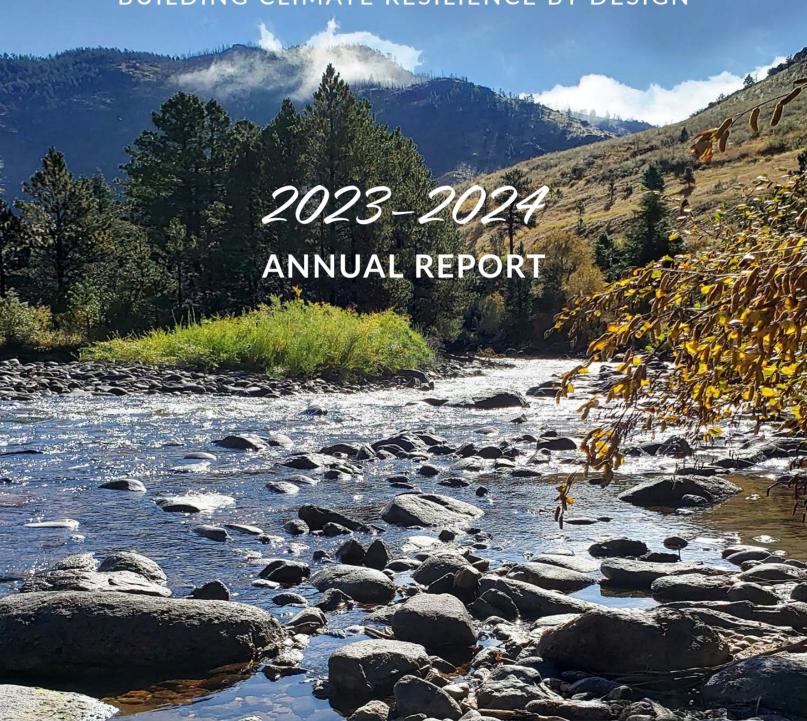
WESTERN WATER ASSESSMENT

BUILDING CLIMATE RESILIENCE BY DESIGN

















Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado Boulder

University of Utah

Haub School of the Environment University of Wyoming

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Cover photo: Cache La Poudre River, Arapaho National Forest, Colorado. Photo credit: Nels Bjarke.













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ABOUT WWA

The Western Water Assessment (WWA) is a university-based applied research program that addresses societal vulnerabilities to climate variability and climate change. particularly those related to water resources. We work across the Intermountain West— Colorado, Utah, and Wyoming—and we are based at the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado in Boulder, CO, the University of Wyoming in Laramie, WY, and the University of Utah in Salt Lake City, UT. We conduct innovative research in partnership with communities and decisionmakers in the region, helping them make the best use of science in planning and managing for climate impacts.

Our mission is to build regional resilience to compound hazards, with a particular focus on underserved Indigenous and small rural communities and utilities. Our research projects fit within two themes—resilient water systems and resilient communities—and bring together interdisciplinary expertise from across our project team. In addition to our research projects, ongoing research integration activities help us to

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A NOAR RISA TEAM

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Worker Water Assessment
Devation maps the National Map (USSS)

WWA's vision is to build regional resilience to compound hazards, with a particular focus on underserved Indigenous and small rural communities and utilities.

collaboratively identify needs and opportunities with our partners, and program evaluation activities help us to track our impact. Through this thoughtful approach to projects, we are advancing resilience science from theory to practice.

Our work draws on the deep interdisciplinary social and natural science expertise on our team, which includes experts in social science, co-production, adaptation and vulnerability research, atmospheric science, hydrology, climate assessment, climate impacts, and equity in adaptation. This unique combination of skills, combined with our 25-year history of climate adaptation research and activities, allows us to make an impact at a time when extreme weather events, climate change, and societal stressors are challenging the resilience of the Intermountain West like never before.

WWA is part of a national network of teams in the NOAA-funded Climate Adaptation Partnerships (CAP, formerly known as RISA) program. This annual report details accomplishments and impacts of projects supported by our most recent NOAA CAP grant which covers 2021-2026. Projects supported by older WWA CAP awards or other funding sources are indicated in the text when applicable.

2023-2024 BY THE NUMBERS

SOCIAL MEDIA

Twitter / X



84 New Followers

1,306 Total Followers

Facebook



81 New Followers

608 Total Followers

LinkedIn



75 New Followers

122 Total Followers

Instagram



72 New Followers

182 Total Followers

Theads



117 New Followers

117 Total Followers

429 Total New Followers Across Accounts

YOUTUBE

3,331Total Views

Total Subscribers **32**

WEBSITE

12,702

Website Users

53,120 Page Views



WEBINARS



2 Webinars

5 Workshops46 Presentations

53 Total Events

MAILING LIST



1,767 Total Subscribers

NEWS & RESEARCH

16 Research Publications

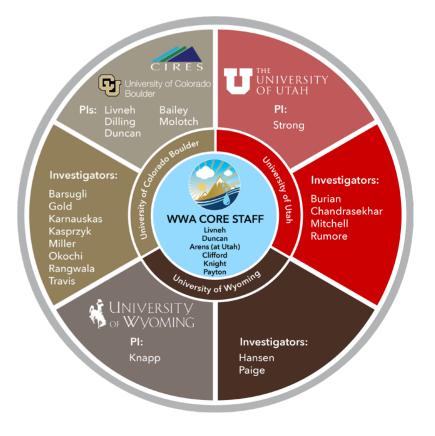




51 Media Mentions

WWA TEAM AND PROGRAM ORGANIZATION

WWA is part of the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado Boulder (CU Boulder); the University of Wyoming; and the University of Utah. WWA is led by our Principal Investigator (PI) group; our full-time staff members focus on program management, research development and synthesis, and coordination of stakeholder science and collaborations. Our broader network of investigators and partners comes from universities and government institutions across our region and provides a wide range of expertise. The WWA External Advisory Board consists of national experts from across the science-policy landscape and provides critical programmatic guidance to the core staff and PIs. Taken together, this network represents a broad base of expertise and relationships that enable WWA to meet stakeholder needs and advance scientific understanding.



In August 2023, former WWA Director Lisa Dilling left the University of Colorado Boulder for a position at a nongovernmental organization. We are deeply grateful for her contributions to WWA over 14 years, serving as Director from 2014-2021 and as a PI from 2007-2021. In addition to advancing scholarship in social and environmental science disciplines, she advanced the practice of usable science and shaped the careers of many students, postdocs, and colleagues.

