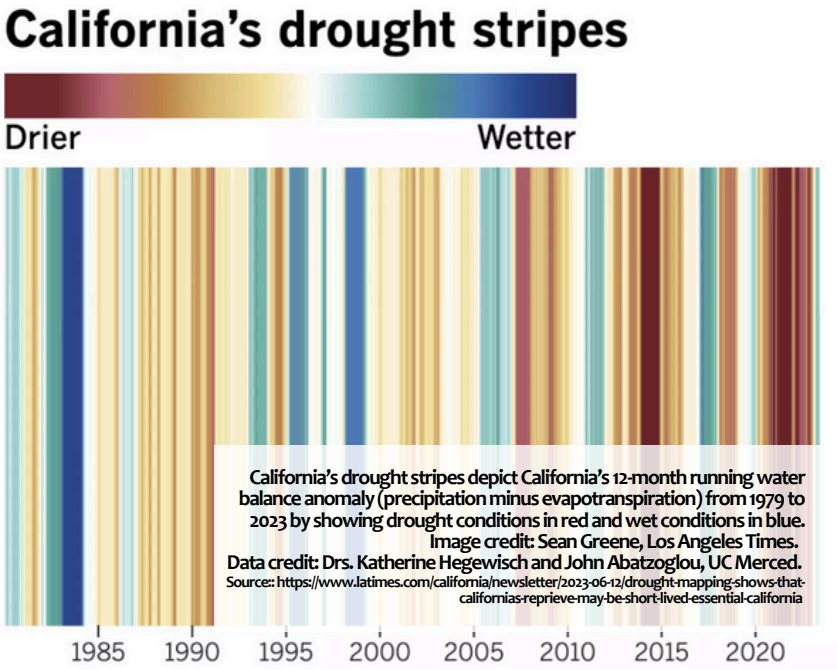
OUTREACH

LIBRARY SHOWCASE

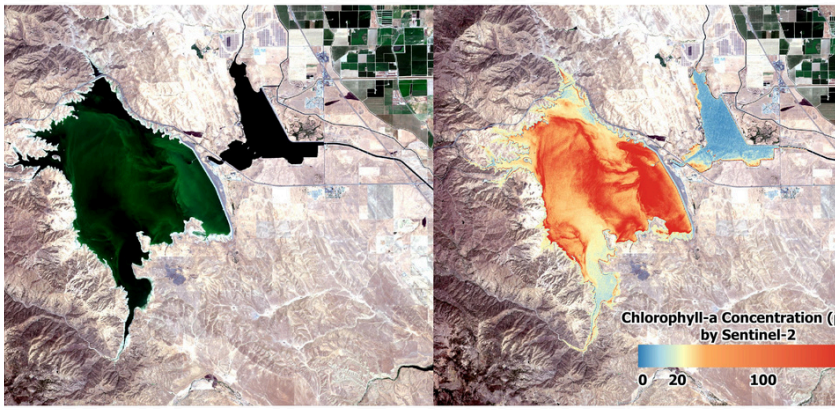
LIVING IN HYDROCLIMATIC EXTREMES: A VISUAL JOURNEY INTO WATER RESEARCH AT UC MERCED

As the newest addition to the University of California system, UC Merced has swiftly risen to prominence for its water research. This ascension can be attributed to the collective impact of projects like Secure Water Future and a constellation of other research endeavors.

During the 2023-2024 academic year, SWF was selected to host the annual Library image showcase.



California's drought stripes depict California's 12-month running water balance anomaly (precipitation minus evapotranspiration) from 1979 to 2023 by showing drought conditions in red and wet conditions in blue.
Image credit: Sean Greene, Los Angeles Times.
Data credit: Drs. Katherine Hegewisch and John Abatzoglou, UC Merced.
Source:: https://www.latimes.com/california/newsletter/2023-06-12/drought-mapping-shows-that-californias-reprieve-may-be-short-lived-essential-california



Satellite images captured from Sentinel-2. The true color image of the western San Joaquin Valley's San Luis Reservoir can be seen on the left. It is the fifth largest reservoir in California, the largest off-stream reservoir in the United States, and is a key part of the State Water Project and federal Central Valley Project. On the right is a measurement of chlorophyll-a, a common metric for measuring algal blooms, derived from data captured by Sentinel-2. With satellite data, we are able to create continuous time series of multiple variables over vast areas. Image credit: Brittany Lopez Barreto. Digital image. August 2023.

THE ROLE OF IMAGES IN WATER RESEARCH

Nestled in the heart of a region grappling with the dual challenges of water scarcity and escalating demands, UC Merced's faculty, students, and staff have dedicated their expertise to essential work that informs water management practices and measurement techniques. Researchers also explore the implications of hydroclimatic whiplash, examine the causes and impacts of groundwater contamination, and promote cross-sector collaboration in the region. These efforts extend beyond innovative research initiatives to include nurturing the next generation of water leaders and amplifying the impact of interdisciplinary team science. This showcase, presented through a blend of photographs and infographics, vividly portrays UC Merced's role in shaping a sustainable and resilient water future amid the uncertainties of our changing climate.

SWF GAME DEVELOPMENT

WHAT IS BEING DEVELOPED?

In Year Three, the New Mexico State University Learning Games Lab was in the structuring game play phase of the water game. The items being addressed were:

- Balancing crop/aquifer performance
- Creating preliminary art
- Finishing backend framework
- Beginning front end functionality

The educational aspects of the game that will be incorporated into the game include:

- Deep Percolation vs. Surface Runoff of Applied Water
- Impact of Irrigation Method on Crop Water Budget
- Land Use Categories
- Year-to-Year Variability in Yield (for various crops)
- Effects of Changing Climate
- Irrigation Technology Cost - Benefit



Graphics and mapping of the SWF water game, 2024.



Showcase of the SWF water game in action, 2024.

THE TEAM BEHIND THE GAME

The Secure Water Future Extension team from New Mexico State University features members of the Learning Games Lab with an aim to produce educational media for all ages. Amy Muise, Editor and Program Manager for the Learning Games Lab, and Dr. Barbara Chaimberlain, Director of the Learning Games Lab, oversee the production and timeline of the water game being developed.

