

# Western Water Assessment



2010 ANNUAL REPORT



Western Water Assessment



University of Colorado **Boulder**



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Bradley Udall (Lead), University of Colorado-Boulder Konrad Steffen, University of Colorado-Boulder Kristen Averyt, University of Colorado-Boulder	Lisa Dilling, University of Colorado-Boulder Nolan Doesken, Colorado State University Robert Gillies, Utah State University Steven Gray, University of Wyoming Douglas Kenney, University of Colorado-Boulder Jeffrey Lukas, University of Colorado-Boulder Jason Neff, University of Colorado-Boulder Thomas Painter, California Institute of Technology Balaji Rajagopalan, University of Colorado-Boulder William Travis, University of Colorado-Boulder Klaus Wolter, University of Colorado-Boulder

*Performance period covered in this report: January 1, 2010–December 31, 2010.*





## Introduction

**The mission of the Western Water Assessment (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.** Using multidisciplinary teams of experts in climate, hydrology, ecology, law, and policy, WWA works with decision-makers across the Intermountain West to produce policy-relevant information about climate variability and change. By building relationships and networks of decision makers, our team is able to develop practical research programs and useful information products. WWA is formally part of the Cooperative Institute for Research in the Environmental Sciences (CIRES) at the University of Colorado in Boulder and is physically located in NOAA's David Skaggs Research Center. Our researchers and affiliates come from universities and federal institutions in Colorado, Wyoming, and Utah, and across the US.

### Current Areas of Focus

In 2009, as part of its successful rebid effort, WWA underwent a significant reorganization to broaden the scope of our work and build on the strengths of researchers throughout the Intermountain West. WWA research and decision support products now fall within one of three thematic categories:

- (1) Decision Support for the Colorado River Basin and Headwaters  
*Providing resource managers with the tools, data, and information about climate necessary to support management decisions in the Colorado River Basin and its headwaters region.*
- (2) Ecological Vulnerabilities, Impacts, and Adaptation  
*Assessing the ecological impacts of climate change and variability in Western landscapes and the resulting effects on water quality and quantity and other ecosystem services.*
- (3) Emerging Initiatives and Adaptation Strategies to Inform Climate Services  
*Responding to the needs of decision makers to find productive strategies to adapt to both climate change and natural climate variability.*

In addition, WWA received funding in 2010 to engage in efforts to support the National Climate Assessment. A full list of research projects broken down by theme is available on pages 11–18.

### WWA Staff and Research Team

WWA is comprised of a core staff of six (Table 1) who focus on program management, research development and synthesis, and coordination of stakeholder interactions. Using an internal proposal and review process, WWA also funds individual researchers at the University of Colorado and other institutions throughout the region. A full list of team members is provided in Table 2.

**Table 1. WWA Core Office Staff**

Brad Udall	Director	<a href="mailto:bradley.udall@colorado.edu">bradley.udall@colorado.edu</a>
Kristen Averyt	Deputy Director	<a href="mailto:kristen.averyt@noaa.gov">kristen.averyt@noaa.gov</a>
Jeff Lukas	Senior Research Associate	<a href="mailto:lukas@colorado.edu">lukas@colorado.edu</a>
Eric Gordon	Program Manager	<a href="mailto:eric.gordon@noaa.gov">eric.gordon@noaa.gov</a>



Tim Bardsley	Utah Liaison	<a href="mailto:www.bardsley@gmail.com">www.bardsley@gmail.com</a>
Heather Glenn	Research Assistant	<a href="mailto:heather_glenn@noaa.gov">heather_glenn@noaa.gov</a>

**Table 2. Western Water Assessment Research Team**

Team Member	Title	Expertise
Averyt, Kristen	Deputy Director, Western Water Assessment	Climatology, assessment processes
Barsugli, Joseph	Research Scientist, CIRES, Univ. of Colorado	Climate dynamics
Berggren, John	Graduate Research Assistant, Univ. of Colorado	Climate adaptation, water policy
Bracken, Cameron	Graduate Research Assistant, Univ. of Colorado	Water resources engineering
Cody, Kelsey	Graduate Research Assistant, Univ. of Colorado	Water policy
Cozzetto, Karen	Postdoctoral Research Associate, Department of Environmental Studies, Univ. of Colorado	Hydroclimatology, surface water hydrology and ecology
Deems, Jeff	Research Scientist, CIRES, Univ. of Colorado	Climate and snow modeling
Dilling, Lisa	Assistant Professor, Environmental Studies, Univ. of Colorado	Climate information and decision-making
Gillies, Robert	Utah State Climatologist, Utah State Univ.	Climatology
Gordon, Eric	Program Manager, Western Water Assessment	Climate adaptation
Gray, Stephen	Wyoming State Climatologist, Univ. of Wyoming	Climatology and paleoclimatology
Guentchev, Galina	Postdoctoral Research Associate, University Corporation for Atmospheric Research (UCAR), CLIVAR, Postdocs Apply Climate Expertise (PACE)	Climate dynamics
Kenney, Douglas	Director, Western Water Policy Program, NRLC, Univ. of Colorado	Western water policy and law
Klein, Roberta	Managing Director, Center for Science and Technology Policy Research, Univ. of Colorado	Environmental policy
Lukas, Jeffrey	Senior Research Associate, Western Water Assessment	Paleohydrology, forest ecology
Mahoney, Kelly	Postdoctoral Research Associate, UCAR, CLIVAR, PACE	Extreme precipitation, numerical modeling, warm season convection
McCutchan, James	Deputy Director, Center for Limnology, CIRES, Univ. of Colorado	Limnology
Neff, Jason	Associate Professor, Geological Sciences & Environmental Studies, Univ. of Colorado	Biogeochemistry
Nowak, Kenneth	PhD Candidate, Civil Engineering, Univ. of Colorado	Water resources engineering
Painter, Thomas	Research Scientist, NASA Jet Propulsion Laboratory, California Institute of Technology	Hydrology
Rajagopalan, Balaji	Associate Professor, Civil Engineering, Univ. of Colorado	Water resources engineering
Rangwala, Imtiaz	Post-doctoral Research Associate, UCAR, CLIVAR, PACE	High-elevation climatology
Ray, Andrea	Scientist, Climate Analysis Branch, NOAA ESRL Physical Sciences Division	Climate-society interactions, water management
Rice, Janine	Research Scientist, CIRES, Univ. of Colorado (located at US	Climate impacts and





Team Member	Title	Expertise
	Forest Service Rocky Mountain Research Station)	adaptation in National Forests
Squillace, Mark	Director, NRLC, Univ. of Colorado	Natural resources and water law
Teel, Julie	Senior Research Associate, Center for Energy and Environmental Security, Univ. of Colorado	Energy law; climate policy; tribal climate adaptation
Travis, William	Associate Professor, Geography; Director, CSTPR, Univ. of Colorado	Natural hazards; climate impacts and adaptation
Udall, Bradley	Director, Western Water Assessment	Colorado River, hydrology, policy
van Drunick, Suzanne	Assistant Director for Science, CIRES, Univ. of Colorado	Hydrology and ecology
Wolter, Klaus	Research Scientist, CIRES, Univ. of Colorado	Climatology and meteorology

### Major Stakeholders & Partners

WWA engages with stakeholders at multiple levels within federal and state agencies, municipalities, universities, and other organizations. Table 3 lists the members of WWA’s Stakeholder Advisory Board, a group of high-level decision makers and other partners who provide guidance on structuring our research agenda to best meet regional needs. The Advisory Board, along with a significant number of other stakeholders and partners, first met in April 2010 (see summary in Appendix D) and is scheduled to meet again September 2011; WWA staff also regularly consult with board members on an informal basis.

Although the Advisory Board represents a number of organizations in the Intermountain West, they represent a small subset of our overall stakeholder network. A more complete list of WWA stakeholders and partners is available at [http://www.colorado.edu/RISA\\_rebid/WWA\\_stakeholders\\_8.09.pdf](http://www.colorado.edu/RISA_rebid/WWA_stakeholders_8.09.pdf).