WWA is fortunate to have welcomed two new postdocs to our core team over the past year. In September 2023, Dr. Nels Bjarke began work as a postdoctoral researcher on a project exploring the impacts of non-stationarity on drought indices. He is working closely with Senior Water Resources Specialist Liz Payton, Director Ben Livneh, and Managing Director **Benét Duncan**, and his work is supported by the National Center for Environmental Information (NCEI). In February 2024, **Dr. Skye Niles** joined the WWA team as a postdoctoral researcher investigating resilience in manufactured housing communities in the face of compound climate hazards. She is working closely with Social Sciences Lead Katie **Clifford** and **Benét Duncan**, and her work is supported by our core CAP program funding.

PROGRAM STAFF



BEN LIVNEH Director



BENÉT DUNCAN Managing Director



SETH ARENS UT Research Integration Specialist



NELS BJARKE* Postdoctoral Researcher



Co-lead PI) Karen Bailey*

PRINCIPAL

INVESTIGATORS

Ben Livneh (Program Director: Co-lead PI) Benét Duncan (Managing Director;

- Joe Barsugli (through 8/2023)
- Lisa Dilling (through 8/2023)
- Corrie Knapp*
- Noah Molotch
- Bill Travis (through 8/2023)
- Court Strong



KATIE CLIFFORD* Social Sciences Lead



ETHAN KNIGHT* Communications Lead and Scientist



SKYE NILES* Postdoctoral Researcher



LIZ PAYTON Water Resources Specialist

INVESTIGATORS, STUDENTS, AND PARTNERS

- Jeremy Barroll+
- Natalie Bennett+
- Kaitlyn Bishay+
- Nathan Boyer-Rechlin+ Steve Miller
- Carli Brucker+
- Emma Galofré García+ Parthkumar Modi+
- Anne Gold
- Kristiana Hansen

- Jacob Hochard
- Kris Karnauskas
- Joseph Kasprzyk
- Logan Mitchell
- Ami Nacu-Schmidt
- Christine Okochi
- Ginger Paige
- Luca Palasti+
- Emily Peters+
- Imtiaz Rangwala
- Danya Rumore
- Alec Wallen+
- Savanna Wolvin+
- Heather Yocum

- * Indicates early career
- + Indicates student

EXTERNAL ADVISORY BOARD

- Kathy Jacobs, Chair (Univ. of Arizona)
- Richard Moss (Princeton University and Pacific Northwest National Laboratory)
- Dannele Peck (USDA Northern Plains Climate Hub)
- Mark Shafer (Southern Climate Impacts Planning Program)
- Michelle Stokes (Colorado Basin River Forecast Center)



FEATURED ACCOMPLISHMENT

SYNTHESIZING KNOWLEDGE AND SHARING EXPERTISE IN THE FIFTH NATIONAL CLIMATE ASSESSMENT

Western Water Assessment (WWA) contributed to the national conversation about climate change and water resources with the release of the Fifth National Climate Assessment (NCA5) in November 2023. Supported by U.S. Global Change Research Program staff, **Liz Payton** led development of the <u>NCA5 Water chapter</u> with her team of 12 expert authors, which included WWA partner **Imtiaz Rangwala** (NC CASC). WWA PI **Corrie Knapp** served as the Chapter Lead Author for the <u>NCA5 Northern Great Plains chapter</u> in partnership with her team of 18 expert authors, which included WWA Investigator **Ginger Paige**.

The Water chapter's focus is on climate change and the nation's terrestrial freshwater systems. Given the chapter space limitations, the Water chapter team elected to cover trends and projections in water cycle components, and the impacts of those changes on hydrologic extremes such as floods and droughts, and water quality. The Water chapter pays particular attention to changes in water-related hazards faced by frontline communities, who will disproportionately bear the burden of climate change. The chapter also describes barriers to adaptation, adaptation approaches, progress toward expanding access to tools and data, and highlights a cooperative effort to prepare for climate change. Meteorological trends, sea level rise, and regional water resources changes are covered in some of the 31 other chapters that comprise the NCA5.

The Northern Great Plains chapter provides a synthesis of the impacts of climate change on the Northern Great Plains region, which includes Montana, Nebraska, North Dakota, South Dakota, and Wyoming. The economy of the region includes many land-based industries, particularly ranching, farming, and outdoor recreation. This makes it particularly vulnerable to climate-related changes in weather and climate impacts on water and wildlife. Residents with land-based livelihoods and those who have been exposed to historical inequities are particularly sensitive to climate impacts, including Indigenous communities, service and energy workers, and rural residents. The chapter provides information about climate impacts on extreme events, human and ecological health, and land-based livelihoods. It also shares information about the complex decisions that communities must navigate and highlights adaptation activities that are building climate resilience across the region.

Over the 2021-2023 development period, **Payton** and **Knapp** guided their respective chapters through six rounds of drafts; public, agency, and peer reviews; comment responses; and revisions. After the report was released, they participated in press events and presented the chapter to a national audience, to national trade groups, and to educators and students. **Payton** was also awarded a prestigious CIRES Outstanding Performance Award for her leadership on the NCA5 Water chapter.

Photo above: Liz Payton presenting at the NCA poster session at AGU23. Photo credit: Stephanie Maltarich.



RESEARCH HIGHLIGHTS

COMMUNITY CLIMATE RESILIENCE WORKSHOP IN LANDER, WY

On July 12-13, 2023, decision-makers and community members from Lander, Wyoming participated in the Lander Community Planning for Climate Hazards workshop, organized, supported, and facilitated by the Western Water Assessment (WWA) team, including Research Integration Specialist **Seth Arens, Katie Clifford**, NOAA Lapenta Intern **Wilzave Quiles-Guzmán**, and **Caitlin Ryan** from the Wyoming Anticipating Climate Transitions (WyACT) group. This effort was supported by a previous WWA CAP award, which supported our program from 2020-2023.

The workshop focused on understanding and planning for the impacts of flooding within city limits. WWA staff worked with local community members **John Burrows** and **Kara Colovich** to identify town officials, staff, and other community stakeholders to participate in the workshop. Through a survey, the group of participants collectively identified flooding as their key climate hazard concern. During the workshop, participants explored existing and anticipated community impacts of flooding, identified gaps in knowledge, and brainstormed strategic short- and long-term actions that may reduce the impacts of flooding.

The facilitation process used by WWA was specifically designed to support communities in building resilience to weather and climate hazards. The workshop began with a presentation about historical and future flooding in Lander. The WWA team then led the group in a facilitated discussion and a participatory diagramming exercise in which participants mapped out the causal chain of flood events, analyzed existing and anticipated community impacts of flooding, identified gaps in knowledge, and brainstormed strategic short- and long-term solutions for mitigating and adapting to increasing flood risks. Workshop discussions were summarized in a report written by Communications Lead and Scientist **Ethan Knight** in partnership with the WWA workshop team.

Photo above: Dinosaur Monument at Split Mountain and the Green River, Utah. Photo credit: Seth Arens.