The water game is a key focus for the team, and its creation is a collaborative effort that draws on the diverse talents and perspectives of students from various interdisciplinary studies. The collective effort of this dynamic team is directed towards creating a meaningful and impactful educational tool that promotes awareness and understanding of water conservation and management.

WATER MANAGER ROUNDTABLE

WHO WAS INVOLVED?

On March 21st, 2023, Utah State University hosted a round-table workshop in St. George, Utah as a part of the Utah Water User Workshop. Over 40 water managers, board members, and engineers from the western US participated. Faculty affiliated with Secure Water Future introduced their research and facilitated discussions to identify key barriers and priorities for water measurement and optimization. Water managers from across the state also shared their concerns and opportunities for improving water management in Utah.



Attendee introductions at the Water Manager Field Day with Bear River Canal Company in October, 2023.

PRIOR TO THE EVENT

In early to mid-2023, we conducted a survey of nearly 200 water managers across Utah and neighbouring states to understand their role in water allocation and their perspectives on optimizing water use, particularly in agriculture. The survey explored how they managed the 2021-2022 droughts, their attitudes toward water markets, and the barriers they face in developing these markets. As key players in water management, these insights are crucial for future efforts to improve water use efficiency.



USU faculty sharing research summaries at the Water Manager Roundtable held at the Water Users Association Annual Conference in St. George, Utah, 2023.

OUTCOMES

A key takeaway from this round-table discussion was the outreach to water managers to understand their needs and concerns. This marked the first time USU has engaged directly with the external water manager community, which will inform and enhance future research and Extension programs to better meet these needs.

Despite their importance to water management in Utah and the western US, few education and training programs have been directed towards water managers. The research and education needs that stemmed from this roundtable discussion were used to form additional outreach and education events for water managers in 2023 and 2024.

WATER MANAGER FIELD DAY

WHAT TOOK PLACE?

On October 27th, 2023, Utah State University partnered with Bear River Canal to host a field workshop in Corinne, Utah that reached 90 attendees.

The workshop encompassed:

- Water managers
- Stakeholders
- Educators
- Secure Water Future affiliates

The workshop consisted of hands-on training in water measurement and management. This was essential for water managers to learn new techniques for water management.

Lunch presentations and discussion at the Water Manager Field Day with Bear River Canal Company, 2023.





Demonstrations of proper water measurement techniques at the Water Manager Field Day with Bear River Canal Company, 2023.

IMPACT

In 2024, we continued to build on the momentum that was created in 2023 by hosting another water manager roundtable at the annual Water Users Conference. About 25 managers attended the field day and the schedule was similar to the 2023 field day with the addition of technologies used for water management at the dam and reservoir level. Attendees again noted that their knowledge increased and they intended to use the information provided. We have another field day event planned for late August 2024 near Vernal, UT to begin to network, train, and educate managers in the Colorado River Basin.

CASA ELE participants at Stahmann's Farm, New Mexico, 2024.



Super Soaker Water Academy students taking water samples on Lake Yosemite, 2024.



"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

AQUA ARCADE GAME JAM



Judging the Aqua Arcade Game Jam, 2024.

GOALS

Our primary goal was to provide students with an opportunity to exercise their passion for game development by creating their own game within a 48-hour time window, showcasing how they can foster these skills to kickstart their future in the gaming industry.



Aqua Arcade Game Jam submission, 2024.

THE CHALLENGE

Secure Water Future held its first game jam in partnership with UC Merced's Game Development Club (GDC) during the weekend of April 5-7, 2024, inspired by the previous year's Water Hack Challenge.

This 48-hour event catered towards UC Merced and Merced College students. Enabling collaboration with one other, teams of 5 or fewer created a game using the engine of their choosing with an educational aspect centered around hydrology. Teams were instructed to integrate one of three prompts into their creation: loss of water, water and dice, or contamination of water in the aquifers.

The Aqua Arcade Game Jam was graciously sponsored with donations by ZOTAC GAMING, Pretty Good Burger, Celsuys, Pepsico, and Five Guys.



The Aqua Arcade Game Jam winning team: Remediation. Sean Grant (UCM), Damian Eaton (UCM), Serge LoBac (UCM), Richie Friedland (UCM), and Joshua Tapia (not pictured, UCM), 2024.

OUTCOMES

Throughout the course of this game jam, participants acquired valuable insights as they collaborated in teams to develop a game while learning about water terminology. The weekend-long event propelled students to step out of their comfort zone to design a game around an unfamiliar subject.

HOSTING THE GAME JAM



Aqua Arcade Game Jam Hosts, 2024

Secure Water Future student intern team, Wendy Haw and Lexie Calderon, and administrative assistant, Kal Li, took the reins in hosting the Aqua Arcade Game Jam. From brainstorming prompts to handing out the prizes, the team of three put together intricate pieces to facilitate an engaging opportunity for UC Merced undergraduate students. Their collaborative efforts in reaching out to the local community to share and showcase the event resulted in generous support and awareness. Lexie, Wendy, and Kal all share their experience being an integral part of the Aqua Arcade Game Jam.

Kal writes, "One of the most enlightening aspects of organizing this event was the opportunity to collaborate with various brands. Working together with sponsors to bring our game jam to life was a game-changer. Being able to work with the company of a leading illustration program, Clip Studio Paint, in the context of supporting the game jam was a dream. Their support provided and lent credibility and visibility to our initiative. We are deeply thankful to all the sponsors who believed in our vision and contributed to making the Aqua Arcade Game Jam a reality.

However, the true highlight of the entire experience was witnessing the enthusiasm and creativity of the participating students. Seeing them transform their ideas into fully-fledged games was incredibly fulfilling. Knowing that we played a part in providing them with a platform to showcase their talents and innovation was immensely gratifying. Each game showcased a unique blend of creativity, technical skill, and passion, reflecting the diversity of talent within our community. Our goal was not just to host an event but to create a lasting impact on the participants and community as a whole."

Lexie recounted, "Bringing together the UC Merced Game Development Club and Secure Water Future for the Aqua Arcade Game Jam has been an incredibly rewarding experience. Being able to foster a shared passion for game development and environmental sustainability has always been our mission, and seeing it come to life is truly gratifying. I'm deeply grateful to the UC Merced, Game Development Club leaders, Sarah Naumes, and Joshua Viers, for their unwavering support and trust. To Kal and Wendy, this wouldn't have been a resounding success without you both. We're a powerhouse team!"