**Table 3. WWA Stakeholder Advisory Board**

Timothy Brick	Chairman, Metropolitan Water District, Southern California
Curtis Brown	Director, Research and Development, Science and Technology Division, US Bureau of Reclamation
Terrance Fulp	Deputy Regional Director, Lower Colorado Region, US Bureau of Reclamation
Jennifer Gimbel	Director, Colorado Water Conservation Board
Melinda Kassen	Independent environmental consultant
Eric Kuhn	General Manager, Colorado River Water Conservation District
Chuck Kutscher	Principal Engineer, National Renewable Energy Laboratory, Department of Energy
Patricia Mulroy	General Manager, Southern Nevada Water Authority
William Neff	Director, Physical Science Division, NOAA Earth System Research Laboratory
Michelle Schmidt	Hydrologist-in-Charge, NOAA NWS Colorado Basin River Forecast Center
Jim Verdin	Deputy Director, National Integrated Drought Information System (NIDIS), USGS
Marc Waage	Manager, Water Resources Planning Division, Denver Water
Robert Wigington	Western Water Policy Counsel, The Nature Conservancy



## WWA 2010 Highlights

### Major Research Findings in 2010

- Dust deposition on snowpacks in the Upper Colorado River Basin ultimately reduces flow in the river by an average of 800,000 acre-feet per year, or five percent of the annual flow, according to research published in Proceedings of the National Academy of Sciences by WWA team members **Tom Painter, Jeff Deems, and Brad Udall** (<http://www.pnas.org/content/early/2010/09/14/0913139107.abstract>).
- Contrary to expectations, widespread tree mortality due to bark beetle infestations does not appear to result in major increases in nitrate levels in nearby streams, according to WWA researchers **James McCutchan and Suzanne Van Drunick** and their colleagues from the US Geological Survey and the US Forest Service (paper in prep; will be submitted to *Science*).
- Wavelet spectral analyses of Colorado River Basin streamflow and climate data indicate that persistent, low-frequency variability in streamflow is a result of temperature fluctuations that modulate of runoff efficiency, as found by WWA researchers **Ken Nowak, Balaji Rajagopalan, and Edith Zagona** (paper submitted to *Journal of Climate*).
- Working in southwestern Colorado, WWA researchers **Jason Neff, Karen Cozzetto, and Dan Fernandez** found that spatial variation in precipitation most strongly predicts vulnerability of vegetation to drought, followed by soil depth and soil texture. However, drought vulnerability also depends on the interactions between vegetation community type, soil depth and texture, and climate (more information at <http://moab.colorado.edu/ClimateImpactsOnPublicLands/>).
- WWA researcher **Joe Barsugli** found that the commonly used bias-correction method of quantile mapping itself may be biased, showing a wetter future in the Colorado River Basin than depicted by the underlying global climate model projections (work presented at American Geophysical Union 2010 Fall Meeting; see <http://adsabs.harvard.edu/abs/2010AGUFMGC51A0737B>).

### Select 2010 WWA Accomplishments

#### Colorado Climate Preparedness Project

**PIs:** Roberta Klein, Eric Gordon, William Travis, Brad Udall, Kristen Averyt, Jeff Lukas

**Stakeholders/Partners:** Colorado Governor's Energy Office, Colorado Water Conservation Board, Colorado Department of Agriculture

**Leveraged Funding:** \$161,000 from State of Colorado

At the request of the state of Colorado, WWA researchers Roberta Klein, Eric Gordon, Kristen Averyt, Brad Udall, Jeff Lukas, and William Travis conducted a survey of climate impacts and adaptation options in five sectors—water; electricity; wildlife, ecosystems, and forests; agriculture; and outdoor recreation. The results

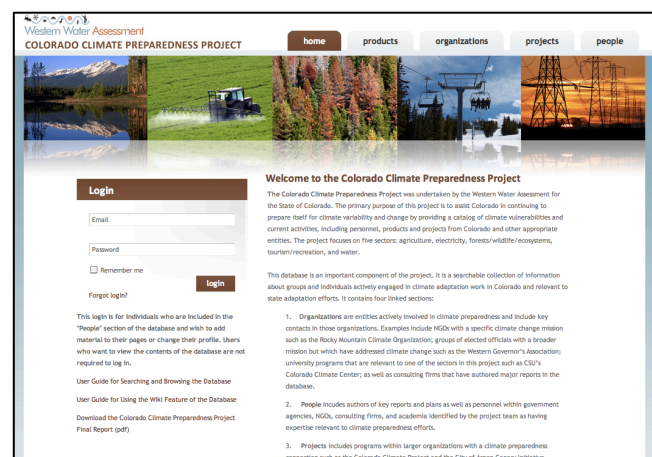


Figure 1. Colorado Climate Preparedness Project database.



of this effort are compiled in a database (<http://www.coloradaptprofile.org>) and a final report presented to Governor Hickenlooper and his staff ([http://wwa.colorado.edu/CCPP\\_report.pdf](http://wwa.colorado.edu/CCPP_report.pdf)). The report and the database are intended to help facilitate future vulnerability assessment and adaptation planning efforts across the state. This work is also intended to contribute to the National Climate Assessment.

## Workshop to Improve NOAA NWS RFC Decision-Support Tools

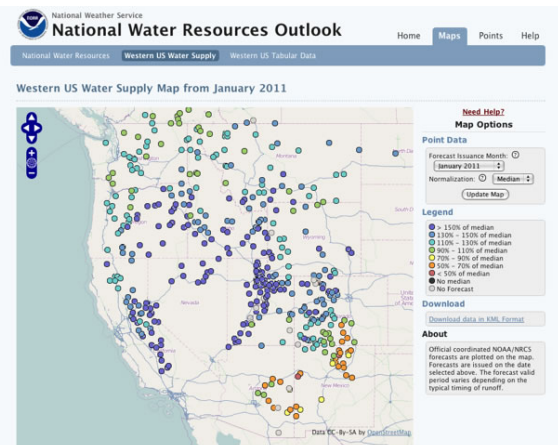


Figure 2. CBRFC Water Resources Outlook Tool.

are being scoped for 2011 for Utah, Oklahoma, and Georgia.

**PIs:** Kristen Averyt, Tim Bardsley, Gigi Owen (CLIMAS)

**Stakeholders/Partners:** NOAA NWS Colorado Basin River Forecast Center

**Leveraged Funding:** In-kind support from CBRFC

WWA researcher Averyt, working with others from the Climate Assessment for the Southwest (CLIMAS) and the NWS Colorado Basin River Forecast Center (CBRFC), collaborated on a stakeholder workshop held in Grand Junction, Colorado in April 2010 that focused on a new CBRFC decision-support tool. The workshop engaged participants with computer-based training exercises and scenario games to provide the CBRFC developers with focused feedback to improve the tool. After the success in Colorado, similar workshops

## Integrated Water-Energy Modeling Workshop

**PI:** Kristen Averyt

**Stakeholders/Partners:** National Renewable Energy Laboratory (NREL); Union of Concerned Scientists (UCS)

**Leveraged Funding:** \$100,000 from UCS

In August 2010, WWA hosted a workshop at NOAA entitled “Integrated Water-Energy Modeling Efforts & Reconciling Water Requirements for Electricity Generation.” The results of the meeting were presented at the American Geophysical Union 2010 Fall Meeting. The consensus around the water requirements for energy (which leveraged WWA efforts to improve the University of California-Santa Barbara’s database) is reflected in an NREL report released in April 2011. At the workshop, our parallel effort with NREL was recognized and subsequently merged into a single effort led by NREL. Averyt will be working with the Union of Concerned Scientists to host a meeting with a similar theme, but focused on the collaboration with UCS, in late Summer 2011.



Figure 3. Valmont power plant, Boulder, Colorado. Photo courtesy Let Ideas Compete.





