



Introduction: Western Water Assessment

Using multidisciplinary teams of experts in climate, hydrology, ecology, law, and policy, the Western Water Assessment (WWA) works with decision makers across the Intermountain West to produce policy-relevant information about climate variability and change. In the West, many of the impacts of climate change will be delivered through changes in the hydrologic cycle that have affected, and will continue to affect, water resources. WWA has focused on building relationships and networks of decision makers and has used these relationships to develop practical research programs and useful informational products. WWA is formally part of the Cooperative Institute for Research in the Environmental Sciences (CIRES) at the University of Colorado in Boulder, CO and is physically located in NOAA’s David Skaggs Research Center. WWA engages researchers and staff at universities and federal research institutions across Colorado, Wyoming, and Utah, and includes a network that expands across the US and beyond.

The mission of the WWA is to identify and characterize regional vulnerabilities to and impacts of climate variability and change, and to develop information, products and processes to assist decision-makers throughout the Intermountain West.

In 2009, the Western Water Assessment underwent a significant reorganization intended to broaden the scope of our research and build on the strengths of researchers in the Intermountain West community. WWA refocused its research and decision-support products so that WWA projects fall within three major thematic categories:

- (1) Decision Support for the Colorado River Basin and Headwaters;
- (2) Ecological Vulnerabilities, Impacts, and Adaptation, and
- (3) Emerging Initiatives and Adaptation Strategies to Inform Climate Services.

WWA is comprised of a core staff of five (Table 1) who focus on program management, research development and synthesis, and stakeholder interactions. This core team will be expanding to seven, as we are adding full-time positions that will be based in both Utah and Wyoming. Using an internal RFP process, WWA also funds individual researchers at a number of institutions throughout the region. A full list of team members is available at http://www.colorado.edu/about_us/teamdir.html.

Table 1. WWA Core Office Staff

Brad Udall	Executive Director	bradley.udall@colorado.edu
Kristen Averyt	Deputy Director	kristen.averyt@noaa.gov
Jeff Lukas	Senior Research Scientist	lukas@colorado.edu
Eric Gordon	Program Manager	eric.gordon@noaa.gov
Heather Glenn	Administrative Assistant	heather.glenn@noaa.gov

The WWA Core Office Staff has expanded in recognition of 1) the demands of managing an ever-expanding research portfolio developed by leveraging NOAA funding and 2) the need for a dedicated staff to represent the organization to stakeholders across the region in a number of formal and informal settings.



FY10 and FY11 Activities

Tables 2–5 show, by theme, funded WWA research and other activities from FY10 (completed) and FY11 (funded and ongoing). Note that the category of “core activities” largely accounts for core staff work in support of WWA’s RISA mission. FY10 projects are highlighted in blue.

Table 2. Decision Support for the Colorado River Basin and Headwaters

Project Title	Description	PIs
Reclamation Review of Stochastic Streamflow Simulation at Interannual and Interdecadal Time Scales and Implications to Water Resources Management (FY10 and FY11)	Expanding seasonal forecasting to improve second-year flow forecasts for the Colorado River Basin and developing a stochastic simulation tool to show future Colorado River streamflow	B. Rajagopalan, E. Zagona, K. Nowak, C. Bracken
Impacts of Coupled Climate Change and Dust Deposition on Water Resources in the Colorado River Basin (FY10 and FY11)	Coupling climate change and dust deposition scenarios to model changes in snowmelt-driven water yield in the Colorado River Basin	J. Deems, T. Painter
Paleohydrology of the Lower Colorado River Basin	Generating paleohydrologic reconstructions of annual flows for the intervening flow between Lees Ferry and the Imperial Dam on the Colorado River	B. Rajagopalan, J. Lukas
Identifying Lessons from the Murray-Darling Basin Potentially Applicable to the Colorado River	Examining the institutional environment in Australia’s Murray-Darling Basin to identify river planning lessons	D. Kenney
Reconciling Colorado River Flow Projections	Narrowing the range of projected Colorado River flows to aid water managers	D. Cayan, T. Das, D. Lettenmaier, J. Overpeck, H. Hartmann, R. Webb, M. Hoerling, B. Udall (Cross-RISA work)
Colorado River inflows between Lakes Mead and Powell: Past, Present & Future	Workshop reconciling data and research on flows between Lees Ferry and Lake Mead	J. Barsugli
Historical and Potential Future Changes in Temporal Precipitation Variability in the Colorado River Basin	Assessed the historical characteristics and potential future variability throughout the Colorado River Basin	G. Gutchenev
Seasonal Climate Forecasts	Monthly synthesis of regional climate conditions on multiple spatial scales	K. Wolter
Treeflow: A Drought Planning Resource for Water Management in the Western U.S.	Developed an updated web-based resource for water managers to access paleohydrologic information	J. Lukas, C. Woodhouse (Cross-RISA Work)