Wendy shared, "Since this was my first time organizing a game jam, I didn't know where to begin, which is why I was so glad that I didn't do this alone. Kal and Lexie both brought unique strengths to the table that really shone through in the organization of this event. From brainstorming sessions to logistics coordination, everyone played a crucial role in ensuring that the game jam was a success.



Aqua Arcade Game Jam hosts Lexie Calderon, Wendy Haw, and Kal Li configuring the kick-off presentation to announce the prompts.

When Lexie came up with the idea for a game jam, I wasn't quite sure what to expect since I only had prior experience organizing hackathons. In many ways, a game jam is similar to a hackathon, with participants working together to brainstorm ideas and complete an innovative project in a short amount of time. However, there are some unique aspects to a game jam, primarily that the end product must be a game. This meant that we needed to find a platform capable of supporting game submissions.

The objective for participants was to create an educational game that encompassed hydrology concepts within 48 hours. Despite facing such a short deadline, participants demonstrated determination and enthusiasm throughout the game jam. It was truly rewarding to be able to create this space for participants to channel their creativity into building innovative games.

I am immensely grateful to our wonderful supervisor, Sarah Naumes, and our sponsors for supporting our vision for this event. Their contributions were instrumental in making the Aqua Arcade Game Jam a reality. Not to mention, I'm incredibly proud of the collaborative effort that brought this event to life. Working alongside Kal and Lexie to coordinate the game jam was an absolute joy, and I am so grateful for the opportunity to have been a part of it."

JORGE CHAM VISIT

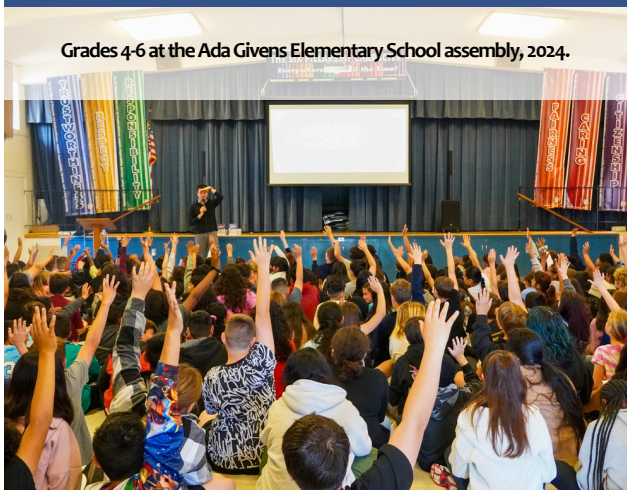
Dr. Jorge Cham at The Partisan, Merced, 2024



WHO IS JORGE CHAM?

Dr. Jorge Cham is the best-selling and Emmy-nominated creator of "PhD Comics," the popular ongoing comic strip about life in Academia. He is the co-creator and co-Executive Producer of the celebrated animated series 'Elinor Wonders Why', which airs on PBS Kids and in 78 countries around the world.

Grades 4-6 at the Ada Givens Elementary School assembly, 2024.



EDUCATIONAL AUDIENCES

On April 18, 2024, Secure Water Future co-hosted and welcomed author, comic, and speaker Dr. Jorge Cham to Merced, CA. Dr. Cham spoke to over 500 students at Ada Givens elementary school during two assemblies, helping to make science, education, and discovery more approachable.

Following the elementary school visit, Dr. Cham led an interactive science communication workshop at UC Merced, catering to researchers and graduate students.

At the end of the day, Dr. Cham gave a comedic performance in downtown Merced to an audience of graduate students, staff, and faculty members.

Attendees of Dr. Jorge Cham's performance at The Partisan, Merced, 2024.



OUTCOMES

These workshops and assemblies urged participants to communicate effectively, despite the complexity of their work, which proved to be beneficial to the participant's experience and ongoing communication efforts.

CASA ELE

WHAT IS CASA ELE?

The Climate Adaptation Science Academy Experiential Learning Expedition (CASA ELE) hosted 16 graduate students from our partner institutions on a week-long immersive learning experience. Students traveled by van and raft, accompanied by faculty, water management mentors, and professionals to experience the semi-arid Western US and its water first-hand. Site visits enabled a deeper understanding of agricultural & natural resources, infrastructure, and processes for decision-making in New Mexico and Texas. This experiential trip consisted of immersive education to prepare the next generation of climate and water leaders.

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

CASA ELE exploring acequia systems, New Mexico, 2024.



OUTCOMES

Through the program, graduate students cultivated a greater understanding of Western water challenges and solutions, developed connections to their research, and built a strong network with fellow researchers. Students produced a 4 to 5-minute-long video discussing their research in relation to the topics covered on the expedition, sharing their experiences with the broader population through scientific communication materials.

CASA ELE participants hiking in a slot canyon, New Mexico, 2024.



TOPICS COVERED

In 2024, CASA ELE engagement covered:

- Headwaters and climate change impacts on snowmelt runoff
- Acequias, agriculture, and community
- Indigenous water topics for ecosystems, farming, and traditional culture
- Ecosystems and river flow
- Recreational water use
- Agricultural management, including hydroclimatic conditions and likely futures
- Transboundary water issues.

CASA ELE participants paddling the Rio Chama, 2024



THE CASA ELE EXPERIENCE

CLIMATE ADAPTATION SCIENCE ACADEMY EXPERIENTIAL LEARNING EXPEDITION

PARTICIPANT RESPONSES

"My graduate research is on snow as a water source, so visiting farmers gave me a new perspective on how downstream water users think about what I work on. Texas and, to some extent, New Mexico are not particularly snowy states, but everyone we met, from small farmers in northern New Mexico to the reservoir hydrologists in El Paso, talked about snow as the origin for their water. They were all thinking about the same questions as me -- what will happen to snow in a future under climate change and how can we manage it? But from a personal, local perspective. " - Marianne Cowherd (UCB)

"Physically seeing and experiencing how people interact with, measure and use water helped me better connect and understand water issues and processes. CASA ELE has helped me connect with fellow researchers, has exposed me to new ideas, and has given me a more holistic view of water management, rights, and issues in the western United States." - Shobha Khanna (UCM)

CASA ELE participants & mentors at the US / Mexico border, 2024.