Photo above: Noah Molotch discusses climate change and water supply at a NASA facility. Photo credit: Pier Gagne, Radio-Canada.

DUST AND AIR QUALITY: IDENTIFYING AN IMPORTANT GAP IN MONITORING NETWORKS

Katie Clifford published a paper identifying important gaps in national air quality monitoring networks' ability to detect dust and highlighting the impacts of this issue on various aspects such as the environment, climate, air quality, and human health. Despite the common occurrence of dust events across the U.S. and the significant role they played in our nation's history (e.g., the Dust Bowl), dust events are underestimated and therefore do not receive the level of attention necessary to fully understand their impacts. This analysis highlights three systematic issues that lead to poor monitoring of dust: 1) monitoring stations are sparse, especially in dust-influenced regions; 2) inconsistency in sampling methods; and 3) lack of continuous monitoring. These three factors result in missed dust events or underestimations of their particle concentration. The paper highlights the need for additional monitoring designed to measure dust so that we can more fully understand its impacts, which are particularly important as dust is expected to increase with climate change.

EXPLORING PERSPECTIVES ON IN-STREAM FLOWS IN MANAGEMENT OF THE CO RIVER

Nathan Boyer-Rechlin, a Master's of the Environment Candidate at CU Boulder studying water resources law and policy, worked with **Liz Payton** and Western Water Assessment on an independent study project researching how environmental flows are being considered in negotiations for Colorado River post-2026 operations of Lakes Powell and Mead. He reviewed hundreds of comments submitted via the Federal Register to identify environmental concerns and analyze trade-offs among water uses, and he developed a useful spectrum of conflict and consensus to summarize the alternatives offered by basin states, federal agencies, and environmental NGOs.

UNDERSTANDING CONNECTIONS BETWEEN SNOWMELT AND FOREST HEALTH IN NEW FIRE REGIMES

WWA Co-PI **Noah Molotch** is working with **Ben Livneh** on a project that will utilize historical and future snowpack simulations to understand the evolving risk of wildfire across the WWA three-state region. By applying ground observations, satellite data, and modeling, **Molotch** and **Livneh** are working to improve our understanding of the connections between fire and snowpack regimes. They will also use a recently developed technique to consider the compounded effects of future snowpack loss and summer precipitation and temperature extremes on wildfire risk. This project has profound implications for future wildfire management and adaptation, particularly in the water sector.

The primary new finding of this project is an illustration of the importance of snowmelt on forest productivity at the beginning of the growing season. They have found that the weeks immediately after snow disappearance represent an important time in the growing season with regard to annual productivity. During this time, soil moisture is elevated due to the previous time period's snowmelt, and solar radiation is relatively high, as are air temperatures. This combination leads to significant carbon uptake in montane forests. This is a new discovery as previous work focused solely on the period of snow cover, which excludes the weeks after snowmelt.

SENSE OF PLACE AND ADAPTIVE CAPACITY IN RURAL RESERVOIR COMMUNITIES

WWA Co-PI **Karen Bailey**, **Katie Clifford**, and **Seth Arens** continued work on a project to better understand how sense of place might be leveraged to assist in adaptation efforts in rural communities across the Intermountain West. This project is looking at how drought and climate change impacts to reservoirs in the Upper Colorado River Basin influence sense of place, and how shifts in sense of place may impact adaptive capacity in locations experiencing visible change. It represents a deepening focus on compound hazards and will include case studies in rural areas that may have more limited adaptive capacity.

Shadia Nagati, an undergraduate honors student working on the project, wrote and successfully defended her honors thesis about Colorado River drought impacts on sense of place and adaptation for Blue Mesa Reservoir communities, and graduated with honors in December 2023. **Nagati** will continue the work and support a future publication, set for submission in summer 2024.

IMPROVING MEDIUM-RANGE WATER SUPPLY FORECASTING IN UTAH

WWA Co-PI **Court Strong** is leading an effort that leverages existing research at the University of Utah to study the impacts of interconnected changes due to climate variability on water supply, demand, and water system reliability with the Salt Lake City Department of Public Utilities (SLCDPU). It builds on years of partnership working with the SLCDPU personnel to conduct climate impact assessments and develop adaptation measures. Working with SLCDPU, the real-world implications of projected conditions will increase understanding of water system performance in this understudied planning period.

Strong, WWA Investigator **Imtiaz Rangwala**, **Seth Arens**, and PhD student **Prasad Thota** have continued development of an online tool for tracking the Atlantic Quadpole Mode (AQM), in collaboration with CIRES and **Rangwala's** group. They expect to release the tool in fall 2024.

ASSESSING RESEARCH NEEDS TO SUPPORT ADAPTATION IN RURAL WYOMING

WWA Co-PI **Corrie Knapp** and graduate student **Emily Peters**, together with **Katie Clifford**, continued work on a project to improve our understanding of adaptation needs in carbon-dependent communities and explore opportunities for building resilience to compound hazards in Wyoming. **Peters** and **Knapp** assessed existing research efforts around climate change impacts and compound hazards in the state, including interviews with long-term researchers, managers, government officials, and NGOs, and a thorough literature review to highlight the status of existing work to provide a baseline of state-wide efforts. The results of the needs assessment helped to inform a second phase of the project: the Wyoming Small Grants Competition.

Peters has revised and submitted a manuscript about this work, and she will be delivering a presentation about it as part of the WWA webinar series. She also completed factsheets for three sectors of interest in Wyoming. Her work has helped to inform the NSF EPSCoR-funded Wyoming Anticipating Climate Transitions (WyACT) project by clarifying how vulnerable communities experience risk and understanding climate-water issues of importance to stakeholders.



WWA SMALL GRANTS COMPETITION

In the summer of 2022, WWA launched the "Adapting to Climate Change in Wyoming" small grants program. This competitive program has provided grants of up to \$30,000 to three community-led projects that help build resilience to climate impacts in Wyoming. The program is led by **Corrie Knapp** with support from **Katie Clifford**, **Benét Duncan**, and **Ginger Paige**.

Over the past year, we have worked directly with the team leading each funded project to explore the ways in which WWA can provide expertise. The first year of the awards program has been a success, with projects rolling out as planned in funded communities. We completed mid-term grant check-ins with each project team to track progress and understand how we can best support their work. Our partnerships with funding recipients have also led to new relationships and opportunities for collaboration.

Photo above: Students from Wyoming Indian High School at the immersive learning event on the Shoshone bison pasture on the Wind River Reservation. Photo credit: Hannah Habermann/Wyoming Public Media.