## Drought Impact and Vulnerability Indicator Suite

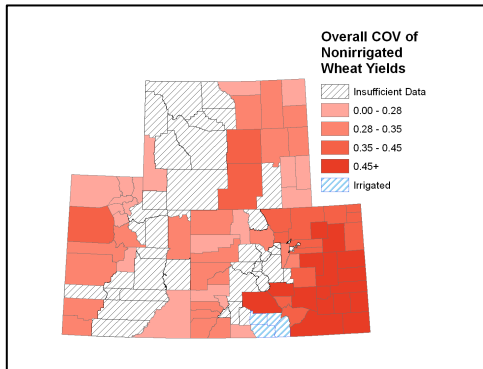


Figure 4. An indicator of drought sensitivity in agriculture: Dryland wheat yield variability measured as the coefficient of variation (standard deviation divided by the mean), 1970-2009.

**PIs:** William Travis, Kristin Gangwer, Roberta Klein  
**Stakeholders/Partners:** National Integrated Drought Information System (NIDIS)

In 2010, WWA researchers worked to meet a recommendation by NOAA’s 2009 Social Science Working Group for improved measures of socioeconomic impacts and better indicators of societal vulnerability to atmospheric hazards. Travis and Gangwer assembled a set of agricultural, water supply, and ecological indicators of drought effects that go beyond precipitation, snowpack and runoff measures. Included in the initial roster are indicators such as inter-annual crop yield variation (Figure 4), abandoned cropland, agricultural disaster declarations, number of declared water shortages among a sample of small to medium size municipal supply systems, and wildfire area. The next step is to fashion the indicators into a “drought dashboard” capable of reflecting impacts of drought in real-time.

## Ongoing Research Projects and Collaborations

### Climate Change Impacts on Public Lands in the Upper Colorado River Basin

**PIs:** Jason Neff, Dan Fernandez, Karen Cozzetto  
**Partners/Stakeholders:** Joint BLM/USFS San Juan Public Lands Center, Mountain Studies Institute  
**Leveraged Funding:** \$92,000 from Department of Interior/Bureau of Land Management

WWA researchers are examining 50-km resolution downscaled precipitation projections for southwestern Colorado produced for the North American Regional Climate Change Assessment Program (NARCCAP). The objectives of this work are 1) to evaluate how well historic projections are able to simulate current precipitation patterns at annual, seasonal, and monthly timescales and to do some preliminary diagnoses as to why certain simulations may or may not be better than others; and 2) to assess whether there is any consensus among the models as to what changes in precipitation can be expected in the future, both in terms of quantity and timing. This involves comparing future projections for the 2041–2070 time period with historic projections for the 1971–1999 time period. Ultimately the historic and future precipitation projections for six different RCM-GCM model combinations will be examined.

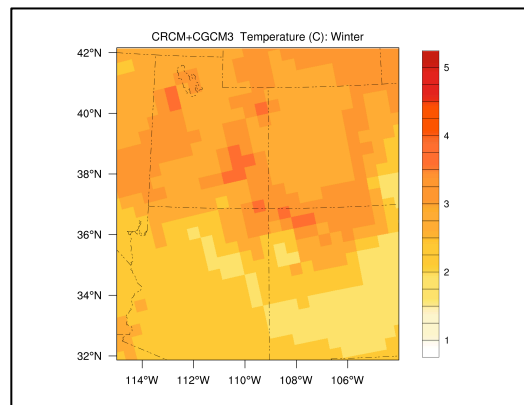


Figure 5. Projected increases in mid-century wintertime mean temperature in the Four Corners region, according to the CRCM+CGCM3 model.



## Climate Adaptation on Western National Forests

**PIs:** Janine Rice, Linda Joyce, Brad Udall, Jeff Lukas

**Partners/Stakeholders:** US Forest Service/Rocky Mountain Research Station and Shoshone National Forest

**Leveraged Funding:** \$120,000 from US Forest Service

As part of a broader US Forest Service effort entitled “A Toolkit for Adapting to Climate Change on Western National Forests: Incorporating Climate into Resource Management and Planning,” WWA post-doctoral fellow Rice worked with others at the Forest Service’s Rocky Mountain Research



Figure 6. Shoshone National Forest.

Station in Fort Collins, CO to complete a technical report covering climate impacts in Wyoming’s Shoshone National Forest. Rice is now working on a climate vulnerability assessment for the forest, which will focus on whitebark pine and aspen range shifts, along with streamflow changes that would affect Yellowstone cutthroat trout and water supply.

## Mapping Drought Vulnerability in Southwestern Colorado

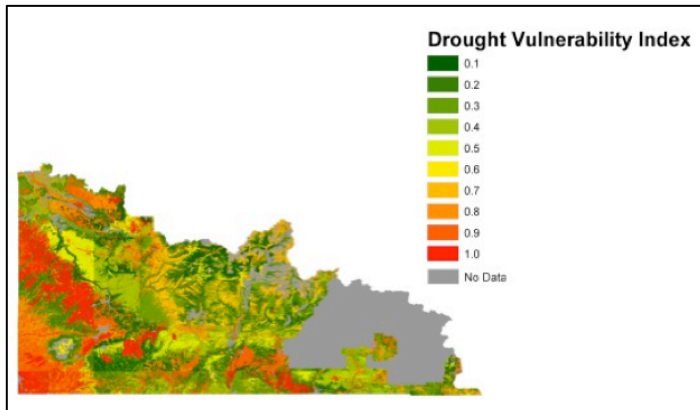


Figure 7. Southwest CO drought vulnerability index developed by Neff et al.

**PIs:** Jason Neff, Dan Fernandez, Karen Cozzetto

**Partners/Stakeholders:** Joint BLM/USFS San Juan Public Lands Center

WWA researchers Neff, Cozzetto, and Fernandez worked in conjunction with managers at the BLM/USFS San Juan Public Lands Center to better understand the vulnerability of public lands to drought based on a variety of ecological and physical factors. Their ecophysiological model produced an initial drought vulnerability map (Figure 6) that can be used by land managers in climate change

analysis and planning efforts. Neff, Cozzetto, and Fernandez are currently working to expand the model with other physical parameters and analyzing downscaled climate projections to provide additional planning tools.



## Impacts of Coupled Climate Change and Dust Deposition on Water Resources in the Colorado River Basin

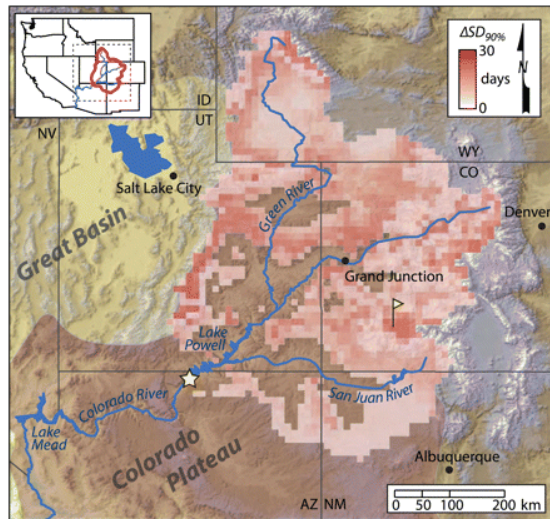


Figure 8. Modeled change in date of 90% snow depletion due to dust loading.

**PIs:** Tom Painter, Jeff Deems

**Partners/Stakeholders:** Center for Snow and Avalanche Studies, NASA Jet Propulsion Laboratory, US Geological Survey

**Leveraged Funding:** \$280,000 from NASA

WWA researchers completed the second year of a three-year project to quantitatively model the influence of dust deposition and climate change on snowmelt and runoff in the Colorado River Basin. They used the Variable Infiltration Capacity (VIC) model to show that dust deposition is not only causing early spring runoff, but also may be responsible for evaporative losses equivalent to 800,000 acre-feet, or nearly 5 percent of the total river flow. Ongoing and future work will incorporate into the modeling both the greater dust deposition seen in 2009 and 2010, and future climate projections.