Participants of CASA ELE listen to Dr. Alfonso Torres-Rua (USU) lecture on remote sensing, 2024.



WORDS FROM OUR MENTORS

"CASA ELE is an excellent experience for graduate students, and especially those part of SWF. It provides an informal, relaxed environment, away from coursework and academic responsibilities, to learn, discuss, and follow up with local specialists, water users, and state and federal officials, providing a wide range of learning and a broad understanding of water issues, solutions, connection to other teams, and develop new friendship and contacts.

"Events like CASA ELE, are of importance to graduate students, because, as these students are deeply involved in understanding current water issues and science, will create connections between the different CASA ELE activities with their research and activities. In addition, since CASA ELE provides a worry-free time, along with fun events, it becomes a memorable experience among students, mentors, and visited sites."

- Dr. Alfonso Torres-Rua (USU)

SUPER SOAKER WATER ACADEMY

Super Soaker Water Academy student kayaking on Lake Yosemite, 2024.



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.



Super Soaker Water Academy students exploring drone applications, 2024.

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 develop a conceptual sense of how water access intersects with users' various economic and social needs.



Super Soaker Water Academy students transferring water quality samples, 2024.

OUTCOMES

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.”

SWF WOW CAMPING RETREAT



Yara Pasner (UCD) and Sarah Naumes (UCM) on a SWF WOW camping trip, 2024.

HIGHLIGHTS FROM SWF WOW CAMPING

Womxn in academia and STEM often face unique career challenges that are frequently acknowledged but seldom openly discussed. SWF WOW provides a valuable platform for womxn-identified members of our community to establish informal mentorship networks across different career stages, locations, and trajectories.

Participants enjoying the water on the SWF WOW camping trip, 2024.



WHO ARE SWF WOW?

Secure Water Future Womxn of Water (SWF WOW) is an ad hoc group dedicated to supporting and mentoring womxn in STEM, with an emphasis on the water sector. The group welcomes individuals at all career stages, including undergraduate and graduate students, staff, faculty, and community partners. SWF WOW has previously hosted regular Zoom coffee chats and organized events such as a networking dinner, mentorship hike, and camping trip. Their unofficial motto proudly states, "Flows before bros!"

SWF WOW campers, 2024.



KEY TAKEAWAYS

Connecting with graduate students and early-career professionals in this supportive environment was a privilege, fostering candid conversations about aspirations and concerns. The informal settings, such as camping, also strengthened our ability to collaborate effectively in more formal professional contexts.



Rio Chama, New Mexico, 2024.

Graduate student researchers Moises Duran (USU), Tejinder Singh (USU), Marianne Cowherd (UCB), and Shobha Khanna (UCM), exploring a slot canyon, New Mexico, 2024.





SWF team members enjoying frozen custard in Las Cruces, 2024.

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 was the Senior Director of Interdisciplinary Research and Strategic Initiatives at UC Merced until June 2024. She was pivotal in creating a culture of collaboration across various disciplines, significantly enhancing the university's research landscape. Sarah was instrumental in UC Merced's success in acquiring prestigious grants, including awards from NSF, USDA, EDA, NASA, NEH, and other critical state and federal agencies. As the Managing Director of Secure Water Future, she catalyzed translational team research into actionable outcomes for water security challenges. Balancing her efforts between research, community outreach, and team leadership, she collaborated closely with partners to guarantee success. Sarah is now the Director of Strategic Research Development at Columbia Engineering.



JOHN ABATZOGLOU

Dr. John Abatzoglou is a 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 and an Assistant Professor of Economics at the University of Nevada Reno. 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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LEADERSHIP



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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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 at the University of California, Davis. 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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LEADERSHIP



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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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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LEADERSHIP



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 was a programmer, geographic information system (GIS) specialist, instructor, web developer, and environmentalist specializing in decision support applications. At UC Merced, Nick developed models, software, databases, and applications to help analyze and understand California agriculture and environmental impacts and indicators. Nick was also the instructor for Coursera's five-course specialization in GIS. Nick is now a GIS Data Engineering Architect with the California Department of Technology.



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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ROBYN GRIMM

Dr. Robyn Grimm was a Director (Climate Resilient Water Systems) at Environmental Defense Fund. Prior to EDF, Robyn worked at the consulting firm CH2M-Hill, where she was a water resources policy analyst and advised the State Department of Water Resources on flood planning. Robyn follows and regularly engages in conversations around the implementation of California's Open and Transparent Water Data Act, and provides input to California's Department of Water Resources. Robyn is now CEO at the California Water Data Consortium.

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, 2023 to August 31, 2024.

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. (UCD)
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)
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)*
Jaishri Srinivisan, Ph.D. (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)

*Departed the SWF Team during Year 3

Graduate Students

Hadia Akbar (USU)
Andrew Calderwood (UCD)*
Gustavo Dourado Facincani (UCM)*
Humberto Flores Landeros (UCM)
Greg Goodrum (USU)
Lucy Hackett (UCB)
Masoumeh Hashemi (USU)
Tasnim Kamal Shamma (NMSU)
Shobha Khanna (UCM)
Liying Li (UCM)*
Raji Lukkoor (UCM)
Jamin Miller (NMSU)
Moises Duran (USU)
Katherine Osorio-Diaz (USU)
Yara Pasner (UCD)
Uduwarage Anushka Chathuranga Perera (NMSU)
Saddy Pineda (USU)
Jorge Preciado (NMSU)
Ken Prewitt (UCM)
Naivy Rodal Morales (UCM)*
Liam Sabiston (NMSU)*
Gabriela Sancho Juárez (USU)
Garrison Schlauch (UCB)
Britta Schumacher (USU)
Berhanu Sinshaw (UCM)
Zada Tawalbeh (NMSU)
Kira Waldman (UCD)
Arthur Wardle (UCB)
Aaron Watt (UCB)

*Degree completed

Undergraduate Students

Alexie Calderon (UCM)*
Lily Chavez (NMSU)
Adam Crawford (UCM)*
Wendy Haw (UCM)*

*Degree completed

Staff

Isaiah Apodaca (NMSU)
Abby Bushman (USU)
Ben Lewis (UCM)
Andrew Silverstien (UCM)
Kal Li (UCM)
Sarah Naumes (UCM)*
Jack Severson (UCM)

External Evaluator

David Meyer, Ph.D. (BSU)

*Departed the SWF Team during Year 3



CASA ELE Participants at Elephant Butte Reservoir, 2024.