PROJECT 1: WIND RIVER INDIGENOUS YOUTH CLIMATE AND CULTURE CAMPS

Led by the Greater Yellowstone Coalition, Haub School of the Environment, and the Wind River Tribal Buffalo Coalition, the Wind River Indigenous Youth Climate and Culture Camps bring together Tribal elders, students, researchers, and other experts to share knowledge and build climate resilience. The first camp was held in September 2023 on the Wind River Reservation, and it was a major success. Students from the Wyoming Indian School participated in the camp, where they connected with Elders, Tribal experts, and researchers from a range of programs and agencies including WWA, the National Park Service, and the Northern Arapaho Tribal Historic Preservation Office. **Seth Arens** hosted one of the nine total stations at the camp, where he led students in observing changes in the landscape that are connected to climate change. A reporter from Wyoming Public Radio highlighted the camp in a news article and radio story, and project leads **Wes Martel** and **Janna Black** participated in a panel organized by the CAP program office at the National Adaptation Forum in May 2024.

Looking to the future, the project leads will host the camp again in July 2024 with a different school on the Wind River Reservation, to ensure as many students as possible are able to participate. The project leads have expressed a strong desire to secure funding to continue this important work so that they can reach students in all of the Wind River Reservation schools. They also hope to expand the work to include school-based and community groups that bring together Elders, children, and all generations of families around issues of culture and climate. To that end, **Seth Arens** and **Benét Duncan** collaborated with the project leads to apply for funding from the USGS NC CASC to support and expand this work.

PROJECT 2: HELPING RURAL WYOMING ORGANIZE FOR CLIMATE ACTION

The Wyoming Outdoor Council (WOC) is working with community members in Pinedale, Cody, and Casper, WY to activate, resource, and empower citizens in these towns to bring about homegrown climate solutions. During the past year, they organized meetings for the Park County Citizens for Sustainability; facilitated interactions for key climate leaders in Cody and assisted in moving Cody forward in an emissions reduction plan; hosted a stakeholder meeting at Casper College; and assisted the city of Cheyenne in an application for funding through the EPA Carbon Reduction Act and the Inflation Reduction Act (IRA). They also partially funded a new Climate and Energy Associate position at the WOC to support activities for the funded project. **Corrie Knapp** attended a Climate Leadership Summit organized by WOC in Lander and contributed a talk on climate communication.

Over the coming year, they plan to continue their work with Casper and may expand to continue work in Cheyenne as interest allows. They will be contributing to the Mountain Towns 2030 Summit and plan to create materials to help communities take advantage of opportunities associated with IRA funding. They also plan to create an online platform to share stories of communities in Wyoming that are taking climate action. We will continue to explore ways in which the project team can leverage WWA expertise, including participating in next year's Climate Leadership Retreat or hosting a community climate workshop similar to the one WWA hosted in Lander in July 2023 (see Research Highlights, above).

PROJECT 3: PARTICIPATORY PLANNING FOR EQUITABLE CLIMATE ACTION IN JACKSON, WY

The Town of Jackson is collaborating with Voices JH, a local community organization, to engage historically disadvantaged and vulnerable residents in the development of the Town of Jackson's Community Sustainability Plan. Over the past year, they have hosted a bilingual large group workshop, conducted interviews with Spanish-speaking residents, and led two focus groups to help inform the Community Sustainability Plan. Over the coming year, they plan to host another bilingual workshop and an additional five focus groups with Spanish-speaking residents. **Corrie Knapp** is working with the project leads and leveraging activities with the NSF EPSCoR-funded WyACT program to develop a fact sheet designed for the local area. WWA is also exploring the potential to participate in discussions with the community about resilience and adaptation.



NEW AREAS OF FOCUS AND PARTNERSHIPS

As a program, WWA strives to advance partner-driven research, synthesis, and engagement activities that help to build community and water system resilience. Over the past year, we have expanded our work in several exciting ways thanks to our partnerships with community groups, agencies, and other engaged climate science programs.

UNDERSTANDING CLIMATE RISK AND BUILDING RESILIENCE IN MHP COMMUNITIES

In spring 2024, Western Water Assessment launched a new project focusing on understanding climate risks and building climate resilience within mobile home park communities. Mobile home park residents face unique and disproportionate exposure to climate-related hazards, including heat, fires, and floods. Further, mobile home residents often are left out from many climate and disaster-related assistance programs, due to the unique ownership structure of mobile home parks. Addressing the needs of mobile home park communities is key to building climate resilience and addressing climate justice needs.

Western Water Assessment received funding from the CIRES Innovative Research Program and the University of Colorado Boulder Community Impact Grant to collaborate with University of Colorado Boulder Geographer **Colleen Reid** on a mixed-method study of the compound climate hazards facing Colorado mobile home communities, focusing in particular on the intersecting hazards of extreme heat and wildfire smoke.

Starting in summer 2024, this research team—led by **Katie Clifford** and **Skye Niles**—will conduct in-depth interviews with mobile home residents about the impacts of extreme heat and smoke, and will employ a pilot program using air quality monitors and temperature and relative humidity monitors within mobile homes in order to measure indoor air quality and heat exposure. This mixed-method approach will aid in understanding the impacts of heat and smoke on the health and well-being of mobile home park residents.

Photo above: Spiral Jetty on the Great Salt Lake, Utah. Photo credit: Seth Arens.

Since the start of this project, Western Water Assessment has been working on building connections with community partners to provide input on this project, including Boulder City and County government, community-based organizations that are working with mobile home park residents, and mobile home park residents and community leaders. Through these relationships, we are designing our research in ways that best meet the needs of mobile home park residents and help improve community resilience to heat and wildfire hazards.

Over the next two years, Western Water Assessment plans to work in several different mobile home parks in Colorado in order to understand the unique climate risks and resilience needs of these parks. These results can help inform policy by identifying key areas of concern and strategies that can help address these climate resilience needs.

INCORPORATING NON-STATIONARITY INTO DROUGHT INDICES

Liz Payton, **Nels Bjarke**, **Ben Livneh**, and **Benét Duncan** kicked off a new NCEI-supported project to explore the implications of implementing non-stationarity within existing drought indices that are most frequently used by stakeholders. They are working with **Imtiaz Rangwala** and **Prasad Thota** to develop a prototype web tool that would help users visualize the impact of non-stationarity on drought indices.

The project is relevant to a range of agricultural and resource management decisions such as planning for watering restrictions, reservoir operations, instream flow scheduling, infrastructure investments, irrigation scheduling, seed purchasing, livestock operations, and urban forestry. Changes in the magnitude, frequency, and duration of extremes suggest that events of the past may offer limited utility for future planning. For example, recent temperatures are consistently higher than expected from long-term historical records, reflecting non-stationarity in the climate, which is expected to have complex interactions with drought statistics. Users who apply drought tools that rely on anomalies from long-term records find that drought indices are showing consistent, rather than episodic, drought.