### Highlights of Translating Science for Decisionmakers

#### *Bark Beetle Impacts on Hydrologic Processes and Water Quality*

In April 2010, WWA researchers Gordon and Lukas hosted a symposium highlighting research on the water-related impacts of bark beetle infestations (see symposium web page at <http://wwa.colorado.edu/ecology/beetle/mpb-water-apr2010.html>). In addition to providing a forum for researchers to discuss their ongoing work investigating beetle-induced impacts to water quality and hydrologic processes, the symposium included time for land managers to discuss significant challenges and shape future research efforts to better meet their needs. A follow-up workshop will be held in April 2011.

#### *Front Range Water Providers Workshop*

In December 2010, WWA researchers met with water managers from six major water utilities and providers along Colorado's Front Range. WWA researchers presented research on seasonal forecasting, dust deposition on snowpack, bark beetles, paleohydrology, and climate adaptation, receiving important feedback that will ensure that WWA research efforts better meet stakeholder needs. A discussion period afterwards allowed WWA staff to learn more about climate challenges facing water managers.

#### *Informing the Appropriate Use of Climate Projections*

WWA researcher Barsugli leads numerous efforts to guide stakeholders in using climate change projections in adaptation planning in a manner consistent with the uncertainties in the projections. His work to educate users about climate models, projections, and downscaling methods, requires a significant amount of direct engagement with resource managers and other stakeholders. Barsugli worked with Linda Mearns of NCAR to develop climate and hydrologic change scenarios for the Gunnison River in Colorado and the Bear River in Utah and Idaho as part of The Nature Conservancy-led





multi-agency climate adaptation workshops in those basins. Barsugli also advised the Joint Front Range Climate Change Vulnerability Study, participated in the Water Utility Climate Alliance (WUCA), and worked with the US Bureau of Reclamation to incorporate NARCCAP data into the Bureau's Colorado River Basin Study.

#### *Media Outreach Relating to the Future of the Colorado River*

WWA Director Udall is a renowned expert on Colorado River issues, including the complexity of managing the river and the future intertwined effects of increased demand along with reduced flows due to climate change. As Lake Mead dropped in fall 2010 to its lowest level since the reservoir was filled, media attention rapidly increased. Udall appeared in magazines such as *Smithsonian*, *Grist*, and *5280*, and in Alexandra Cousteau's *Expedition Blue Planet* series, providing a researcher's perspective on the future of the Colorado River, a critical lifeline in the American Southwest. For more examples of WWA researchers in the media, see Appendix B.

#### *Tribal Climate Workshop*

In October 2010, WWA researchers Teel and Alvord worked with NIDIS and the University of Colorado Law School to organize the "Tribal Climate Change Adaptation Workshop," intended to share with tribal leaders and natural resource staff the most current information and strategies for climate adaptation and drought response. Representatives from tribes in the Pacific Northwest and Four Corners attended and learned about the process of climate adaptation planning and the federal science and legal resources available to help move such processes forward.

#### *Managing for Resiliency in the San Juan Mountains*

WWA co-sponsored and helped organize the Mountain Studies Institute's 2010 conference "Managing for Resiliency in the San Juan Mountains: Adaptation and Planning for Climate Change." This meeting brought together scientists and land managers to assess existing and future threats to the San Juan Mountains region posed by climate change, and to develop strategies to plan for, adapt to, and reduce the effects of climate change on ecosystems and society. WWA researchers Rangwala and Cozzetto served on the conference planning committee, and they, along with Deems and Barsugli, presented WWA research to conference participants.

#### *Testimony to Congress*

In March 2010, WWA Director Udall testified in front of the House Subcommittee on Water and Power during an oversight hearing regarding the budget for both the Bureau of Reclamation and the USGS Water Resources Division. Udall's testimony focused on the need for adequate decision support mechanisms to help water managers deal with the impacts of climate variability and change on water resources in the West. This testimony was an opportunity to provide members of Congress with scientific information about climate impacts on water management and to highlight the work of both the RISA program and the DOI's new Climate Science Centers and Landscape Conservation Cooperatives. (Full testimony available at

<http://naturalresources.house.gov/UploadedFiles/UdallTestimony03.11.10.pdf>).



## WWA 2010 Project Reports

### Decision Support for the Colorado River Basin and Headwaters

#### Stochastic Streamflow Simulation at Interannual and Interdecadal Time Scales and Implications to Water Resources Management in the Colorado River Basin

Primary Investigator(s): B. Rajagopalan, E. Zagona, K. Nowak, C. Bracken

WWA Funding: January–December 2010

Leveraged Funding: \$253,000 from Bureau of Reclamation (2009-2011)

**Analysis of historic variability of streamflow in the Colorado River with the goal of producing more accurate projections at multiple time scales and improving reservoir operations.**

WWA researcher Nowak continues to work on decadal variability in Colorado River streamflow to produce stochastic projections that will ultimately be used to guide reservoir operations in the Basin. Soon he will test the utility of these decadal projections using the Bureau of Reclamation's long-term planning model, CRSS. He recently submitted a paper to *Journal of Hydrology* on stochastic simulation of multisite streamflow with nonstationary spectral features which was demonstrated on the Colorado River Basin flows. Another paper, soon to be submitted to *Journal of Climate*, documents the climatic drivers of multidecadal variability of streamflow in the basin. Bracken, working on forecasting algorithms for seasonal flow, has completed work extending a disaggregation framework to all the natural flow nodes in the Upper basin. Work is also in progress on methods to predict out-year flows that exploit variability in the paleostreamflow record. In addition, development of the new probabilistic midterm operations model continues at CADSWES with help of a Reclamation consultant and CADSWES software team. This model will serve as the test bed for Cameron Bracken's new forecasting methods.

#### Impacts of Coupled Climate Change and Dust Deposition on Water Resources in the Colorado River Basin

Primary Investigator(s): J. Deems, T. Painter, B. Udall

WWA Funding: January–December 2010

Leveraged Funding: \$280,000 from NASA (2009-2011)

**Hydrologic modeling used to understand the influence of dust deposition and climate change on snowmelt and runoff in the Colorado River Basin.**

In September 2010, Proceedings of the National Academy of Sciences published "Response of Colorado River Runoff to Dust Radiative Forcing in Snow," a summary of work by Painter and Deems on the impacts of dust on snowpack in the Colorado River Basin. This research used the Variable Infiltration Capacity (VIC) model to show that dust deposition is not only causing early spring runoff, but also may be responsible for evaporative losses equivalent to 800,000 acre-feet, or nearly 5 percent of the total river flow. The study will be updated to incorporate data from 2009 and 2010, and to incorporate future climate projections.

#### Historical and Potential Future Changes in Temporal Precipitation Variability in the Colorado River Basin

Primary Investigator(s): G. Guentchev, J. Barsugli

WWA Funding: January–July 2010

Leveraged Funding: PACE Postdoc Program support for G. Guentchev

**Assessing the historical characteristics and the potential future changes in precipitation variability throughout the Colorado River Basin.**

Three gridded data sets derived from precipitation observations were used in this analysis: the Maurer et al. (2002) data set, the Hamlet and Lettenmaier (2005) data set, and the PRISM data set (Daly et al. 1994, 1997). In addition, the projections of a set of about 30 CMIP3 GCM runs were used in this project. As an initial step the homogeneity of the observed gridded data sets was evaluated using the methodology proposed by Wijngaard et al. (2003). Next, a set of variability measures was chosen to represent the historical (1951-1999) and projected future temporal precipitation variability. These measures were utilized to assess the differences between the model simulated and the observed precipitation variability for the historical period. These differences indicate how skillfully the models represent the observed precipitation variability. Results of this work are summarized in Guentchev et al. (2010), published in *Journal of Applied Meteorology and Climatology*.



### TreeFlow: A Drought Planning Resource for Water Management in the Western U.S.

Primary Investigator(s): J. Lukas

WWA Funding: July–December 2010

**Further development of a comprehensive web-based tree-ring data and applications resource (<http://treeflow.info>) that addresses regional needs and interests and is designed to be expandable to include additional regions of interest and reconstructions generated in the future.**

A round of maintenance on the TreeFlow.info web resource was done in mid-2010, with many pages updated to reflect new references and applications of the data. New pages and data files were then added to provide access to new reconstructions for the Santa Fe River in New Mexico developed by researchers with the University of Arizona, demonstrating the flexibility of the TreeFlow architecture in accommodating new data. Also, in 2010, a research team at Utah State University engaged WWA researchers J. Lukas and S. Gray to provide that team with guidance on conducting applied paleohydrologic work in the Wasatch Front in Utah, along the lines of the work conducted by WWA. Both Lukas and Gray participated in a workshop in Logan, UT, in September 2010 to convey lessons from the NOAA CPO-funded work featured in TreeFlow.