Rio Chama, New Mexico, 2024.

CASA ELE participant at Don Bustos' farm, 2024.



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. (2023, September 29). Cultivating excellence seminar series: Navigating climate change: Science, impacts, and solutions [Presentation]. Boise State University, Boise, ID. https://www.boisestate.edu/coen-mbe/2023/09/25/cultivating-excellence-seminar-series-navigating-climate-change-science-impacts-solution/

Abatzoglou, J. (2024, May 9). Drought in the west [Presentation]. 2024 Western Interstate Region Conference. Fish Camp, CA.

Abatzoglou, J. (2024, April 29). California's 2023 snow deluge: Contextualizing an extreme snow year against future climate change. https://doi.org/10.1073/pnas.2320600121

Abatzoglou, J. T., Lee, S., & Lee, S. (2023, September 1). Effects of water surplus on prevented planting in the US Corn Belt for corn and soybeans. IOPscience. Environmental Research Communications. https://iopscience.iop.org/article/10.1088/2515-7620/acf919/meta

Akbar, H. & Rosenberg, D. (2023, December 9). Using a real-time online collaborative environment to elicit hydrologic, social and behavioral drivers to implement a water bank. AGU Fall Meeting, San Francisco, CA, Paper Presentation.

Akbar, H. & Rosenberg, D. (2023, December 12). Using a Real-time Online Collaborative Environment to Elicit Hydrologic, Social and Behavioral Drivers to Implement a Water Bank. AGU Fall Meeting, San Francisco, CA, Paper Presentation.

Almela, P., Elser, J. J., Giersch, J. J., Hotaling, S., & Hamilton, T. L. (2023, October 27). Brief communication: Influence of snow cover on albedo reduction by snow algae. EGUsphere. Advance online publication. https://doi.org/10.5194/egusphere-2023-2379

Ayres, A. (2024, June 5). Groundwater markets & consolidation [Presentation]. UC Davis NatuRE Policy Lab, Davis, CA.

Ayres, A. (2024, July 1). Groundwater markets & consolidation [Conference presentation]. 2024 WEAI Conference, Seattle, WA.

Bruno, E. M., Jessoe, K. K., & Hanemann, W. M. (2024). The dynamic impacts of pricing groundwater. Journal of the Association of Environmental and Resource Economists, 11(5), 1201–1227. https://doi.org/10.1086/728988

Bruno, E.M., & Jessoe, K.K. (2024). Designing water markets for climate change adaptation. Nature Climate Change, 14(4), 331–339. https://doi.org/10.1038/s41558-024-01964-w

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Bruce, M., Sherman, L., Bruno, E., Fisher, A.T., & Kiparsky, M. (2023). Recharge net metering (ReNeM) is a novel, cost-effective management strategy to incentivize groundwater recharge. Nature Water, 1(10), 855–863. https://doi.org/10.1038/s44221-023-00141-1

Clifton, B., Viers, J., Fremier, A.K., Ghezzehei, T.A., & Hestir, E.L. (2023, December 15). Long-term monitoring quantifies the multi-benefits of process-based floodplain restoration along a free-flowing river in California's Delta [Paper presentation]. AGU Fall Meeting, San Francisco, CA.

Clifton, B., & Viers, J.H. (2024). Complex drivers of geomorphic response and habitat formation revealed in multiyear monitoring of Cosumnes River Experimental Floodplain reconnection. PLOS Water, 3(4), e0000132. https://doi.org/10.1371/journal.pwat.0000132

Clifton, B., Ghezzehei, T.A., & Viers, J.H. (2024). Carbon stock quantification in a floodplain restoration chronosequence along a Mediterranean-montane riparian corridor. Science of The Total Environment, 946, 173829. https://doi.org/10.1016/j.scitotenv.2023.173829

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, CO. https://events.rdmobile.com/Sessions/Details/1732587

Escriva-Bou, A. (2023, December 14). Assessing drought impacts through a hazard-exposure-vulnerability methodology in complex water systems: The case of California [Poster presentation]. H43F-2140, AGU Fall Meeting, San Francisco, CA. https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1352880

Escriva-Bou, A. (2024, February 7). Water partnerships to promote infrastructure investment and flexible water management [Oral presentation]. SPP Webinar, Riverside, CA.

Hanak, E., Ayers, A., Peterson, C., Escriva-Bou, A., Cole, S., & Joaquín Morales, Z. (2023, September 20). Managing water and farmland transitions in the San Joaquin Valley. Public Policy Institute of California. Retrieved from https://www.ppic.org/event/managing-water-and-farmland-transitions-in-the-san-joaquin-valley/

Escriva-Bou, A., Viers, J., Medellin-Azuara, J., & Hanak, E. (2024, February 16). The outlook for water management: Implications for agriculture [Oral presentation]. 2024 Agricultural Outlook Forum, Arlington, VA. https://www.usda.gov/oce/ag-outlook-forum/2024-aof-program

Facincani Dourado, G. (2024). Balancing trade-offs for sustainable water resources management: Reconciling climate change, hydropower, and environmental flows in the Central Sierra Nevada, California. University of California, Merced, CA. ProQuest ID: FacincaniDourado_ucmerced_1660D_11079. Merritt ID: ark:/13030/m53k4msf.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Facincani Dourado, G., & Viers, J. H. (2024). Reliability and resilience of environmental flows under uncertainty: Reconsidering water year types and inconsistent flow requirements in California. Environmental Research Letters. https://doi.org/10.1088/1748-9326/ad6d80

Facincani Dourado, G., Viers, J. H., Abatzoglou, J. T., & Rheinheimer, D. E. (2024). Stress testing California's hydroclimatic whiplash: Potential challenges, trade-offs and adaptations in water management and hydropower generation. ESS Open Archive. https://doi.org/10.22541/essoar.171345399.91248863/v1

Fernald, A., Heerema, R., & Preciado, J. (2023, December 11). Groundwater recharge in pecan fields under different irrigation systems to reduce the impacts of climate change [Oral presentation]. AGU Fall Meeting, San Francisco, CA.

