

Case Study Article

Western Water Network: A Case Study in Water Network Formation

Travis Warziniak¹, Robert Heinse², Alexander Fernald³, Michael Gaffney⁴, *Kristiana Hansen⁵, Bret Hess⁶, Lyla Houglum⁷, Ginger Paige⁸, and Qin Zhang⁹

¹Rocky Mountain Research Station, USDA Forest Service; ²Department of Soil and Water Systems, University of Idaho; ³New Mexico Water Resources Research Institute, NM State University; ⁴Washington State University Extension, Washington State University; ⁵Department of Agricultural and Applied Economics, University of Wyoming;

⁶Western Association of Agricultural Experiment Station Directors, University of Nevada; ⁷Western Extension Directors Association, Oregon State University; ⁸Department of Ecosystem Science and Management, University of Wyoming; ⁹Department of Biological Systems Engineering, Washington State University

*Corresponding Author

Abstract: Increased water scarcity and drought frequency are creating water management challenges for many communities in the western U.S. In response, the Western Association of Agricultural Experiment Station Directors sponsored a virtual summit in August 2020 to develop a framework for identifying and addressing the most pressing water issues in the western United States (the West). Summit attendees were research scientists, university extension specialists and professionals, and federal/state agency representatives with knowledge and expertise of water management in the West. The summit elicited opinions from 54 experts on pressing water issues and possible methods for addressing them. A follow-on survey of 49 individuals increased the depth and breadth of perspectives collected. Summit and survey results show that water scarcity is a growing concern among water scientists and other experts. Increased water scarcity is leading to overallocated river basins, depleted aquifers, and elevated tensions between water use sectors. Summit and survey participants emphasized the need for increased integration—across research, extension, and education efforts; across the social and physical sciences; across uses (including ecological); and across surface and groundwater systems. These results serve as a sensing of what many of our colleagues believe to be the major western water issues over the next 30 years and, in some cases, possible solutions for addressing them. The expert opinions elicited through the summit and survey informed the creation of the Western Water Network, whose mission is to advance collaborative, proactive, science-based water decision-making that supports dynamic human and natural systems in the West.

Keywords: *water management, water scarcity, water quality, water resilience, water security, expert survey*

Climate change is increasing average temperatures, water supply variability, and the frequency of long-term drought in the western United States (Aliyari et al. 2021; Heidari et al. 2021; Zhang et al. 2021). These changes have significant implications for water management in all sectors of the economy. In its recent Adaptation Plan for Climate Adaptation and Resilience, the U.S. Department of Agriculture (USDA) identified threats to water quantity and quality as a major vulnerability and called for increased support

for science and broader outreach and education efforts (USDA 2021). This paper describes efforts responsive to that call and to the needs of water managers faced with growing challenges, sometimes without an existing road map.

In August 2020, the Western Association of Agricultural Experiment Station Directors (WAAESD) hosted a virtual summit on water security to develop a framework for identifying and addressing the most pressing water issues in the western United States (the West). The summit

Research Implications

- Research scientists and extension specialists with expertise in water management are well-positioned to identify water challenges in the western U.S. and to provide input on improving climate adaptation, resolving water conflicts, and increasing resilience to water scarcity and variability.
- Surveyed water experts in the western U.S. emphasized the need for increased integration—across research, extension, and education efforts; across the social and physical sciences; across uses (including ecological); and across surface and groundwater systems, to solve water challenges.
- As droughts in the western U.S. become more frequent and competition for water increases, the need to address problems and opportunities at a basin scale (rather than within a state) becomes more acute. A research- and extension-focused network that transcends state boundaries, such as the Western Water Network, may improve coordination and collaboration between states.

provided a venue for research scientists, university extension specialists and professionals, and federal/state agency representatives to discuss climate adaptation, water conflict resolution, and resilience to water scarcity and variability. The summit was focused on themes outlined in the USDA Science Blueprint: sustainable intensification, environment and climate adaptation, and science policy leadership. Summit participants identified the need for continued dialogue regarding how to most effectively organize and undertake research and outreach activities. Thus, WAAESD leadership convened a subset of summit participants (this article's coauthors, the Leadership Team) to continue the discussion initiated at the summit. The Leadership Team has been meeting regularly since August 2020 to build a network of researchers, extension specialists, and the stakeholders with whom they work that can help water managers and decision-makers adapt to climate change and increase resiliency.