### Paleohydrology of the Lower Colorado River Basin

Primary Investigator(s): B. Rajagopalan, J. Lukas, C. Woodhouse (U. of Arizona/CLIMAS)

WWA Funding: July–December 2010

Leveraged Funding: Colorado Water Institute, U. of Colorado Civil Engineering Dept.

**Generation of paleohydrologic reconstructions of annual flows for the intervening flow of the Colorado River between Lees Ferry and Imperial Dam and the Gila River at its mouth.**

The project formally commenced with an all-day project meeting in Boulder, CO in late September 2010. The participants included the investigators from CU/WWA, CSU, and University of Arizona, as well as stakeholders Jim Prairie (US Bureau of Reclamation), Michelle Garrison (Colorado Water Conservation Board), and Eric Kuhn, Dave Kanzer, and John Currier (Colorado River District). The investigators presented the previous dendrohydrological work on which this project builds and discussed and refined the project workplan and methodologies for each step. By the end of 2010, the project team had identified the tree-ring chronology dataset that would be calibrated with the flow record, researched previous efforts to estimate the natural flow of the Gila River, and established an overall project schedule. Work began on developing new natural flow estimates for the Gila and the mainstem Lower Colorado rivers in preparation for reconstruction modeling in spring 2011.

## Ecological Vulnerabilities, Impacts, and Adaptation

### Forests, Climate, and Change

Primary Investigator(s): E. Gordon, J. Lukas

WWA Funding: January–December 2010

**Engaging with a diverse set of stakeholders and researchers dealing with the ongoing mountain pine beetle (MPB) epidemic and developing integrated, decision-oriented information that can help stakeholders understand and plan for the current MPB epidemic, with a particular focus on water quality and hydrologic impacts.**

Building on the results of a December 2009 workshop that brought together stakeholders and researchers concerned about the ongoing MPB epidemic, we focused our efforts on integrating ongoing efforts to understand water quality and hydrologic impacts of widespread tree death due to beetle infestations. In April 2010, we held a workshop bringing together hydrologists, ecologists and other researchers who presented their work in front of a variety of land and water resource managers. Gordon has also been working on a conceptual model of hydrologic impacts over the course of an MPB infestation and presented the model in a poster at the American Geophysical Union 2010 Fall Meeting.

### Climate Change Impacts on Public Lands in the Upper Colorado River Basin

Primary Investigator(s): J. Neff, K. Cozzetto, D. Fernandez

WWA Funding: January–December 2010



**Working in conjunction with managers at the BLM/USFS San Juan Public Lands Center to better understand the vulnerability of public lands to drought based on a variety of ecological and physical factors.**

Development of a simple ecophysiological model produced an initial drought vulnerability map that could be used by land managers in climate change analysis and planning efforts. The initial map is complete for Colorado and we are now testing model predictions for this region. WWA researchers are also carrying out model analysis of sites in eastern Utah where detailed dendrochronology is available for comparison of tree drought responses across two soil types. The model will be expanded to include other physical parameters. Researchers presented the drought vulnerability assessment ideas to BLM managers in January 2011 and are now carrying out further validation of the model results.

**Downscaled Precipitation Projections for Southwestern Colorado**

Primary Investigator(s): I. Rangwala, K. Cozzetto, J. Neff

WWA Funding: January–December 2010

Leveraged Funding: PACE Postdoc Program support for I. Rangwala; \$92,000 from Department of Interior/Bureau of Land Management

**Analyzing downscaled precipitation projections for the San Juan Mountains to understand their accuracy at simulating precipitation patterns in the region.**

Researchers are examining 50-km resolution downscaled precipitation projections for southwestern Colorado for two purposes: 1) to evaluate how well historic projections are able to simulate current precipitation patterns at annual, seasonal, and monthly timescales and to do some preliminary diagnoses as to why certain simulations may or may not be better than others; and 2) to assess whether there is any consensus among the models as to what changes in precipitation can be expected in the future, both in terms of quantity and timing. This involves comparing future projections for the 2041-2070 time period with historic projections for the 1971-1999 time period. Ultimately the historic and future precipitation projections for six different RCM-GCM model combinations will be examined. A white paper providing a primer on climate models for land managers in the region has already been delivered to the San Juan Public Lands Center, and a paper focusing on downscaled climate projections for the region is in preparation.

**Effects of Mountain Pine Beetle on Water Quality in Colorado**

Primary Investigator(s): J. McCutchan, S. Van Drunick

WWA Funding: January–July 2010

Leveraged Funding: In-kind support from National Park Service

**Measuring water quality criteria in streams in Rocky Mountain National Park as a means to understand if widespread tree death from bark beetle infestations has a significant impact on stream chemistry.**

Preliminary analyses of water quality “snapshots” in Rocky Mountain National Park have shown that the effects of mountain pine beetle on nutrient chemistry in streams have been modest in comparison with some other examples of forest disturbance (e.g., clear cutting). Mountain pine beetle may significantly increase nutrient concentrations in some lakes and reservoirs, in that the changes could result in measurable changes in phytoplankton growth or water clarity, but it does not appear that such changes will be dramatic (except possibly in the case of widespread fire). Ongoing work is investigating whether carbamate pesticides are detectable in streams. Results have been presented to National Park Service managers through a summary report. An analysis of why mortality due to bark beetle infestations does not result in major increases in nitrate levels in nearby streams is in preparation with colleagues from the US Geological Survey and the US Forest Service and will be submitted to *Science*.

**Controls on pH and Ammonia Toxicity in Rivers of the Colorado Plains**

Primary Investigator(s): J. McCutchan, S. Van Drunick, M. Huisenga

WWA Funding: July–December 2010

**Determining the relative importance of factors leading to high pH in Colorado Plains streams that are dominated or strongly influenced by wastewater effluent, including temperature, hydrology (volume of flow), and photosynthetic rate.**

Samples and field measurements have been collected on 18 dates from stations on the South Platte River and Boulder Creek, and flow models have been developed for each of the sampling locations to reconstruct records of discharge and velocity for the sampling locations. A preliminary analysis of the interactions between physical variables related to climate variation (discharge, flow velocity, temperature) and algal biomass, photosynthesis, and pH is underway and will be completed in spring 2011. In addition to measurements of algal biomass and open channel measurements of temperature, pH, and dissolved oxygen, a series of measurements were made with metabolism chambers to estimate rates of photosynthesis and respiration in the water column of the South Platte River. It is widely accepted that photosynthesis in shallow rivers and streams is dominated almost entirely by attached algae. Chamber incubations have shown, however, that as much as 20% of photosynthesis in the South Platte may occur in the water column (i.e., by suspended algae) at some locations during summer months. The ultimate goal with this work will be to provide a basis for modeling effects of climate variation on metabolism and pH in Plains rivers.



### The Green River Headwaters Network: Building Partnerships, Infrastructure and Knowledge for Sustainable Resource Management

Primary Investigator(s): S. Gray

WWA Funding: *Intended July–December 2010; not delivered until April 2011*

**Design and preliminary installation of a monitoring network that will link stream discharge and watershed structure to water temperatures and other controls on aquatic ecosystems; exploration of modeling techniques that will link precipitation, discharge, air temperatures, and water temperatures in critical headwaters ecosystems; and creation of a broad, well-informed and thoroughly engaged stakeholder network that recognizes the importance of both traditional and non-consumptive uses of water.**

This project was did not begin in 2010 as planned due to subcontracting delays at both NOAA and the University of Colorado, which prevented funding from being delivered to the PI (at the University of Wyoming) until spring 2011.