Green Nylen, N. (2024, February 12). An (incomplete) overview of California water rights and management with a focus on the Central Valley. Climate Story Lab: Food, Water, and Equity in California, UC Berkeley Graduate School of Journalism, Berkeley, CA, Oral Presentation.

Green Nylen, N. (2024, March 13). Allocating water in times of scarcity [Oral presentation]. UC Davis Institute of the Environment Seminar Series, held virtually. https://www.youtube.com/watch?v=os4pYFfwtqU

Hanak, E., Ayres, A., Peterson, C., Escriva-Bou, A., Cole, S., & Morales, Z. J. (2023, September 19). Managing water and farmland transitions in the San Joaquin Valley. Public Policy Institute of California. https://www.ppic.org/publication/managing-water-and-farmland-transitions-in-the-san-joaquin-valley/

Heerema, R. (2023, December 7). Growing pecans and other agricultural/water topics [Oral presentation]. Water Leaders Workshop, Las Cruces, NM. https://newmexicowatereducation.org/event/fall-2023-water-leaders-workshop/

Hotaling, S. (2023, November 2). Overview of climate change impacts on mountain aquatic biodiversity [Oral presentation]. Oregon State University, Corvallis, OR.

Hotaling, S. (2023, November 3). Climate change and the fate of high mountain aquatic biodiversity [Seminar presentation]. Oregon State University, Corvallis, OR. https://events.oregonstate.edu/event/ecology_evolution_and_conservation_biology_seminar_scott_hotaling

Hotaling, S. (2023, November 15). Potential for rock glaciers to serve as a climate-resilient water resource in northern Utah [Oral presentation]. Salt Lake City, UT.

Hotaling, S. (2023, October 30). Climate change and the future of western water supplies [Oral presentation]. Chico State University, Chico, CA.

Hotaling, S., Becker, K., & Morriss, M. (2024). Rock glaciers in Utah [Fact sheet]. Utah State University Extension. https://digitalcommons.usu.edu/extension_curall/2417/

Lee, S., & Abatzoglou, J. T. (2023, September 25). Effects of water surplus on prevented planting in the US corn belt for corn and soybeans. Environmental Research Communications, 5(9), 095014. https://doi.org/10.1088/2515-7620/acf919

Lukkoor, R. (2024, June 19). Life cycle assessment of alfalfa in the southwestern United States [Oral Presentation]. 2024 ISSST Conference, Baltimore, MD. https://www.conftool.org/issst2024/index.php?page=browseSessions&form_session=160&presentations=show

Marshall, A. M., Abatzoglou, J. T., Rahimi, S., Lettenmaier, D. P., & Hall, A. (2024, April 29). California's 2023 snow deluge: Contextualizing an extreme snow year against future climate change. Proceedings of the National Academy of Sciences, 121(20). https://doi.org/10.1073/pnas.2320600121

Mashaly, A., Fernald, A., Geli, H. M., Bawazir, S., & Steiner, R. (2023, December 13). Dynamic simulation of potential agricultural practices for sustainable water management under climate change in a semi-arid region [Paper presentation]. AGU Fall Meeting, San Francisco, CA. https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1437636

Medellin-Azuara, J. (2023, December 14). Exploring western states regional water market cases for agriculture and community climate extreme resilience: Tulare Lake Basin, CA, Mesilla Valley, NM, and Cache Valley, UT [Oral presentation]. AGU Fall Meeting, San Francisco, CA. https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1415530

Medellín-Azuara, J., Escriva-Bou, A., Gaudin, A. C., Schwabe, K. A., & Sumner, D. A. (2024). Cultivating climate resilience in California agriculture: Adaptations to an increasingly volatile water future. Proceedings of the National Academy of Sciences, 121(32). https://doi.org/10.1073/pnas.2310079121

Michaels, K., Becker, K., Lamm, A., & Hotaling, S. (2024). Cap-and-trade carbon pricing in Utah: Challenges and potential impact [Fact sheet]. Utah State University Extension. Retrieved from https://digitalcommons.usu.edu/extension_curall/2431/

Miller J. & Heerema R. (2023, October 27). Soil water-holding capacity: How to schedule irrigations optimally [Oral presentation]. Western Pecan Growers Association (WPGA) Webinar.

Miller J. & Heerema R. (2023, November 14). Irrigation scheduling [Oral presentation]. Western Pecan Growers Association (WPGA) Webinar.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Miller, J. & Heerema, R. (2024, March 3). Irrigation Scheduling Considerations [Oral presentation]. NM.

Miller, J. & Heerema, R. (2024, August 15). Techniques to Improve Irrigation Scheduling and Water Use Efficiency in Pecan Orchards [Oral presentation]. NM.

Morrisett, C. N., Van Kirk, R. W., & Null, S. E. (2024). Can agricultural managed aquifer recharge (Ag-MAR) recover return flows under prior appropriation in a warming climate? Water Resources Research. https://doi.org/10.1029/2023WR036648

Moyers, K., Sabie, R., Waring, E., Preciado, J., Naughton, C. C., Harmon, T., Safeeq, M., Torres-Rua, A., Fernald, A., & Viers, J. H. (2023). A decade of data-driven water budgets: Synthesis and bibliometric review. Water Resources Research, 59(11). https://doi.org/10.1029/2022WR034310

Moyers, K., Abatzoglou, J. T., Escriva-Bou, A., Medellín-Azuara, J., & Viers, J. H. (2024). An invisible water surcharge: Climate warming increases crop water demand in the San Joaquin valley's groundwater-dependent irrigated agriculture. PLOS Water, 3(3). https://doi.org/10.1371/journal.pwat.0000184

Naumes S. (2024, April 5). Putting relationality at the centre of international studies. ISA 2024 Annual Convention, San Francisco, CA, Paper Presentation. https://www.isanet.org/Conferences/ISA2024

Osorio-Diaz, K. & Torres-Rua, A. (2023, June 26). Remote sensing resources for agricultural water management research. Sensing Applications for Field Evaluation of Irrigated Agriculture Workshop. Logan, UT.