The project team is working closely with researchers, resource managers, and other partners to understand how they use drought indices and how they consider non-stationarity in their decision-making. Through this project, we have developed new relationships with the scientists at the Montana Climate Office, NIDIS staff, and NCEI staff, and have strengthened relationships with the Climate Hub, NC CASC, and NOAA PSL.

LONG-TERM WILDFIRE RECOVERY IN RURAL COMMUNITIES

In January 2024, **Katie Clifford** helped to kick off a collaborative project led by **Christina Greene** at Climate Assessment for the Southwest (CLIMAS), a partner CAP team in the Southwest. The Intermountain West and Southwest have had many devastating wildfires in recent years, and while we often track near-term, quantitative metrics like deaths or structures lost, many of the longer-term impacts that affect communities trying to recover remain less visible. These "invisible" impacts—including mental health issues, homelessness, displacement, loss of marginalized populations, etc.—are prevalent in rural communities that have fewer resources and less capacity than their urban and suburban counterparts. The project team is working with social workers and public health workers in rural communities that experienced significant wildfire events to understand these impacts and better support future emergency response, rural capacity, and social work in these communities.

Post-wildfire research is a new area of partnership that extends to both rural communities impacted by wildfire (in CO, we will focus on the East Troublesome Fire, mostly in Grand County) and social workers and public health workers. These new partnerships help expand our support for communities in the WWA region and grow our health, well-being, and social vulnerability work through our connections with social workers. Social workers are often boundary spanners on the ground serving the most marginalized, so better equipping them to work on climate issues and capturing their knowledge about invisible dimensions of wildfire recovery will be useful in promoting rural resilience.



OUTREACH AND ENGAGEMENT

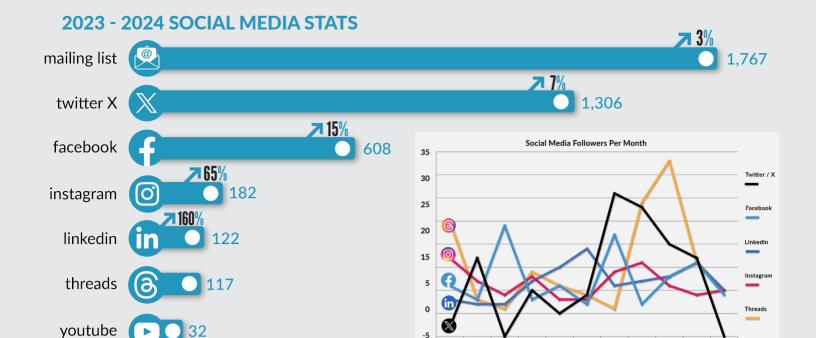
Outreach and engagement are central to WWA, as they enable us to center partner priorities and needs in the work we do, and they help to maximize our impact in scientific and stakeholder communities, which include municipalities, resource managers, and state and federal agencies. Throughout our research and engagement activities, we prioritize mentorship for students and early career professionals, through internships, research assistantships, fellowships, and staff positions.

WWA continues to make effective communication and outreach a priority by implementing the communications strategy developed in 2020 by **Ethan Knight**. The plan aligns core communications goals with key stakeholder sectors and spans a range of communication channels, including email outreach, quarterly newsletters, our website, social media, and in-person or virtual meetings. We continue to use our communications plan, website, and other engagement to help us strengthen relationships and share resources with stakeholders across the Intermountain West.

Since the launch of our new website in 2021, we have increased the utility of the site's resources for our team and for visitors. For example, our site's most popular and critical tools, such as the <u>Intermountain West Climate Dashboard</u> and the <u>High-Impact Events Database</u>, are more accessible and functional. Our website continues to have a consistent number of users, page views, and other types of engagement (clicks, scrolls, etc.) each year. During the reporting period, our website had a total of **12,702** users and a new record of **53,120 page views**. Since website analytics tracking began in 2013 for our site, we have had an average of **14,251 users** and **37,239 page views** per year.

Knight. We use Twitter, Facebook, Instagram, LinkedIn, and Threads to stay connected with our current stakeholders, while also reaching a wider and more diverse audience to share our research and other regionally relevant climate information. During the reporting period, our Twitter account gained 84 new followers for a total of 1,306 followers; our Facebook account gained 81 new followers for a total of 608 followers; our Instagram account gained 72 new followers for a total of 182 followers; our LinkedIn account gained 75 new followers for a total of 122 followers; and our new Threads account has 117 new followers. Collectively, we got 429 new followers across social media accounts. We also continue to upload webinars to our YouTube account, which now has a total of 3,331 views and 32 subscribers. Lastly, we continue to send out quarterly newsletters, climate briefings, and more through our mailing list, which got 50 new subscribers during the reporting period for a total of 1,767 subscribers.

Photo above: Benét Duncan speaks with Katie Clifford and Ethan Knight during the poster session at CIRES Rendezvous 2023. Photo credit: Lauren Lipuma.



TARGETED ENGAGEMENT WITH PARTNERS

WWA is committed to engaging with communities and decision-makers across our region, and with the broader scientific community. During the reporting period, WWA researchers and staff worked with communities and resource managers within and beyond the Intermountain West to connect them with information about climate impacts to support planning and resilience-building efforts. The following are highlights from this work.

-5

Aug 2023 Sep 2023 Oct 2023 Nov 2023 Dec 2023 Jan 2024 Feb 2024 Mar 2024 Apr 2024 May 2024

Court Strong continued to engage with Salt Lake City Department of Public Utilities (SLCDPU) in his project assessing the usability of medium-range forecasting for water system reliability. The innovative tools and models developed in this project will provide guidance to decision-makers starting in the fall, potentially transforming the approach that SLCDPU and other providers use in operations. Leveraging the WWA network in Utah, Strong and his team will introduce other water utilities along the Wasatch Front in Utah to this new understanding and capability while continuing to build on WWA's partnership with SLCDPU.

In partnership with the NC CASC, **Karen Bailey** and her team successfully applied to work with a USGS-funded student in summer 2024 to extend her work on sense of place and contribute to development of a community of practice to support community visioning on climate adaptation and drought resilience for the project on sense of place. Partnerships are in development following an initial exploratory research phase.

Corrie Knapp and graduate student Alec Wallen worked with U.S. Forest Service (USFS) Wildfire Preparedness Staff to interview residents of the small town of Ryan Park, Wyoming, which was in close proximity to the perimeter of the Mullen Fire. Partners in the Medicine Bow/Routt USFS office were interested in understanding the effectiveness of preparedness communication prior to and during the Mullen Fire as well as how proximity to the fire impacted perceptions and actions toward preparedness. Wallen completed over 20 interviews with Ryan Park residents and has transcribed and coded all of the data. The researchers plan to provide assessment and suggestions for best practices for internal and external communication around compound wildfire-related hazards to improve communication in high-risk situations, and will summarize the data for the residents of Ryan Park.