### Climate Adaptation in Western National Forests

Primary Investigator(s): J. Rice, L. Joyce (USFS), B. Udall, J. Lukas

WWA Funding: *January–December 2010*

Leveraged Funding: *\$120,000 from US Forest Service*

**Conducting a pilot climate vulnerability assessment for the Shoshone National Forest as part of a broader effort by the US Forest Service to develop a climate adaptation toolkit.**

As part of a broader US Forest Service effort entitled “A Toolkit for Adapting to Climate Change on Western National Forests: Incorporating Climate into Resource Management and Planning,” WWA post-doctoral fellow Rice worked with others at the Forest Service’s Rocky Mountain Research Station in Fort Collins, CO to complete a technical report covering climate impacts in Wyoming’s Shoshone National Forest. Rice is now working on a climate vulnerability assessment for the forest, which will focus on whitebark pine and aspen range shifts, along with streamflow changes that would affect Yellowstone cutthroat trout and water supply.

## Emerging Initiatives and Adaptation Strategies to Inform Climate Services

### A Drought Impact and Vulnerability Indicator Suite

Primary Investigator(s): W. Travis, R. Klein, K. Gangwer

WWA Funding: *January–July 2010*

**Development of a suite of key indicators of drought and other climate-related vulnerability in the WWA research area at appropriate scales using both physical and social data.**

Travis, Gangwer, and Klein assembled a set of agricultural, water supply, and ecological indicators of drought effects that go beyond precipitation, snowpack and runoff measures. Included in the initial roster are indicators such as inter-annual crop yield variation, abandoned cropland, agricultural disaster declarations, number of declared water shortages among a sample of small to medium size municipal supply systems, and wildfire area. This effort has been aimed at enhancing drought vulnerability analyses like the study that fed into an update of Colorado’s state drought response plan. The next step is to fashion the indicators into a “drought dashboard” capable of reflecting impacts of drought in real-time.

### Drought Adaptation among Ranchers in the Intermountain West (and building a network of agriculturalists to inform WWA)

Primary Investigator(s): W. Travis, K. Gangwer

WWA Funding: *July–December 2010*

**Identifying and measuring the effects of adaptations among agriculturalists in the “Three Corners” region of CO, WY, and UT via detailed surveys of their decision-making and by building a typology of responses that reflect the direct and indirect outcomes of both impacts and adaptations.**

The researchers received Institutional Review Board Approval for human subjects research in June 2010 and conducted interviews with 21 ranchers, 8 USFS and BLM range managers, and other key informants in Colorado, Utah, and Wyoming between July 2010 and January 2011. The interviews are helping paint a picture of ranchers’ perceptions of climate, along with their needs for climate information. This work is intended to lead to a master’s thesis, WWA white paper, and paper for publication.



### **Towards Frameworks for Climate Services: Meeting the needs of different users with different information requirements**

Primary Investigator(s): K. Averyt, G. Owen (CLIMAS)

*WWA Funding: January–December 2010*

*Leveraged Funding: In-kind support from NOAA CBRFC*

*CROSS-RISA WORK*

#### **Presenting the RFC Water Resources Outlook tool at a user workshop to help identify differences in the user populations and determine changes in the Water Resources Outlook product that might be necessary for a different suite of users.**

In April 2010, WWA and the CBRFC hosted a workshop in Grand Junction, Colorado, where we tested the usability of the new RFC Water Resources Outlook online tool. We tested the climate literacy of participants and assessed the utility of the tool using decision gaming and scenarios. The information gathered fed directly back to the developers who intend to use the information to improve the online product. The workshop report can be found here: <http://www.climas.arizona.edu/files/climas/project-documents/public/1367/User%20Engagement%20Progress%20Report.doc>. The planned workshop in Salt Lake City has been postponed until 2011 in order to more fully engage the new WWA Utah Liaison (Bardsley) in the process. We also held a workshop in January 2011 at the AMS Meeting in Seattle, WA in conjunction with a short course on water resources (<http://www.cbrfc.noaa.gov/shortcourse/agenda.htm>). During this time we introduced a gaming exercise that involved forecasted flows and reservoir schedules.

### **Water, Energy, and Climate Change in the Colorado River Basin**

Primary Investigator(s): K. Averyt, B. Udall

*WWA Funding: January–December 2010*

*Leveraged Funding: \$100,000 from Union of Concerned Scientists*

#### **Efforts to reconcile multiple models of water consumption for energy production and create an integrated model of water, climate, and energy in the Colorado River Basin with stakeholder input.**

In August 2010, WWA hosted a workshop at NOAA entitled “Integrated Water-Energy Modeling Efforts & Reconciling Water Requirements for Electricity Generation.” The results of the meeting were presented at the American Geophysical Union Fall 2010 Meeting. The consensus around the water requirements for energy (which leveraged WWA efforts to improve the University of California-Santa Barbara’s database) is reflected in an NREL report released in April 2011. At the workshop, our parallel effort with NREL was recognized and subsequently merged into a single effort led by NREL. Averyt will be working with the Union of Concerned Scientists to host a meeting with a similar theme, but focused on the collaboration with UCS, in the late summer 2011.

### **Water-Energy-Climate Change Nexus**

Primary Investigator(s): D. Kenney, K. Averyt

*WWA Funding: January–December 2010*

#### **Writing and publishing of a book providing an overview of the nexus among water, energy, and climate issues in the western United States.**

Over the past year, the WECC thread of WWA research has reached a major milestone with the submission of the manuscript entitled *The Water-Energy Nexus in the Western United States*. This book, edited by Kenney (WWA) and Robert Wilkinson, features contributions from 24 authors drawn from the network of WECC researchers and decision-makers that we have cultivated over the past two years. Averyt is the author of the chapter on coal. The book is scheduled for publication in October 2011 by Edward Elgar Publishing.

### **Watershed & Climate Educational Session to Supplement SOARS Seminar Program**

Primary Investigator(s): C. Alvord, J. Lukas, J. Deems

*WWA Funding: July–December 2010*

*Leveraged Funding: In-kind support from National Park Service.*

#### **Development of a field trip supplement to UCAR’s Significant Opportunities in Atmospheric Research and Science (SOARS) program, which provides underrepresented undergraduate students with opportunities to pursue graduate work in atmospheric and related sciences.**

On July 9, 2010, WWA staff (Alvord, Lukas, and Deems), with support from the UCAR SOARS program staff, conducted a one-day bus tour from Boulder to Rocky Mountain National Park (RMNP) in the Colorado River headwaters. Ten SOARS students and 6 students from RESESS (a partner program to SOARS, for the geosciences) participated in the tour. The tour featured several stops inside and outside the park, and presentations by researchers Lukas (WWA), Deems (WWA) and Paul McLaughlin (National Park Service) on the impacts of climate variability and change on natural resources in the region, including water supply and water quality, wildlife and ecosystem integrity, and forest ecology.





Feedback from the students and SOARS program staff indicated that this session was a very useful addition to the SOARS and RESESS programs.

#### Tribal Climate Change Adaptation Workshop for Colorado Plateau Tribes

Primary Investigator(s): C. Alvord

WWA Funding: July–December 2010

**WWA support for a workshop intended to help Western tribes learn about climate adaptation and to begin the process of developing a network of tribal contacts for WWA.**

In October 2010, WWA worked with NIDIS and the University of Colorado Law School to organize a workshop aimed at providing tribal leaders and natural resource personnel with information about climate adaptation and drought response. Tribes from the Pacific Northwest and Four Corners regions attended and learned about both the process of climate adaptation planning and federal science and legal resources available to help move such processes forward.