Table 3. Ecological Vulnerabilities, Impacts, and Adaptation

Project Title	Description	PIs
Controls on pH and Ammonia Toxicity in Rivers of the Colorado Plains	Determining the relative importance of factors leading to high pH in Colorado Plains streams	J. McCutchan, S. Van Drunick
Climate Change Impacts on Public Lands in the Upper Colorado River Basin	Developing ecologically-oriented drought vulnerability spatial assessments for BLM land in southwestern Colorado	J. Neff, K. Cozzetto, D. Fernandez
The Green River Headwaters Network: Building Partnerships, Infrastructure and Knowledge for Sustainable Resource Management	Pilot project to gather observational data to understand climate-water-ecosystem linkages in the Green River Headwaters area	S. Gray
Bark Beetles & Forest Change (FY10 and FY11)	Bringing together scientists and stakeholders to engage in problem-oriented discussions of the ongoing bark beetle epidemic in CO, WY, and UT	E. Gordon, J. Lukas



Engaging New Federal Stakeholders	Engaged federal agencies in Intermountain West to expand WWA stakeholder network	A. Ray
Effects of Mountain Pine Beetle on Water Quality in Colorado	Examined whether bark beetle epidemic has affected water chemistry, including nitrate concentrations	J. McCutchan, S. Van Drunick

Table 4. Emerging Initiatives and Adaptation Strategies to Inform Climate Services

Project Title	Description	PIs
Drought Adaptation among Ranchers in the Intermountain West (and building a network of agriculturalists)	Using surveys to identify and measure effects of adaptations among agriculturalists in CO, WY, and UT	W. Travis, K. Gangwer
Towards Frameworks for Climate Services: Meeting the needs of different users with different information requirements	Working with the River Forecast Centers to refine Water Resources Outlook tools	K. Averyt, G. Owen (Cross-RISA Work)
Water, Energy, and Climate in the Colorado River Basin (FY10 and FY11)	Creating an integrated model of water, energy, and climate in the basin	K. Averyt, R. Klein, D. Kenney
Water-Energy-Climate Change (WECC) Nexus	Aiding in the creation of a book on water-energy-climate connections	D. Kenney
Climate Change Adaptation Planning Workshop for Colorado Plateau Tribes	Workshop for tribes engaged in drought, energy, and climate planning	S. Krakoff, J. Teel, R. Pulwarty, C. Alvord, K. Cozzetto
Watershed & Climate Educational Session to Supplement SOARS Seminar Program	Supplementing UCAR’s SOARS program with a tour of the CO River Headwaters	C. Alvord, R. Pandya, R. Haacker-Santos
Addressing Tribal Climate Service Needs Through Educational Outreach: NASA/NDATC Tribal Faculty Sabbatical Program	Hosting a drought and climate session at NOAA to inform development of tribal faculty climate change curricula	C. Alvord, C. McNutt, K. Averyt
A Drought Impact and Vulnerability Indicator Suite	Developed socio-economic drought indicator variables in WWA research area	W. Travis, L. Dilling, R. Klein
Evaluating the Utility of an Uncertainty Framework for Regional Climate Information	Worked on developing a process for addressing uncertainty in regional climate issues	K. Averyt
Joint Front Range Climate Change Vulnerability Study	Used downscaled climate projections in hydrologic models to help CO Front Range water providers plan for climate change	D. Yates, B. Udall, J. Barsugli
Colorado Climate Roadshow: Developing a Framework for Identifying Impacts and Vulnerabilities to Climate in Support of Adaptation	Series of workshops aimed at helping stakeholders throughout Colorado understand climate change impacts in the state	J. Barsugli, N. Doesken, R. Gillies, K. Averut
State Drought Planning in the Western U.S.A.: Multi-RISA-Agency-NIDIS Collaboration	Using group meetings and a workshop to improve the ability of drought information to meet user needs	A. Steinemann (Cross-RISA Work)