The Leadership Team conducted an online survey of research scientists, university extension specialists and professionals, and federal/state agency representatives in the winter of 2021 to increase the depth and breadth of perspectives collected during the summit. Respondents were asked to identify the most important existent and emerging issues related to water security in the West.

This paper summarizes the results of the summit and survey. The survey was not meant to be rigorous and comprehensive, but rather a sensing of what researchers and extension specialists believe to be the major water issues in the West over the next 30 years and, in some cases, possible solutions for addressing them. Highlights from the summit include the need for innovative funding solutions and original ideas for extension and outreach, themes that would arise in the survey as well. The survey gave further details on pressing water issues in the West and offered topics for continued dialogue on potential solutions. Survey results also informed the creation of the Western Water Network (WWN), whose mission is to advance collaborative, proactive, science-based water decision-making that supports dynamic human and natural systems in the West.

Methods

Information was gathered through a virtual summit on water security and an online survey administered by the Leadership Team. The virtual water summit was primarily attended by representatives of organizations that would eventually be surveyed. The summit and survey are described here.

Virtual Summit on Water Security in the Western U.S.

WAAESD received funding for the *Mini-Summit on Water Security in the Western U.S.* (referred to here as “summit”) from USDA-NIFA (Proposal No. 2020-04914) to convene leaders of water-related multistate research projects, directors of Water Resource Research Institutes in the West, leaders of the western USDA Climate Hubs, and select members of the First Americans Land-Grant Consortium (FALCON). The focus of the summit was to develop a framework for identifying, then

addressing, either through extension or research, the most pressing water issues in the West. Originally planned for an in-person meeting in Boise, Idaho, the summit was held virtually due to the COVID-19 pandemic on August 8, 2020. Fifty-four people attended the summit.

The summit consisted of plenary sessions and breakout sessions. One of the plenary session speakers, then Deputy Under Secretary for USDA's Research, Education, and Economics mission area, Scott Hutchins, introduced the USDA Science Blueprint themes, which informed topics for breakout sessions later in the day: Sustainable Agriculture Intensification, Agriculture Climate Adaptation, Food and Nutrition Translation, Value-Added Innovations, and Agricultural Science Policy Leadership. Hutchins emphasized the need for sound science to guide agricultural policy and innovative agricultural methods to cope with climate change.

Of the 54 participants, 30 self-selected into breakout groups on environment and climate adaptation; 12 selected into a breakout group on science policy leadership; and 12 selected into a breakout group on sustainable intensification. The environment and climate adaptation topic was divided into two groups to facilitate more active discussion; the other two topics had one breakout group each. Each breakout group addressed three questions: 1) Who are the target audiences we need to influence?; 2) Where do we want to move the target audiences?; and 3) What method to move the target audiences should be considered in an "audacious proposal" that would ensure the attainment of ample water with sufficient quality to meet future demands of the Western Region? The term "audacious" was used to encourage "outside-the-box" thinking in imagining how to solve big water challenges in the western U.S.

Each group had a facilitator and a reporter/note-taker. Notes were compiled via shared online documents, viewable by group participants and developed in real-time with group feedback. Following the breakout sessions, participants re-convened in the full group, where each group shared the main themes discussed in the breakout sessions. The summit concluded by asking for volunteers to continue the work via regular meetings coordinated by WAAESD. Those

volunteers formed the Leadership Team.

Expert Survey on Water Security in the West

In Spring 2021, the Leadership Team conducted an online survey to identify water security issues existent or emerging in the West. The survey was conducted through Padlet (padlet.com) and included the following seed question: *What are the significant, region-wide issues you see coming our way over the next 30 years that will affect freshwater security in the West?* The survey was, in essence, an online brainstorming activity. Participants responded to the question on digital cards that were visible to other respondents, who were then able to comment on other participants' responses. Responses were thus not anonymous. The ability to comment on other cards contributed a conversational tone to the survey and was intended to spark creative interactions among colleagues.

The survey was sent to summit participants and an expanded group of stakeholders and experts identified by experiment station and Extension directors, including members of the water-related multistate committees represented in the summit, directors of Water Resource Research Institutes in the West, leaders of the western Climate Hubs, and representatives of the 1994 land-grant colleges and universities. The survey was eventually sent to over 500 people.