## Support of the National Climate Assessment

#### Colorado Climate Preparedness Project

Primary Investigator(s): R. Klein, E. Gordon, W. Travis, J. Lukas, K. Averyt, B. Udall

WWA Funding: July–December 2010

Leveraged Funding: \$161,000 from State of Colorado

**Preliminary analysis of climate impacts and adaptations relevant to state agencies in Colorado; development of an online adaptation database.**

At the request of the state of Colorado, WWA researchers conducted a preliminary analysis of climate impacts and adaptation options in five sectors—water; electricity; wildlife, ecosystems, and forests; agriculture; and outdoor recreation. The results of this effort are compiled in a database of people, projects, products, and organizations relevant to adaptation in the state (<http://www.coloadaptationprofile.org>) and a final report presented to Governor Hickenlooper and his staff ([http://wwa.colorado.edu/CCPP\\_report.pdf](http://wwa.colorado.edu/CCPP_report.pdf)). The report and the database are intended to help facilitate future vulnerability assessment and adaptation planning efforts across the state. The database code is being made available to other RISAs as needed and will be used in future WWA assessment work.

#### Utah & Wyoming Climate Adaptation Databases

Primary Investigator(s): T. Bardsley, E. Gordon, S. Gray, K. Averyt, H. Glenn

WWA Funding: July–December 2010

**Creation and maintenance of two databases; each containing information related to the people, products, documents, and projects in the state of Utah, and the state of Wyoming, respectively, that support climate adaptation in each state.**

Similar to the completed effort in Colorado, these proposed databases add ‘product maps’ of existing science efforts in Utah & Wyoming. Each database effort will be supported by a WWA liaison each state. Progress as of the end of 2010 includes hiring Bardsley as the WWA Utah liaison who will be leading development of the Utah database along with other preliminary assessment work in the state; a WWA Wyoming liaison has not yet been identified.

#### Developing a Comparative Framework for Future Stakeholder Interactions

Primary Investigator(s): L. Dilling, J. Berggren, K. Averyt, M. Carmen-Lemos (GLISA), K. Dow (CISA)

WWA Funding: July–December 2010

CROSS-RISA ACTIVITY



**This effort is focused on developing a database of user needs for the Intermountain West states, using the database framework to conduct several analyses, and then transferring the user needs into the aforementioned public databases.**

This project is a cooperative effort with two other RISAs, GLISA and CISA. The goal is to catalog user needs that have already documented, and analyze the evolution of those needs. Such an approach will be crucial to understanding how stakeholder communities might function in a future “nested matrix” approach to assessment. Work during 2010 included preliminary data and report gathering, and participating in several calls with the other two RISAs to set up the protocol and project methods for 2011.

#### Colorado River Basin Workshop

Primary Investigator(s): G. Garfin (CLIMAS), J. Overpeck (CLIMAS), D. Cayan (CNAP), B. Udall (WWA), E. Gordon (WWA)

WWA Funding: July–December 2010

CROSS-RISA ACTIVITY

**In collaboration with CLIMAS and CNAP, we are developing an adaptation workshop for key stakeholders and agencies from across a spectrum of sectors in the Colorado River Basin.**

Most organized discussion about climate change within the Colorado River Basin (CRB) has addressed projected climate impacts and specific rules for operating under surplus and shortage. This project will move the discussion from awareness to action and coordination by assessing regional adaptation capabilities and cataloging existing adaptation efforts in the broader CRB. The following are expected deliverables: (1) Report that summarizes needs, capacity, and projects (existing and planned), (2) Database of existing projects, contacts, and related literature, and (3) Development of a core group for ongoing activities. The workshop is scheduled for June 2011.

## Core Activities

#### Building a Network of Stakeholders for Future WWA Research

Primary Investigator(s): B. Udall, K. Averyt, J. Lukas, E. Gordon, A. Ray, T. Bardsley

WWA Funding: January–December 2010

**Participation in numerous stakeholder events and direct interactions with decision-makers to build trusted relationships in the region in order to further develop WWA’s stakeholder network and identify future research opportunities.**

WWA staff, along with team members, spent a significant amount of time interacting with stakeholders throughout our three-state region. Examples of such interactions include attending water users’ conferences, meeting with key stakeholders at state and federal agencies, and participating in NIDIS pilot workshops. Although this work did not produce direct research results, it is both critical to ensuring that WWA work is relevant and accepted by the stakeholder community and extremely time-intensive.

#### WWA Speakers Bureau

Primary Investigator(s): B. Udall, K. Averyt, J. Lukas, J. Barsugli, K. Wolter, E. Gordon

WWA Funding: January–December 2010

**Responding to stakeholder requests for WWA team members to speak on climate-related topics at events throughout the WWA region.**

WWA receives dozens of requests every year to speak at events throughout our region. Examples of speaking engagements in 2010 include the Colorado Water Users Conference (Udall), a presentation on applied tree-ring research to US Forest Service staff in western Colorado (Lukas), a presentation to the Western Association of Agricultural Extension Station Directors’ W2190 group (Gordon), and a lecture on weather and climate to a forum organized by Denver’s Channel 7 News (Averyt).

#### Informing the Responsible Use of Regional Climate Models by Stakeholders

Primary Investigator(s): J. Barsugli

WWA Funding: January–December 2010

**Connecting stakeholders with climate change projection data and methodologies in a manner that leads to impacts and vulnerability assessments that accurately reflect the state of scientific understanding of the climate.**



WWA team member Barsugli, an expert in climate dynamics, works with multiple stakeholder groups to help provide appropriate downscaled climate information and guide its use throughout planning processes. This has included working with The Nature Conservancy to develop hydrologic change scenarios for a climate adaptation workshop on the Bear River Basin in Utah (May 2010) and continuing work for a similar effort in the Gunnison Basin in Colorado; collaborating with Levi Brekke from the Bureau of Reclamation on the interpretation of NARCCAP data in the Colorado River Basin Study; and providing expert analysis for the state of Colorado in the Colorado River Water Availability Study (CRWAS).

#### Intermountain West Climate Summary (IWCS)

Primary Investigator(s): J. Lukas, H. Glenn, E. Gordon, T. Bardsley, K. Averyt

WWA Funding: January–December 2010

##### **Publication of a bi-monthly summary of climate information for WWA’s three-state region, with in-depth articles communicating WWA research and related efforts.**

In 2010, WWA continued on its schedule of producing six web-based issues of the IWCS, whose release is announced to a list of 400 stakeholders. All of the Feature and Focus articles in 2010 were written expressly for the IWCS, with the Feature articles highlighting WWA research on Colorado River water management, dust-on-snow, and ENSO-based streamflow forecasts; WWA workshops; and the NIDIS Upper Colorado River Pilot. The release of each issue of the IWCS continues to be announced on the homepages of NOAA NWS forecast offices throughout the region and other partner organizations.

#### Update of WWA Website and Other Communication Materials

Primary Investigator(s): J. Lukas, H. Glenn, E. Gordon

WWA Funding: July–December 2010

Leveraged Funding: In-kind support from CIRES staff

##### **WWA’s website and other communication materials, critical to effective communication with stakeholders, are being revised to better meet stakeholder needs and appropriately reflect WWA’s mission and activities.**

The “Current Projects” section of the website was updated in 2010 to reflect the activities outlined in the WWA FY2011 statement of work. In late 2010, WWA staff and the CIRES webmaster outlined the approach for a major upgrade of the entire WWA website to be completed in 2011, including both a redesign and re-coding of page templates to greatly simplify maintenance of the site. At that time, many other pages and resources will be updated. The WWA publications database and presentations databases are in the process of being transferred to a user-searchable FileMaker database, and being integrated into the main CIRES publication database. In fall 2010, Program Manager Gordon carried out the first quarterly update of WWA research and outreach activities, which was produced as a PDF, emailed to the WWA stakeholder list, and posted on the WWA website.

#### Best Practices for Observational Datasets

Primary Investigator(s): K. Wolter, R. Gillies, N. Doesken

WWA Funding: July–December 2010

##### **Developing a publication of findings and recommendations on best practices for developing and interpreting historic records and time series.**

The Utah Climate Center at Utah State University, in collaboration with the Colorado Climate Center at Colorado State University, the Western Water Assessment at the University of Colorado and the Cooperative Institute for Research in the Atmosphere in the CSU Department of Atmospheric Science, is developing a publication of findings and recommendations on best practices for developing and interpreting historic records and time series, specifically for temperature and precipitation records. This paper will document the process of selecting the best station records in Colorado and Utah. The goal is to make climate data from the instrumental record (late 1800s until the present) accessible to public audiences, decision makers and educators in a manner that the seasonality, interannual variability and long term trends can be easily visualized and accurately portrayed.