Table 5. WWA Core Activities

Project Title	Description	PIs
Informing the Responsible Use of Climate Models & Projections by Stakeholders	Connecting stakeholders to climate projection data in ways that reflect the scientific state of climate modeling	J. Barsugli
Intermountain West Climate Summary	Periodic updates on regional climate conditions sent to a variety of stakeholders	J. Lukas, K. Averyt, E. Gordon
WWA Website & Communication Materials	Updating website and other materials to improve ability to reach stakeholders	E. Gordon, J. Lukas
WWA Speakers Bureau	Meeting regular requests for WWA experts to speak at various events	B. Udall, K. Averyt, J. Lukas, E. Gordon
Best Practices for Identifying Quality Observational Datasets	Recommendations for best practices for developing and interpreting historic records and time series	N. Doesken, R. Gillies, K. Wolter



Assessment Services

This section describes activities and products intended to fit within the goals identified thus far for the National Assessment. Specifically, these efforts (Table 6) will provide a framework within which WWA intends to (1) collate the large suite of research, tools, products and information currently available and in development that are intended to aid decision makers coping with the impacts of climate change and variability; and to (2) identify, track, and evaluate the informational and service needs of stakeholders in the Intermountain West. The proposed activities outlined below will be fully integrated with our existing networks and projects, thus leveraging both our base RISA funding as well as the new Regional Assessment Services funding. We propose to manage and coordinate this effort from the WWA Core Office.

A key element of WWA’s National Assessment support activities entails the geographic expansion of WWA’s reach further into Utah and Wyoming. To improve our engagement with climate-sensitive decision-makers in these states, WWA is hiring a liaison position for each state. These liaisons will be responsible for reaching out to stakeholders and using contacts to populate a database of climate-sensitive decisions in their respective states.

Table 6. Activities in Support of the National Assessment

Project Title	Description	PIs
<i>Stakeholder and Science Provider Databases</i>	Create and maintain two separate databases: 1) stakeholders and “spectators” and their climate-related needs and 2) science providers, products, and projects	R. Klein, E. Gordon, L. Dilling, K. Averyt, E. Pugh, K. Cody
<i>Assessment Services for Colorado: Impacts, Vulnerabilities, and Adaptation Study</i>	Following up on WWA’s “Climate Change in Colorado” report, identify the extent to which state government and other entities are planning for and preparing to adapt to climate variability and change	R. Klein, W. Travis, E. Gordon, L. Dilling, K. Averyt, K. Cody
<i>Assessment Services for Utah and Wyoming</i>	Hire liaisons to expand WWA operations into WY and UT, identify regional providers of climate information, populate and expand stakeholder and science provider databases	S. Gray, R. Gillies, B. Udall, K. Averyt, E. Gordon
<i>Developing a Comparative Framework for Future Stakeholder Interactions</i>	Create a scientific framework for analyzing interactions captured in science-stakeholder databases	L. Dilling, R. Klein, K. Averyt, M. Carmen-Lemos (Cross-RISA Work)
<i>Colorado River Basin Workshop</i>	Convene a workshop of stakeholders and agencies to foster communication around adaptation and decision-making needs in the Colorado River Basin	G. Garfin, J. Overpeck, D. Cayan, B. Udall (Cross-RISA Work)