Two weeks before the survey was administered, an email was sent telling participants to expect a survey with a short description of the survey topic. One week later, another email told participants that the survey itself would consist of a single question, asking respondents to identify the issues that a WWR should tackle. Finally, the actual survey was sent to participants and was open for two weeks. A reminder to complete the survey was distributed one week before the survey closed. In some cases, leaders representing the groups surveyed also encouraged their members to participate in the survey. There was no financial incentive for participation.

Responses were analyzed using the key phrase extraction prebuilt model in Microsoft Power Automate to identify topic-based clustering in participant responses. Prior to key-word extraction, common phrases without semantic content (stop words) were removed.

Results

Summit on Water Security in the Western U.S.

Results from the virtual summit mainly consisted of breakout session notes and chat transcripts. Each group addressed three main questions: 1) Who are the target audiences we need to influence?; 2) Where do we want to move the target audiences?; and 3) What method to move the target audiences should be considered in an audacious proposal? Results for each question are summarized below.

1) Who are the target audiences we need to influence? The unifying theme among groups was that the target audience and range of stakeholders for water-related issues is broad and inclusive. Target audiences spanned types of users (urban, agricultural, industrial, households) and roles in providing water (technical service providers, conservation districts, government agencies, and political leaders). While all groups recognized that the list of traditional audiences is broad, some also highlighted the need to target communities that are often left out of the discussion (for example, low-income communities, tribes, minority groups). In recognizing water's broad role, it was suggested that care needs to be taken to ensure everyone has a voice at the table. Part of this discussion involved outreach to children through schools and programs like 4H.

All groups expressed concern about increasing conflict between target audiences, particularly between urban consumers and farmers. Participants predicted that pressure to transfer water from agriculture to municipal uses will increase, particularly in times of drought, further increasing conflict between these target audiences. All groups acknowledged this tension and expressed concern over the disconnect between urban resident perceptions of agriculture and agricultural production needs. Most participants had ties to agriculture either through research or extension and stressed the importance of agriculture in local and regional economies. To this end, groups also identified economic development agencies and authorities as target audiences and the need to consider water resources in strategies for sustainable economic growth.

Funding was seen as an impediment to sustainable water use in the West, both for

research and for carrying out water conservation programs. Innovative funding sources might include connecting with green investors and venture capitalists. Members of the environmental community, tribes, water managers, agencies, and lawmakers were all identified as target audiences.

2) Where do we want to move them? When thinking about where to move target audiences, all groups mentioned legal and regulatory barriers that can make efficient use of water difficult. Participants mentioned legal barriers imposed by the doctrine of prior appropriation, which largely governs water allocation in the western U.S. They also mentioned that variation in water law between states can hinder water management at the scale needed for real change (e.g., at the basin scale, or joint management of ground and surface water). A key point brought up was what one group called the different "colors of water" and the costs of changing water from one use to another. Given these costs, participants thought sustainability would require sacrifice by all parties, for example, by removing irrigated lawns, which was mentioned as a way to reduce pressure placed on the agricultural system from urban growth. They felt that education and increasing people's respect for the land and passion for natural resources would increase awareness of water issues and impacts of individual actions on regional, if not global, resources.

All groups talked about the need to move audiences and water users (presumably the same in many cases) from a competitive approach to water use to one of collaboration. Education and more holistic views of water and aquatic systems were seen as the keys to this movement. Educating the public about the role water plays in urban areas, agricultural systems, and industry, and how those uses interact with and are affected by environmental outcomes were seen as important steps to reducing conflict over water. Participants mentioned management case studies of win-win situations and thought learning from those case studies and spreading their message are important.

3) What method to move them should be considered in an "audacious proposal?" Participants of the summit struggled with the concept of an audacious proposal. Participants wanted more clarification on what such a proposal

would be, whether there already was or would be funding for such a proposal, and who would implement the proposal. One key takeaway from the exercise is that more targeted goals should be articulated by summit leaders. In spite of the challenges associated with thinking outside of familiar boxes, all groups eventually engaged in brainstorming parts of an audacious proposal.