WWA funded a project through the Wyoming Small Grants Program to conduct climate camps with students from schools on the Wind River Reservation in Wyoming. **Seth Arens** participated in two days of the camps in September 2023 where he taught students about drought, climate, and climate change in an outdoor classroom. Working with partners for this event helped to establish relationships with tribal members of the Wind River Reservation. Arens also worked with

WWA Investigator **Danya Rumore** and University of Utah graduate student **Kris Land** to conduct a climate and natural hazards needs assessment for Gateway and Natural Amenity Region (GNAR) communities, partnering with the GNAR program at the University of Utah and Utah State University. **Land** conducted 17 interviews with planners and town managers from small gateway communities in the western U.S. He asked questions about how climate hazards impacted communities, mitigation actions taken, climate information used, and what additional information might be needed in the future. He wrote a report entitled "Climate and Natural Hazards Needs Assessment and Tool Development for GNAR Communities." The results of his report will be used to develop a survey to send out to all the GNAR community contacts. The results of the survey will identify needs related to climate information and climate tool development.

OUTREACH WITH SCIENTIFIC AND ADAPTATION PRACTITIONER COMMUNITIES

As a NOAA CAP team, WWA places a strong emphasis on contributing to the broader base of knowledge about the impacts of climate variability and change and advancing adaptation science. An important component of this is regular engagement with the academic and adaptation practitioner community. This type of engagement helps us to identify opportunities to conduct research that both advances scientific understanding and meets stakeholder needs.

Since the NCA5 was published in November 2023, Water chapter lead **Liz Payton** presented a poster at the 2023 AGU Fall meeting and has given five presentations exclusively about the NCA5 and two in-person presentations that incorporate and reference NCA5 content. Northern Great Plains chapter lead **Corrie Knapp** has also done outreach for the NCA5 since its release, including two in-person workshops in Montana and Nebraska, four conference presentations, and two invited community presentations. As the NCA5 is still in the rollout phase, **Payton** and **Knapp** continue to accept requests for presentations and media interviews.

Katie Clifford served on a few panels, including the University of Colorado Panel on Climate Justice Research cosponsored by the Institute of Behavioral Science and the Chancellor's Office, and the Engaging Frontline Communities Panel at the National CAP meeting. **Clifford** also served as an AAG Public Scholar in their inaugural "Elevate the Discipline" fellowship in 2023, showcasing WWA work and receiving skills training in engaging with media and policymakers. She was also invited by the AAG president to be a member of the Public and Engaged Scholarship Taskforce for AAG to develop disciplinary guidelines for promotion and the value of community-engaged work. Lastly, she attended the "After the Flames" meeting in Estes Park, Colorado run by COCO (Coalitions & Collaboratives, Inc.) which focused on wildfire recovery.

Ethan Knight and **Benét Duncan** continued to work with the NSF-funded <u>We Are Water</u> project led by the CIRES Center for Education, Engagement, and Evaluation (CEEE). The goal of the project is to engage with water-stressed communities in the Four Corners region by developing educational and accessible materials to inform these communities about where their water comes from, how much water is available, and more. In October 2023, **Knight** and **Duncan**, alongside the We Are Water team, were awarded the Pathfinding Partnerships Award, one of the Colorado Governor's Awards for High-Impact Research.

Knight also presented our Intermountain West Climate Dashboard and methods to use the dashboard in the classroom at an educator workshop convened by the Summer Climate Change Institute in July 2023. This was the third consecutive year of presenting the dashboard to a group of educators to teach students about current climate, drought, and water resources.

Ben Livneh had 11 presentations at the American Geophysical Union (AGU) Fall Meeting in December 2023, including presentations on changes in snow water storage in western North America with **Noah Molotch** and **Nels Bjarke**, hydrologic 'memory' from water storage in snowpack with PhD student **Parthkumar Modi** and WWA Investigator **Joe Kasprzyk**, global declines in lake water storage with postdoctoral scientist **Fangfang Yao**, and more. In August 2023, **Livneh** also gave a talk at the Colorado Climate Services Summit in Denver on the predictability of water supply in the Intermountain West today and into the future.



Photo above: CIRES We Are Water team receiving the Governor's Award for High-Impact Research in October 2023.

WWA maintains a close relationship with the USGS North Central Climate Adaptation Science Center (NC CASC) and the USDA Northern Plains Climate Hub. We continue to meet twice a year at "Three Centers Retreats," which provide opportunities for coordination and collaboration across our programs. These retreats include presentations about existing research projects; discussions about how to leverage our existing work to meet stakeholder needs; and identification of opportunities to conduct new collaborative projects that help to advance scientific knowledge in stakeholder-relevant ways. The two Three Centers Retreats held in person and virtually in August 2023 and April 2024 resulted in new communications coordination among the three centers and input to WWA's non-stationarity drought index work that expanded our outreach for the project, among other outcomes.

ENGAGING WITH OUR BROAD STAKEHOLDER COMMUNITY

In 2020, we established the WWA webinar series to share research highlights and timely climate information with our broad stakeholder network. We continued the webinar series during this reporting period with two webinars. The first webinar, "New insights into the role of snow and machine learning tools in water supply prediction," from September 2023 featured **Ben Livneh** and NOAA MAPP-supported PhD students **Madeline Pernat** and **Parthkumar Modi**. They shared their findings about alternative ways to use snow information to improve the performance of existing forecast techniques. They also compared the utility of machine learning tools versus the inclusion of additional, non-snow based observational predictions in improving water supply predictions. The second webinar, "Following perfection: a summary of the 2024 water year," from May 2024 featured **Seth Arens** who summarized weather conditions from the fall and winter of 2023 and provided insight into how the remainder of the water year may unfold. He answered questions such as, "After a record to near-record water year in 2023, how would the 2024 water year compare?" and "Would 2024 mark a return to wetter conditions or a slide back into drought that has plagued the region for decades?" in this webinar.

A number of significant international, national, regional, and local news outlets have featured WWA team members, research, tools and resources, or our organization as a whole over the reporting period, including Aspen Public Radio, CIRES News, CU Boulder For Media, CU Boulder Outreach, CU Boulder Today, CU Boulder: Colorado Arts and Sciences Magazine, CU Independent, Colorado Governor's Office, Coloradoan, Courthouse News Service, Coyote Gulch, Deseret News, FOX 5 Las Vegas, INSTAAR, KCPW Salt Lake Public Radio, LA Times, Meteorological Technology International, Municipal Sewer & Water, NASA Earth Observatory, NIDIS, Newsweek, Phys.org, Planet Forward, Sheridan Media, Smithsonian Magazine, Snow News, Summit Daily, The Aspen Times, The Guardian, The Water Desk, Time Magazine, University of Wyoming News, Wyoming Public Media, Wyoming Tribune Eagle, and more.