Osorio-Diaz, K. & Torres-Rua, A. (2024, March 20). Opportunities for water conservation and market in Utah using remote sensing and GIS data [Oral presentation]. Utah.

Parker, L.E., Zhang, N., Abatzoglou, J.T. et al. A variety-specific analysis of climate change effects on California winegrapes. Int J Biometeorol 68, 1559–1571 (2024). https://doi.org/10.1007/s00484-024-02684-8

Pasner, Y. M., Fogg, G. E., & Dahlke, H. E. (2023, December 12). Scale matters: Assessing aquifer connectivity through vertical hydraulic gradients. In Challenges and solutions for hydrologic scaling across multiple processes and scales [Conference session]. AGU Fall Meeting 2023, San Francisco, CA, USA. https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1356988

Preciado, J., Fernald, A., & Heerema, R. (2024, April 14–19). Groundwater recharge in pecan orchards under different irrigation systems to reduce the impacts of climate change in the Southwest USA [Conference presentation]. EGU General Assembly 2024, Vienna, Austria. https://doi.org/10.5194/egusphere-egu24-6804

Rodríguez-Flores, J. M., Fernandez-Bou, A. S., Ortiz-Partida, J. P., & Medellín-Azuara, J. (2023). Drivers of domestic wells vulnerability during droughts in California's Central Valley. Environmental Research Letters, 19(1), 014003. https://doi.org/10.1088/1748-9326/ad0d39

Rodríguez-Flores, J. M., Gupta, R. S., Zeff, H. B., Reed, P. M., & Medellín-Azuara, J. (2023). Identifying robust adaptive irrigation operating policies to balance deeply uncertain economic food production and groundwater sustainability trade-offs. Journal of Environmental Management, 345, 118901. https://doi.org/10.1016/j.jenvman.2023.118901

Sabie, B., Tawalbeh, Z., Sabiston, L., Bawazir, S., & Fernald, S. (2024, February 27). Comparisons of OpenET to pecan and alfalfa field measurements in the Mesilla Valley, New Mexico [Oral presentation]. OpenET Applications Conference, Las Cruces, NM. https://www.eventcreate.com/e/openet-applications-conference

Sabie, R., Bawazir, A. S., Buenemann, M., Steele, C., & Fernald, A. (2024). Calculating vegetation index-based crop coefficients for alfalfa in the Mesilla Valley, New Mexico using harmonized Landsat Sentinel-2 (HLS) data and eddy covariance flux tower data. Remote Sensing, 16(16), 2876. https://doi.org/10.3390/rs16162876

Sabiston, L., Sabie, R., Buenemann, M. et al. Comparing field-scale eddy covariance measurements and crop coefficient estimates of alfalfa evapotranspiration to OpenET model estimates and exploring water budget implications in a dryland environment. Irrig Sci (2024). https://doi.org/10.1007/s00271-024-00941-7

Santos N. (2023, October 5). "Python tutorial supporting learning how to work with spatial data." https://github.com/nickrsan/spatial-python-tutorial

Santos, N., Sabie, R., Torres-Rua, A., & Waring, E. (2024, February 27). Water resource management across the semi-arid southwestern United States: Insights from OpenET applications in California, Utah, and New Mexico [Conference presentation]. OpenET Applications Conference, Albuquerque, NM.

Shamma, T. K., Preciado, J., Fernald, A., & Heerema, R. (2023, December 13). Benefits of water-saving farming: Drip irrigation for pecans and young pistachios in a water-scarce valley [Paper presentation]. GC33N-1320, AGU Fall Meeting, San Francisco, CA. https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1427676

Storrud, S., Becker, K.M.L., & Hotaling, S. (2024). Artificial carbon sequestration in Utah [Fact sheet]. Utah State University Extension.

Tawalbeh, Z., Bawazir, S., Fernald, A., & Sabie, R. (2023, November 10). Spatiotemporal variability of alfalfa ET under farming practices in the Mesilla Valley [Oral presentation]. Graduate Research and Arts Symposium (GRAS), New Mexico State University, Las Cruces, NM.

APPENDIX I: PRODUCTS WITH NIFA SUPPORT ACKNOWLEDGED

Tawalbeh, Z. M., Bawazir, S., Fernald, A., Sabie, R., & Heerema, R. (2024, April 17). Assessing satellite-derived OpenET platform evapotranspiration of mature pecan orchard in the Mesilla Valley, New Mexico. Remote Sensing, 16(8), 1429. https://doi.org/10.3390/rs16081429

Tawalbeh, Z. M., Bawazir, A. S., Fernald, A., & Sabie, R. (2024). Spatiotemporal variabilities in evapotranspiration of alfalfa: A case study using remote sensing METRIC and SSEBop models and eddy covariance. Remote Sensing, 16(13), 2290. https://doi.org/10.3390/rs16132290

Torres, A. F., & Osorio, K. (2024, February 27). Identifying Utah water conservation opportunities by farm water balance and OpenET data [Oral presentation]. OpenET Applications Conference, Las Cruces, NM. https://www.eventcreate.com/e/openet-applications-conference.

APPENDIX II: OTHER PRODUCTS

Research Instrumentation

- The SWF team at USU purchased and installed pressure transducers to measure the streamflow and temperature of freshwater streams to monitor flows and intermittency.