One group member suggested “redefining state boundaries according to watersheds,” and while members of the full group did not seem to take this suggestion seriously, it did spark conversation and the need to expand boundaries of water management to areas of common use. Some groups mentioned that the “method to move” the target audiences would need integration of science, education, and policy; others noted that data by itself is not enough. Decisions are based on deep-seated beliefs about water and social values. To this end, there is a need to integrate social sciences with hydrology and agronomy studies. Similarly, revising economic incentives to better align with social goals, more efficient water use, and the One Water approach proposed by Howe and Mukheibir (2015) were mentioned by all groups.¹

Participants thought the key to accomplishing something audacious in the realm of western U.S. water challenges was to break the problem down into manageable parts. Real change requires research, policy change, social acceptance, and education. The most consistent theme in answering this question, much like the other questions, was the need to make meaningful connections between the people in different user groups. Participants thought case studies, demonstration sites for xeriscaping, creation of roundtables and interstate forums, and more savvy use of marketing and social media would benefit the water community. Overall, participants emphasized the need to address the human dimensions of water use. As several groups stated, inspiration and a clear vision

¹The One Water approach, “considers the urban water cycle as a single integrated system, in which all urban water flows are recognized as potential resources, and the interconnectedness of water supply, groundwater, stormwater, and wastewater is optimized, and their combined impact on flooding, water quality, wetlands, watercourses, estuaries, and coastal waters is recognized (Howe and Mukheibir 2015, 3).”

of the future are critical to the success of any endeavor, audacious or otherwise.

Online Survey on Freshwater Security in the West

The survey consisted of the following seed question: *What are the significant, region-wide issues you see coming our way over the next 30 years that will affect freshwater security in the West?* Forty-nine people posted initial comments on the Padlet survey cards, i.e., entered their opinions as a discreet, stand-alone narrative in the survey tool. Participants commented on those cards, thereby creating over 100 total comments. Fifty-one issues were raised in the online survey that the key phrase extraction model in Microsoft Power Automate grouped into six categories: research, extension, and education needs; water quantity, water quality, and water equity; spatial scale (global, regional, local); groundwater, surface water, and coupled surface-groundwater systems; water uses (agricultural, municipal, industrial, and ecological); and data and science synthesis, communication, and implementation (Figure 1). Responses in each category are summarized below.

Research, Extension, and Education Needs. Of the survey responses, 41 addressed research, extension, and education needs. The majority of survey responses (73%) indicated greater need for research, 12% indicated a greater need for extension, and 15% indicated a greater need for education. Themes that emerged were frequently centered around coupled water systems, indicating that research needs to better integrate policy and social preferences in water planning and management. There was agreement that both research and engagement are needed at basin-scales, recognizing the large regional impacts of water-related decisions.

Other research directions included studies on more efficient water allocation and improvements in water use efficiency. Several respondents suggested rethinking the doctrine of prior appropriation, which was mentioned throughout this project as an impediment to real change in water management in the West. Others thought the best way to address future water scarcity would be to increase water storage, both with human-built infrastructure and by increasing soil health so it

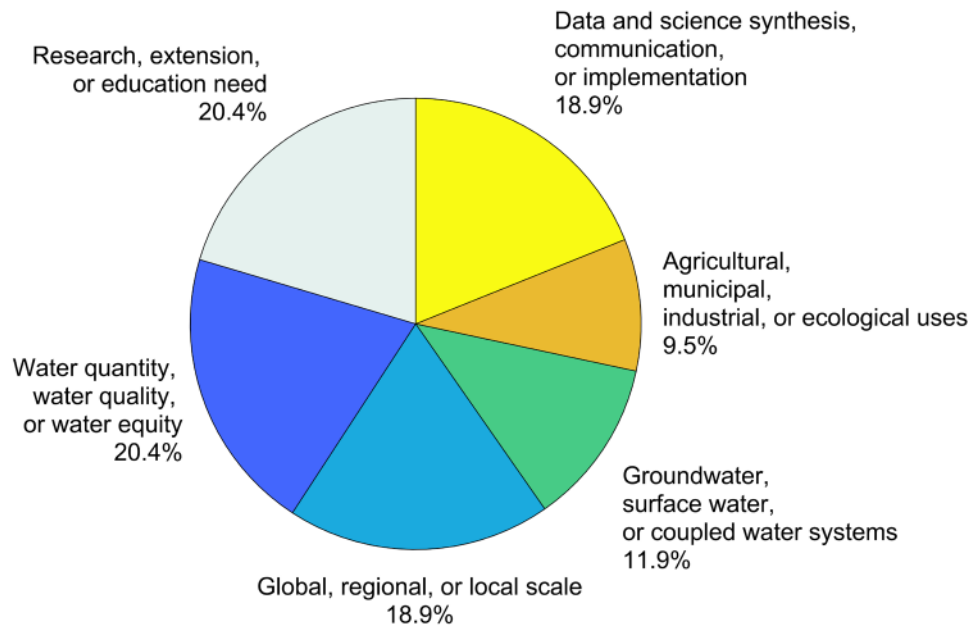


Figure 1. Survey response categories for water issues affecting freshwater security in the West.