MAKING AN IMPACT

WWA's work is grounded in our deep relationships with resource managers, communities, researchers, and other stakeholders, and a commitment to co-production and collaboration to design and conduct our projects. This means that our projects are intended to build regional adaptive capacity and support climate-informed decisions and planning in the Intermountain West. Feedback and decisions from a range of stakeholders demonstrate the tangible, on-the-ground impact of our recent program activities. While one can learn about impacts of our activities throughout this report, we have highlighted several specific impacts here.

Ben Livneh and **Katie Clifford** served as advisors for Colorado's first-ever <u>Climate Preparedness Roadmap</u>. The report was led by the Governor's Office of Climate Preparedness and Disaster Recovery. It describes how state agencies will better understand, plan for, and adapt to climate impacts. It includes sections that provide scientific information about observed changes in Colorado, identify key climate hazards of concern in the state, provide guidance on risks that the state is facing, and compile actions that state agencies can take in the near term. **Livneh** and **Clifford** plan to participate in the next update of the roadmap, slated to occur every three years. The roadmap will inform an update of the Colorado Resiliency Framework in 2025 and the development of Colorado's Outdoors Strategy. It is also guiding thinking across state agencies on how to proactively collaborate and coordinate to build resilience.

Karen Bailey and her students are developing a learning module that describes the importance of sense of place and climate adaptation for integration into the Gateway and Natural Amenity Region (GNAR) training academy. This brings together **Bailey's** work on sense of place in rural reservoir communities and **Danya Rumore's** work on the GNAR initiative. The training academy is an online course library aimed at capacity building in rural communities in the West.

Corrie Knapp and **Emily Peters** wrapped up an assessment of current and future research needs among vulnerable communities in Wyoming. WyACT (an NSF-supported EPSCoR program at University of Wyoming) has used information from the needs assessment to better understand vulnerable communities in Wyoming and their needs. In addition, several partnerships and ongoing conversations about future collaborations have emerged from **Peters'** work, and several project participants who were interviewed subsequently applied for funding in the "Adapting to Climate Change in Wyoming" small grants program.

Photo above: Seth Arens conducting field work in Cottonwood Gulch, Utah. Photo credit: Alex Hager/KUNC.

IMPACT CASE STUDY 1: WATER SYSTEM RESILIENCE UTAH

Court Strong continued his partnership with the SLCDPU, exploring how to improve medium-range water supply forecasting in the Wasatch Front Range in Utah. As described in the Research Highlights section above, this partnership has extended for years. **Strong** found that the Atlantic Quadpole Mode (AQM) is a strong predictor of water supply in the region, and partners at SLCDPU requested that he explore opportunities to make up-to-date AQM data available to water managers to help inform their decision-making processes.

During the summer of 2023, **Strong** worked with **Seth Arens** and partners **Imtiaz Rangwala** and **Prasad Thota** to develop an online tool that would visualize data about the Atlantic Quadpole Mode to make it accessible and usable for water managers at SLCDPU and beyond. SLCDPU partners provided feedback on the initial prototype tool. The WWA team will be updating the tool in the summer of 2024 to reflect this feedback, and we plan to make it publicly available on the WWA website in the fall of 2024. SLCDPU plans to use the tool to improve their water supply forecasting in the fall/winter of 2024.

IMPACT CASE STUDY 2: COMMUNITY CLIMATE CONVERSATION IN WYOMING

In July 2023, **Katie Clifford**, **Seth Arens**, **Caitlin Ryan**, and **Wilzave Quiles-Guzmán**, led a community climate workshop in Lander, WY (see Research Highlights above for more details). The workshop was convened with guidance and support from Lander residents **Kara Colovich** and **John Burrows**, and it brought together town officials, municipal staff, water managers, and other residents to consider the impacts of flooding on Lander and identify tangible actions that could build resilience. The workshop marked an important milestone for WWA's work with communities in Wyoming and demonstrates that rural communities are experiencing and planning for climate impacts. In the fall of 2023, **Clifford** and **Arens** worked with **Ethan Knight** and **Benét Duncan** to develop a report summarizing the workshop discussions. In a subsequent conversation with a workshop attendee, we learned that the workshop report had helped to inform the town's recently adopted greenhouse gas emissions goals.

Photo below: Wilderness Trail, Ptarmigan Peak, Colorado. Photo credit: Nels Bjarke.



IMPACT CASE STUDY 3: WIND RIVER YOUTH CLIMATE AND CULTURE CAMP

WWA provided funding to support a series of Indigenous youth climate and culture camps on the Wind River Reservation. This funding was part of our "Adapting to Climate Change in Wyoming" small grants competition, which is described in more detail in the 'Small Grants' section earlier in this report. The camps were led by **Janna Black** (formerly University of Wyoming; currently USGS NC CASC) and **Wes Martell**, **Signa McAdams**, and **Colleen Friday** (Greater Yellowstone Coalition), and **Seth Arens** who provided planning support and served as a climate change expert at the camp. The first round of camps was held in September 2023 and a second round is planned for July 2024.

The camps and the collaborations and relationships that they have fostered have led to a wide range of impacts. Students, Tribal Elders, and others were greatly impacted by the 2023 camp, and it has led the project leads to expand their vision to connect culture and climate, and to build resilience across the Wind River Reservation. They are actively working to secure additional funding to continue the camps beyond 2024, and **Seth Arens** and **Benét Duncan** are collaborating with them on a proposal.

WWA PROGRAM EVALUATION

During the 2023-24 performance period, WWA continued to implement our program evaluation plan. **Benét Duncan** and **Katie Clifford** are working closely with Investigators **Anne Gold** and **Christine Okochi** to lead the evaluation implementation with support from **Ethan Knight**. Drawing from a framework developed by **Gigi Owen** and **Allison Meadow** at the Climate Assessment for the Southwest (CLIMAS) CAP team, our evaluation approach (Figure 1) includes ongoing tracking and evaluation of our program impact, tracking communications and outreach metrics, and an evaluation of our internal program operations. This thoughtful and integrated evaluation approach is designed to ensure that our program activities remain closely aligned with stakeholder needs, and to track our effectiveness in meeting program goals and building resilience in the Intermountain West.