Workshops and Outreach

- We hosted a workshop for growers and landowners within the Merced Subbasin Groundwater Sustainability Agency (GSA) on November 2, 2023 to demonstrate the Groundwater Accounting Platform. This workshop was held in partnership with Environmental Science Associates (ESA), California Water Data Consortium, and Merced Subbasin Groundwater Sustainability Agency GSA. Growers and landowners were able to view their parcels and provide valuable feedback to support future rollout of the platform to the entire subbasin. Landowners and water managers also discussed policy decisions and implications for the platform. This was our second workshop with Merced Subbasin growers, following a workshop held in June.
- We hosted the State of the Basin conference in Tulare, CA to unite with the community in learning, awareness, and problem solving with a goal to inspire further collaboration and communication among community advisors within the region. The conference hosted 74 attendees and featured 18 speakers from different backgrounds. This year's conference theme was "Managing Hydroclimatic Extremes." The event provided a forum to increase awareness on the rich history of the basin and discussed challenges and opportunities brought about by the recent droughts and floods. The conference had a high impact on the attendees on understanding the importance for building social, economic, and environmental resilience in the region. This event supported SWF extension and outreach efforts.
- On December 8, 2023 we hosted a workshop with the Kaweah and Tule basins case study where a few irrigation district and GSA representatives gave us feedback about the intent of doing the case study research.
- Over the past year, we conducted 4 interactive model feedback sessions on the water bank model of Cache Valley, UT. We engaged 13 professionals with expertise in water management, including academics, practitioners, and experts working primarily in Cache Valley, UT. The participants represented canal companies, cities, and environmental users in the model. Through these immersive sessions, the users adjusted their water withdrawal, consumption, conservation, and banking strategies in response to changing assumptions about water availability and prior actions of others. Their input also helped our SWF research team refine key assumptions in the model related to hydrology, species interactions, social inclusion, and other factors critical for creating an engaging, useful tool for diverse stakeholders.
- Secure Water Future (SWF) invited graduate students, postdocs, and other interested individuals to a grants workshop hosted by Sarah Naumes, UC Merced Senior Director of Interdisciplinary Research and Strategic Initiatives. This workshop focused on 1) granting 101; 2) the lifecycle of a grant; and 3) where to find funding. At the end of this workshop, participants gained a better understanding of how to approach extramural funding.

Workshops and Outreach, Continued

- The Secure Water Future exhibit and reception took place on Friday, April 12. At 4:00 p.m. to showcasing the year's research through selected images and text.
- On March 12, 2024, Ellen Bruno presented research to a group of 20 water professionals at the California Natural Resources Headquarters building in downtown Sacramento. It was the monthly meeting of the Sacramento Chapter of the Environmental & Water Resources Institute -- a civil engineering specialty institute of the American Society of Civil Engineers. Attendees included engineers and scientists working for the Department of Water Resources, the State Water Resources Control Board, and private consulting firms. Dr. Bruno first provided an overview of water allocation issues and policy solutions for California's groundwater from an economics perspective. Then, she discussed how farmers might be responding in anticipation of future regulation under California's Sustainable Groundwater Management Act.
- We hosted an Extension event titled "Digital Tools for Water Resource Management" in Merced, California at the Merced County Cooperative Extension office. This event served approximately 20 agricultural and water professionals and showcased several resources that can be used by water users and water managers alike to support climate-informed decision-making. Workshop participants were introduced to tools including OpenET, the Groundwater Accounting Platform, OpenAg, the Water Data Decisions Dashboard, and the Climate Toolbox for gathering data. Workshop participants benefited from a start-to-finish example and in-depth tutorials informing the stages of their decision-making to manage water resources more effectively in the West.
- On April 19, 2024 members of the Secure Water Future team introduced our project to a group of 20-30 community members and participants as a part of a UC Merced extension event with Self Help Enterprises (SHE). In addition to presenting the Secure Water Future project to the participants, SWF team assisted in facilitating the day's events, including a tour of the Merced Vernal Pool Grassland Reserve and UCM Experimental Smart Farm. This event brought together leaders from various communities in the central valley to open the discussion on integrating climate research into disadvantaged communities. The resulting experiences allowed participants to learn more about research being conducted on campus and how the findings relate to communities in the San Joaquin Valley. SWF outreach efforts also benefitted from this as collaboration with other departments at UC Merced were discussed.
- On April 21st and 22nd, 2024, Secure Water Future supported a field trip and collaboration session with AgAid. This event took place at the UC Merced campus, as well as various sites in the area, including Don Pedro Reservoir, Fiorini family farm, and the Diamond J Dairy. This event gave participants valuable insight into the different ways technology and AI has been integrated into water-related and agricultural sectors. Participants and SWF supporters benefitted through learning and expanding ideas in collective work sessions.
- SWF collaborated with AgAID to plan and facilitate a panel discussion where students were able to learn about the skills and qualifications that AgTech companies are looking for in recent graduates. They were also able to directly ask company representatives questions and learn about future internship opportunities.

APPENDIX II: OTHER PRODUCTS

Educational and Student Support Programming

- Three former SWF members hosted a panel with 10 attendees over Zoom for an hour to discuss their experience with transitioning from being a graduate student on SWF to landing their careers. This was a great opportunity for graduate students who attended to listen to their stories and ask pressing questions that they may have had regarding their own role when it comes to the future. This panel comes about as graduate student training.
- Aqua Arcade Game Jam' was hosted on the days of Friday, April 5th to 7th, 2024, in collaboration with Secure Water Future and the UC Merced Game Development Club (GDC). Our primary goal was to provide students with an opportunity to exercise their passion for game development by creating their own game within a 48-hour time limit and to showcase how they can foster these skills to kickstart their future in the gaming industry. This weekend-long event hosted UC Merced and Merced College students collaborating with each other in teams of 5 or less to create a game with an educational aspect of hydrology.
- 16 Graduate students from UCM, UCD, UCD, USU, and NMSU and 5 mentors participated in a weeklong Experiential Learning Expedition throughout the great state of New Mexico, May 22nd-30th, 2024. While on the trip, participants learned about the Rio Grande and some of the climate related challenges that the region faces. With multiple site visits along the way, students and mentors gained insight from multiple different perspectives in how water is used from the Rio Grande in New Mexico. This benefitted all parties involved, creating strong networks among students and mentors, encouraged engaging discussions, and bolstering the skills necessary to become the next generation of water and climate leaders. This program allowed the SWF team to collaborate on and address various climate and water related issues. Additionally, the graduate students produced 4 to 5-minute-long videos discussing their research in relation to the topics covered on the expedition, that will be made public on the SWF website.
- Through our Super Soaker Water Academy (SSWA), 15 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 measuring the evapotranspiration of plants. 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.

Additional Funding

- The Utah Division of Water Rights, an agency of the Department of Natural Resources, has awarded SWF team members an additional $511,605 for a parallel project titled "Great Salt Lake Measurement and Telemetry Gap Analysis; Hydrologic Gains and Losses; and Distribution Accounting White Paper." This funding supports efforts to enhance water resource management by analyzing hydrologic data gaps, understanding water gains and losses, and improving distribution accounting around the Great Salt Lake.



Bosque del Apache National Wildlife Refuge, New Mexico, 2024.