could better retain water (i.e., green water). Some responses emphasized the need to improve water-use efficiency with technology, support tools, and smart water systems; other respondents cautioned that overreliance on efficiency reduces resilience and increases susceptibility to drought.

Summit and survey participants repeatedly mentioned the three land-grant pillars of research, extension, and education and the importance of connections between communities of water users, managers, researchers, and decision-makers. Respondents noted that successful water-smart communities rely on effective networks of researchers, extension educators/ specialists, and managers. As droughts become more frequent and competition for water increases, the need to address problems and opportunities at a larger scale becomes more acute. Networks of researchers, extension educators/specialists, and managers based on state boundary lines are often not adequate to address water management issues when rivers and watersheds cross state boundaries.

Water Quantity, Water Quality, and Water Equity. Many of the respondents directly addressed water quantity, water quality, and more equitable distribution of water. Forty-one responses were included in this category, of which the majority (56%) addressed water quantity as the main

issue likely to affect the West, noting increased frequency of drought and projections that indicate a drier future with larger populations for much of the region. Twelve percent of responses addressed water quality, and 32% mentioned that water quantity and water quality were highly coupled. This category includes threats to water resources, of which the following were listed: wildfire; erosion, infiltration, and forest management; spread of pests in water-stressed environments; adaptation to less snow and more rain; nonpoint source water contamination; water reuse; drinking water safety; and alternative water storage.

Equitable distribution of water was raised as a concern. Respondents noted disparity in infrastructure improvements among communities and that many groups, such as tribes, have been left out of regional management and planning efforts. And while conflict seems to be the norm in water-related issues, managing by conflict avoidance was also raised as a concern.

Spatial Scale (Global, Regional, and Local). Thirty-eight responses mentioned that different water issues span global, regional, and local scales and noted the importance of getting the spatial scale of water management right. Global climate change was indicated as a driver for many of the research needs, but most responses (66%) indicated

that water issues are predominantly regional in scale. (Local issues were indicated by 29% of responses.) Thus, stressors to water systems might come from outside the region (e.g., the impacts of climate change), but solutions must ultimately come from within the region. The survey did not define local vs. regional, and some respondents questioned what ‘regional’ means with respect to water resources. Hypoxic zones, for example, are caused by stressors at multiple spatial scales, from global to hyper-local, and connect communities throughout a river basin or aquifer. In that vein, respondents thought governance should recognize linkages between surface water and groundwater systems, both geologically and economically. Coupled ground and surface water systems arose both with regard to spatial scales of management and with regard to better science of coupled systems, discussed below.

Water Uses (Agricultural, Municipal, Industrial, and Ecological). There were 19 survey responses in this category.² Responses primarily addressed measurement of use, more efficient use, and overallocation. One of the issues most frequently raised by summit and survey participants was increased levels of conflict between water users. Conflict, it seems, is a defining feature of water in the West. The nature of the conflict often stems from a mismatch in scale; water decisions are local but conflicts are regional, or vice versa. Summit and survey participants also emphasized the need for increased integration—across research, extension, and education efforts; across the social and physical sciences; across uses (including ecological); and across surface and groundwater systems.

Responses recognized that agriculture is the biggest water user (74% of responses were about agricultural systems) and emphasized the need for more resilient agriculture and more efficient irrigation methods. Other solutions included crop breeding for more efficient water use, planting crops that use less water, and implementing best practices for groundwater and irrigation systems. In overallocated river systems, participants called out the need to reserve instream flows for

²Survey responses related more to extension and education – engaging communities to reduce conflict – are included in the section above.

ecological values and expressed concern over constraints (political, social, scientific uncertainty) that often hinder this aspiration. Policy suggestions to address overallocation and conflict between uses included more holistic management of water resources at the watershed and ecosystem levels and wider use of scarcity pricing.