Western Water Assessment Program Evaluation Plan

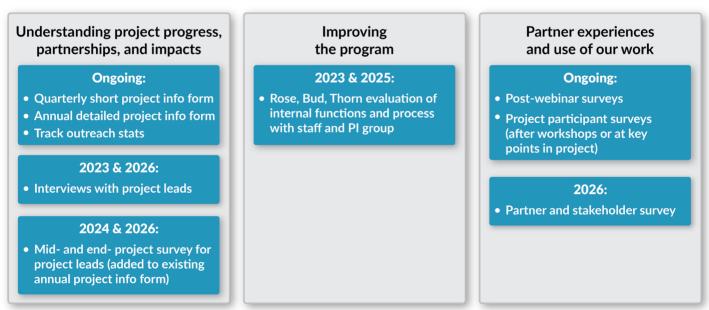


Figure 1: WWA Program Evaluation Plan

WWA's evaluation activities are guided by the following questions:

WWA program-level evaluation:

- To what extent is WWA reaching its key audiences and goals?
- In which ways does WWA prioritize justice and equity in their work?
- In which ways do WWA activities impact its stakeholders and audiences such as project partners, event attendees, and communities?
- How could WWA activities and offerings be improved?

WWA project-level evaluation:

- To what extent are WWA projects reaching their project goals?
- In which ways are WWA projects reaching their key audiences and building relationships, partnerships, and networks?
- How does WWA project work communicate usable science and in which ways does it impact communities?

During the fall of 2024, **Clifford** conducted interviews with the WWA PI group. Her interviews have helped us to identify that there is a strong desire across the WWA PI and staff team to expand collaboration across states and disciplines, and we are excited to identify opportunities to do this.

Also, during the fall of 2024, **Okochi** and **Gold** led a midpoint program reflection that built on the Rose-Bud-Thorn evaluation framework to evaluate WWA's internal operations and progress toward program-level goals. For this evaluation, ten core members of the WWA team including leadership, staff, and project investigators (PIs) reflected on a brief survey about operations such as communication, collaboration, and support across WWA, as well as the extent to which WWA is reaching its goals of prioritizing justice and equity; working across scales; and reaching underserved communities. Survey responses were aggregated, summarized, and shared during a subsequent focus group with these ten team members and used to facilitate further discussion on program-level successes, challenges, and areas for growth.

At the program level, team members highlighted successful communication and outreach efforts over the past several years; increased collaboration among researchers, between scientists and social scientists, and across institutions in the region; and increased community engagement, trust, and inclusivity. The team also recognized opportunities for growth and expansion, such as identifying and leveraging linkages between projects, training on topics like co-production, and continued relationship-building with communities. This program-level evaluation will be repeated with the same core team members in 2025.

Duncan and **Knight** developed a survey for users of the <u>Intermountain West Climate Dashboard</u>, WWA's most-used online resource. During the reporting period, we received 42 survey responses. Results indicate that the dashboard is a popular tool for professionals working in various sectors, particularly state agencies, the private sector, and federal organizations. Most respondents work in climate/water information provision, water supply planning, and agriculture in Colorado, Utah, and New Mexico. Users frequently consult the dashboard for its comprehensive array of climate data tools, particularly the NRCS current snowpack maps, U.S. Drought Monitor maps, and HPRCC precipitation maps. Most respondents access the dashboard at least once a month and regularly read the monthly briefings, and they consider the dashboard to be of high importance. Users noted that they have found similar information elsewhere but have not found all of these data sources in one place, nor have they found climate briefings like ours readily available on other platforms. One respondent shared, "I would not take the time to assemble all of this information on my own. Five minutes a week on this site leaves me much more situationally aware across a wide area."

Respondents use the information from the dashboard in different ways, from personal education and general knowledge, to having a better understanding of the current or forecasted state of water, weather, and climate in the region to help make decisions or inform others through class or work. One respondent noted, "I produce reports for our municipal leaders including Council and manager's office every month to update them on water supply and climate conditions... The dashboard has become a vital component of my daily operations as we strive to optimize our water resource portfolio and respond to customer demand numbers and supply planning." Another respondent who works in the agricultural sector shared that they "use the information to help aid in the creation of management plans and contingency plans."





During the coming year, WWA will advance user-driven projects that build community and water system resilience to compound hazards in the Intermountain West. We will also continue to expand our connections with regional partners, with emphasis on underserved and frontline communities disproportionately affected by climate impacts. Three initiatives are highlighted below:

BUILDING CLIMATE RESILIENCE WITHIN MOBILE HOME PARK COMMUNITIES

As described in the New Areas of Focus and Partnerships section above, in spring 2024, WWA launched a new project focusing on understanding climate risks and building climate resilience within mobile home park communities. Over the next two years, **Katie Clifford** and **Skye Niles** plan to work in several different mobile home parks in Colorado in order to understand the unique climate risks and resilience needs of these parks. These results can help inform policy by identifying key areas of concern and strategies that can help address these climate resilience needs. In the next year specifically, **Niles**, **Clifford**, and Sociology PhD student **Valentina Serrano Salomón** will conduct interviews with mobile home residents about their climate resilience needs, and pilot air quality and heat monitoring within mobile homes to measure heat and wildfire smoke exposure, in collaboration with **Colleen Reid**.

ADAPTING TO CLIMATE CHANGE IN WYOMING

In May 2023, the Adapting to Climate Change in Wyoming small grant competition awarded \$30,000 each to three projects over two years for climate adaptation planning or implementation for rural and tribal communities in the state (see the Small Grants section above for more details). The project leads received funds and began work on their projects in July and August 2023. **Corrie Knapp**, as well as **Benét Duncan**, **Katie Clifford**, and **Ginger Paige**, will continue supporting the small grant awardees over the next year. **Knapp** plans to present at the Climate Leaders Summit that Wyoming Outdoor Council is hosting in June 2024, she plans to send volunteers to assist with the Greater Yellowstone Coalition camps, and she is considering developing factsheets for the Town of Jackson. In addition, there are several emerging and collaborative grant opportunities with each of these partners. She expects to receive final reports and deliverables in this reporting period and will link them to WWA. In addition, **Knapp** and the Greater Yellowstone Coalition are presenting at the National Adaptation Forum.

NCEI NON-STATIONARY DROUGHT INDEX PROJECT

In September 2023, **Nels Bjarke**, **Liz Payton**, **Ben Livneh**, and **Benét Duncan** started developing a prototype drought index that accommodates hydroclimate non-stationarity (see the New Areas of Focus and Partnerships section above for more details). The team is creating this tool for planners and producers to assess current conditions in the context of non-stationarity. This project is a new partnership with NOAA NCEI and has given the project team the opportunity to explore and build relationships with other drought researchers, particularly in Colorado and Montana. Over the next year, the team will work on the design and testing of the prototype, have meetings with funders and experts, and deliver the final prototype to funders in December 2024.

Photo: Overgrown Trail on Flagstaff Mountain, Colorado. Photo credit: Nels Bjarke.



APPENDIX

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Photo above: Central Wasatch Mountains, Utah. Photo credit: Seth Arens.

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