WWA-Supported Long-Range Planning Decisions

- 1) **Colorado River Water Supply Management**—The Colorado River serves as a water supply lifeline for much of the southwestern United States. Local, state, and federal agencies all participate in managing water resources in the basin, with the U.S. Bureau of Reclamation taking an overarching role. To support the 2007 EIS, which for the first time prescribed the sharing of water shortages by the Lower Basin, WWA researchers helped Reclamation apply paleohydrologic records of flow to their system model, and provided a framework for incorporating climate change science into long-term planning. Since the EIS was released, WWA researchers have continued to support water supply planning in the basin by helping Reclamation refine their mid-term operations model, assessing the impact of flow reductions from climate change on basin water supply under different management scenarios, and characterizing the hydrologic effects of dust deposition on basin snowpacks.
- 2) **Development of State Adaptation Plans**—WWA is actively working on assessments of ongoing and planned adaptation activities throughout our three-state region. With funding from the state of Colorado, WWA has developed a “Climate Change in Colorado” report and has interviewed state and other officials to better understand impacts, vulnerabilities, and adaptation actions. This effort will be replicated in Utah and Wyoming.
- 3) **Drought Planning in Colorado**—In response to federal requirements, the Colorado Water Conservation Board has developed and updated its Drought Mitigation and Response Plan, with the most recent version released in final form in September 2010. WWA researchers have aided in the development of these plans, by convening stakeholder workshops on drought and climate change at which input for the plan was solicited from participants, and providing guidance to the state on the incorporation of the results of climate change modeling into the plan documents.
- 4) **Development of BLM and USFS Land Management Plans**—Shifting priorities from the public and policymakers lead to complex planning environments for federal land managers responsible for much of the land across Colorado. WWA researchers have helped identify variation in ecological vulnerability to climate change on BLM lands in southwestern Colorado, and have worked with the US Forest Service on pilot projects to incorporate climate information into planning and management activities.
- 5) **Increase in Renewable Energy Generation**—Concerns about carbon emissions and attempts to create jobs has prompted legislation in Colorado requiring greater renewable energy generation. WWA researchers are trying to understand the impact of renewable generation on water supplies and on efforts to adapt to future climate change.

Local Decisions with Regional Significance

- 1) **Residential water demand**—Colorado’s prior appropriation doctrine for water rights means that cities with more “junior” water rights are more vulnerable than others to drought and to long-term reductions in flow from climate change. The ability of more vulnerable cities to curtail residential water use as necessary has major implications for larger decisions on the building of water supply infrastructure, the implementation of agricultural-to-M&I (municipal and industrial) water purchases, and the development of future interbasin water transfers.



- 2) **Reaction of farmers to perceived climate changes**—Adaptation by individual farmers and ranchers, a current topic of WWA research efforts, can have broader impacts on water supply, the rural economy, and grassland conservation. Ongoing WWA research indicates that ranchers and farmers may already possess significant abilities to adapt to a changing climate, regardless of their beliefs about the causes of climate change.
- 3) **Electric generation facility siting**—Population growth, water supply constraints, and concerns about carbon emissions have collided in what WWA researchers refer to as the “energy-climate-water nexus.” Individual decisions about siting new power facilities—either fossil plants or renewable sources like wind and solar—collide across the region with larger concerns about water availability, future carbon pricing, and aesthetics.
- 4) **Forest treatments for insect infestations and fire mitigation**—Bark beetle infestations and wildfires are the dominant disturbance regimes in many forested areas of the Rocky Mountains. Concerns about falling tree hazards, life-threatening fires, and impacts to water quantity and quality have prompted a number of response actions from local, state, and federal agencies, as well as from private landowners, all of whom have implemented thinning and pesticide applications on huge patches of forest.
- 5) **Construction of reservoirs and other water supply infrastructure**—As climate change and population growth collide to stress water supplies in the Intermountain West, water providers and others are proposing new water supply projects such as reservoirs and pipelines. Building large water supply projects often impacts a large area and requires planning and approval at local, state, and federal levels.