Groundwater, Surface Water, and Coupled Surface-Groundwater Systems. Twenty-four respondents focused on water source, whether groundwater, surface water, or coupled systems. The majority of responses in this category (67%) were about coupled systems rather than just groundwater or surface water in isolation. Participants stated the need to address surface and groundwater as coupled systems in research, management, and policy. Key groundwater issues included improving recharge and soil water holding capacity. Responses in this category focused heavily on the role of groundwater sources in meeting current needs, but they also indicated concern about sustainable groundwater use.

Data and Science Synthesis, Communication, and Implementation. Forty-eight responses fell under this category and were approximately evenly split between the three subcategories, though the largest group of responses addressed data needs and synthesis science. Respondents wanted to see more science addressing social and human behavior, culture, values, beliefs, norms, ideas, decision-making biases, and buying behavior. Needs identified ranged from better understanding and synthesis to better implementation and communication. No response indicated a need for more data, but several voiced the need for wider adoption of data-driven support tools and for guidance to help users distinguish between good and bad data.

Discussion and Conclusion

The objective of this case study has been to document the development of a water network in the western U.S., from initial problem identification to formal network creation. The Padlet survey was critical to network formation, in that key observations made by summit participants and survey respondents have guided

development of the network. First, competition for water, exacerbated by climate change, is altering patterns of water availability in the West. Second, agriculture and rural extension will be critical in addressing the challenges water users face in the region, because the agricultural sector uses more water in the western U.S. than any other (Dieter et al. 2018). Third, the three land-grant pillars of research, extension, and education build more connected communities – of water users, managers, researchers, and decision-makers.

The survey was exploratory in nature and designed to elicit the maximum number of responses possible from acknowledged water researchers and other experts. It was an early step in an iterative process of determining whether support existed for the idea of a network. Study limitations should thus be noted. The survey methods were designed to elicit the maximum number of responses possible from acknowledged water researchers and other experts. Future iterations of the network formation process need to be more intentional about identifying and incorporating feedback and membership from representatives of marginalized and under-represented communities.³

In response to summit and survey participant feedback, the Leadership Team moved forward to develop the WWN, whose mission is to advance collaborative, proactive, science-based water decision-making that supports dynamic human and natural systems in the West. The WWN held a workshop in June 2023 in conjunction with the Universities Council on Water Resources annual meeting in Fort Collins, Colorado, to establish priorities and to chart a vision for land-grant focused research and engagement to address western U.S. water challenges for the next ten years.

The keystone of the WWN is the research (Agricultural Experiment Station) and engagement (Extension) pillars of the land-grant university, along with the stakeholders/groups with whom

land-grant researchers and Extension professionals regularly collaborate and serve. The WWN is thus a “network of networks” that aims to connect the broad, West-wide community of stakeholders, researchers, educators, Extension professionals, service providers, and policymakers tasked with confronting the most pressing water issues in the West. The WWN has created a new USDA National Institute of Food and Agriculture (NIFA) project intended to unite the many water-related multistate projects and convene a regular congress on water in the West, focused on collaborative fact-finding and cooperative solutions.

In an important sense, then, the audacious proposal originally sought by WAAESD leadership during the 2020 summit is the formation of the WWN itself—the creation of a framework that facilitates collaboration and coordination across state boundaries, across academic disciplines, and between researchers and practitioners, for those working on transboundary water issues. Moving forward, the WWN seeks to support the next wave of innovations for water resiliency; explore the feasibility of innovative water management practices, policies, and institutions; characterize, in collaboration with the USDA climate hubs, the patterns of water availability expressed as water budgets in the West; and build teams of stakeholders and professionals to support decision-making and policy formulation for a secure water future in the West.

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³This is already occurring. For example, the Fort Collins Workshop referenced below included a thematic area on Diversity, Equity, and Inclusion. There was also a broadly shared understanding among Fort Collins Workshop participants that research and engagement activities directed toward increasing water security in the western U.S. must include diverse voices and approaches to be effective.

Author Bios and Contact Information

DR. TRAVIS WARZINIACK is a research economist with the USFS Rocky Mountain Research Station. His work focuses on valuation of ecosystem services, with an emphasis on watershed health, climate impacts to water resources, and nature's role in regional economies. He serves as the water specialist for the Resource Planning Act (RPA) Assessment, which looks at the status and trends of the nation's renewable natural resources, and leads the development of the U.S. natural capital accounts for forests. He may be contacted at travis.w.warziniack@usda.gov or 240 W. Prospect Rd, Fort Collins, CO 80526.

DR. ROBERT HEINSE is an Associate Professor of Soil and Environmental Physics in the Soil and Water Systems Department at the University of Idaho. His research interests revolve around water in the soil environment and characterization using geophysical methods. He is a past director of the interdisciplinary water resources program. Above all, however, he has a growing appreciation for the complexities of human and ecosystem interactions with the physical world. Dr. Heinse completed a Ph.D. in Soil Science at Utah State University. He may be contacted at rheinse@uidaho.edu or 875 Perimeter Drive, Moscow, ID 83843-2339.

DR. ALEXANDER "SAM" G. FERNALD was appointed Director of the New Mexico Water Resources Research Institute (NM WRRI) in July 2013 after having served as interim director since January 2011. His research interests include coupled human and hydrologic systems; water quality hydrology; land use effects on infiltration, runoff, sediment yield, and nonpoint source pollution; and effects of surface water/groundwater exchange on water availability and water quality. Dr. Fernald has a Ph.D. in watershed science from Colorado State University. He may be contacted at afernald@nmsu.edu or PO Box 30001, Las Cruces, NM 88003-8001.

MICHAEL J. GAFFNEY is the Assistant Director of WSU Extension and Director of Extension's Community and Economic Development Program Unit. He has conducted research and published on a number of topics, including Social Capital, Community-Oriented Policing, Regional Planning, Economic Development, Citizen/Government Relationships, Natural Resource Stewardship, Biased Policing, Project and Program Evaluation, Disaster Response, and Community Resilience. Mike previously served as the Director of the WSU Division of Governmental Studies and Services – an applied public policy research unit. Mike can be contacted at: mjgaffney@wsu.edu or 411E Hulbert Hall, Washington State University, Pullman, WA 99164.

DR. KRISTIANA HANSEN (corresponding author) is an Associate Professor and Extension Water Resource Economist in the Department of Agricultural & Applied Economics at the University of Wyoming. Dr. Hansen's current research is in water resource economics and community adaptation and response to changes in weather and climate variability. Her extension programs seek to inform and improve regional decision-making in water allocation. Several current research/extension projects focus on informing Colorado River Basin water management challenges, through analysis of economic impacts, conservation program design, and collaborative decision-making. Dr. Hansen completed a Ph.D. in Agricultural and Resource Economics from the University of California, Davis. She may be contacted at kristi.hansen@uwyo.edu or 1000 E. University Ave Dept 3354, Laramie, WY 82070.

DR. BRET HESS serves as the Executive Director for the Western Association of Agricultural Experiment Station Directors. He provides leadership and manages the western region's portfolio of multistate projects which are funded through the multistate research fund, including development of integrated multistate projects involving research, extension, and academic programs. Additionally, he provides leadership for national activities through the Experiment Station Committee on Organization and Policy. Dr. Hess completed a Ph.D. in Animal Science from the University of Missouri-Columbia. He may be contacted at bhess@unr.edu or 5890 Britannia Drive, Reno, NV 89523.

DR. LYLA E. HOUGLUM, Oregon State University Professor Emeritus, served as Executive Director of the Western Extension Directors Association from 2005-2021. Dr. Houglum previously served as Dean and Director of the Oregon State University Extension Service helping design and implement the concept of "Scholarship Unbound" resulting in an organizational model at OSU that allows Extension to work University wide, creating partnerships with 9 of OSU's 11 Colleges. Houglum served on numerous national, regional, and state boards and committees, including Chairing the Extension Committee on Organization and Policy (ECOP – the national Board of Directors for Extension).

DR. GINGER PAIGE is a Professor and Water Resource Extension Specialist in the Department of Ecosystem Science and Management at the University of Wyoming. Dr. Paige's current research focuses on the measurement and modeling of watershed hydrologic processes in the snow-rain transition zone of the intermountain West. Her extension programs include the development of hydrologic decision support tools for water resource management from field to basin scale. Dr. Paige has a Ph.D. in Watershed Management

from the University of Arizona. She may be contacted at gpaige@uwyo.edu or 1000 E. University Ave., Dept 3354, Laramie, WY 82071.

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