## WWA 2010 Publications

**Alvord, C.**, 2010. Understanding the Climate Vulnerabilities, Needs, and Resources of Tribal Communities. *Intermountain West Climate Summary* 6(1).

[http://wwa.colorado.edu/IWCS/2010\\_January.html](http://wwa.colorado.edu/IWCS/2010_January.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Alvord, C.**, 2010. The New NOAA Climate Web Portal ([www.climate.gov](http://www.climate.gov)). *Intermountain West Climate Summary* 6(2).

[http://wwa.colorado.edu/IWCS/2010\\_March.html](http://wwa.colorado.edu/IWCS/2010_March.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Alvord, C.** and W. Ryan, 2010. Weekly Climate, Water and Drought Assessment for the Upper Colorado Basin: A new webinar series from the Colorado Climate Center and NIDIS. *Intermountain West Climate Summary* 6(4).

[http://wwa.colorado.edu/IWCS/2010\\_May.html](http://wwa.colorado.edu/IWCS/2010_May.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Averyt, K.**, in press, 2010. The Coal Conundrum. In: *The Water-Energy Nexus in the Western US*, Kenney and Wilkinson (Eds.), Edward Elgar Publishing, Inc.

**Averyt, K.**, 2010. Colorado Climate Trends Website: A New Tool from the Colorado Climate Center. *Intermountain West Climate Summary* 6(1).

[http://wwa.colorado.edu/IWCS/2010\\_January.html](http://wwa.colorado.edu/IWCS/2010_January.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Averyt, K.** and K. Werner, 2010. The NOAA NWS Water Resources Outlook Tool. *Intermountain West Climate Summary* 6(5).

[http://wwa.colorado.edu/IWCS/2010\\_July.html](http://wwa.colorado.edu/IWCS/2010_July.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Barsugli, J.**, and **J. Lukas**, 2010. What is the risk to Colorado River storage and deliveries under climate change scenarios? A review of several recent studies. *Intermountain West Climate Summary* 6(2).

[http://wwa.colorado.edu/IWCS/2010\\_March.html](http://wwa.colorado.edu/IWCS/2010_March.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

Bracken, C., **B. Rajagopalan**, and J. Prairie, 2010. A Multi-Site Seasonal Ensemble Streamflow Forecasting Technique. *Water Resources Research* 46: W03532.

<http://www.agu.org/journals/ABS/2010/2009WR007965.shtml>

*Information communicated to Bureau of Reclamation, whose researchers were partners in this work.*





Brickey, C., K.H. Engel, K. Jacobs, J. Matter, D.F. Luecke, M.L. Miller, J.T. Overpeck, and **B. Udall**, 2010. How to Take Climate Change into Account: A Guidance Document for Judges Adjudicating Water Disputes. *Environmental Law Reporter* 40: 11215.

[http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1722857](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1722857)

**Guentchev, G., J. J. Barsugli**, and J. Eischeid, 2010. Homogeneity of Gridded Precipitation Datasets for the Colorado River Basin. *Journal of Applied Meteorology and Climatology* 49: 2404–2415.

<http://journals.ametsoc.org/doi/abs/10.1175/2010JAMC2484.1>

*Information communicated directly to Bureau of Reclamation.*

**Kenney, D.**, and Robert Wilkinson (Ed.), in press, 2011. *The Water-Energy Nexus in the Western United States*. Edward Elgar Publishing Inc.

**Lukas, J.**, and **E. Gordon**, 2010. Impacts of the mountain pine beetle infestation on the hydrologic cycle and water quality: A symposium report and summary of the latest science. *Intermountain West Climate Summary* 6(4).

[http://www.colorado.edu/IWCS/2010\\_May.html](http://www.colorado.edu/IWCS/2010_May.html)

*Information communicated to numerous land and water managers through dissemination of Intermountain West Climate Summary and symposium held in April 2010.*

**Nowak, K.**, J. Prairie, B. Rajagopalan, and U. Lall, 2010. A nonparametric stochastic approach for multisite disaggregation of annual to daily streamflow. *Water Resources Research* 46: W08529.

<http://www.agu.org/pubs/crossref/2010/2009WR008530.shtml>

*Information communicated to Bureau of Reclamation, whose researchers were partners in this work.*

**Painter, T.H., J.S. Deems**, J. Belnap, A.F. Hamlet, C.C. Landry, **B. Udall**, 2010. Response of Colorado River Runoff to Dust Radiative Forcing in Snow. *Proceedings of the National Academy of Sciences* 107 (40): 17125-17130.

<http://www.pnas.org/content/107/40/17125.short>

*Information disseminated to Department of Interior Assistant Secretary for Water and Science; NASA Headquarters; US Global Change Research Program; variety of stakeholders at Heinz Foundation Colorado Plateau Workshop.*

Verdin, J., L. Darby, and R. Pulwarty, 2010. The National Integrated Drought Information System (NIDIS) in the Upper Colorado River Basin: A Progress Report. *Intermountain West Climate Summary* 6(5).

[http://www.colorado.edu/IWCS/2010\\_July.html](http://www.colorado.edu/IWCS/2010_July.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*

**Wolter, K.** and **J. Lukas**, 2010. ENSO and Intermountain West Water Supply: A Review of WY 2010 and Outlook for WY 2011. *Intermountain West Climate Summary* 6(6).

[http://www.colorado.edu/IWCS/2010\\_October.html](http://www.colorado.edu/IWCS/2010_October.html)

*Information communicated to various stakeholders throughout the region via distribution of Intermountain West Climate Summary.*



## Links with Other NOAA Programs

- WWA is physically housed in the **Physical Sciences Division** (PSD) of the NOAA Earth Systems Research Laboratory at the David Skaggs Research Center in Boulder, CO. This co-location provides frequent opportunities to interact with PSD researchers. PSD Director William Neff is a member of the WWA Advisory Board.
- WWA team members work extensively with staff at the **NOAA Colorado Basin River Forecast Center** (CBRFC) in Salt Lake City (see “Towards Frameworks for Climate Services” above) and WWA Utah Liaison Bardsley is located in the CBRFC office, and CBRFC Hydrologist-in-Charge Michelle Schmidt is a member of the WWA Advisory Board.
- WWA collaborates with the **National Integrated Drought Information System** (NIDIS) on multiple efforts, including the “Tribal Climate Adaptation Workshop” described above. Jim Verdin from NIDIS is a member of the WWA Advisory Board.
- WWA staff members Udall and Bardsley are members of the Western Region Climate Science and Services Committee assembled by **NOAA Western Region Climate Services Director** DeWayne Cecil.
- WWA staff coordinate activities with **NOAA Central Region Climate Services Director** Doug Kluck and are participating in the development of the Missouri River Basin Climate Consortium.

## Current Cross-RISA Activities

- WWA researchers Averyt and Bardsley are working with **CLIMAS** to organize workshops aimed at improving CBRFC decision support tools for users.
- WWA researcher Lisa Dilling is coordinating with M. Carmen-Lemos at **GLISA** and K. Dow at **CISA** to develop a comparative framework for analyzing stakeholder and science provider databases.
- The database developed by WWA for the Colorado Climate Preparedness Project has been shared with K. Ingram and others at **SECC**.
- **CLIMAS**, **CNAP**, and WWA are co-convening a workshop on adaptive capacity in the Colorado River Basin, which will be hosted by WWA at the University of Colorado Boulder.



## **APPENDIX A: List of 2010 WWA Presentations**

### **January 21, 2010**

K. Averyt, G. Owen, K. Werner

“Climate Service Frameworks for Different Users with Distinct Informational Needs.”

American Meteorological Society Annual Meeting, Atlanta, GA.

### **January 21, 2010**

G. Owen, K. Averyt, K. Werner, and D. Ferguson

“Developing useful science: methods for engaging stakeholders and evaluating integrated climate tools.”

American Meteorological Society Annual Meeting, Atlanta, GA.

### **January 26, 2010**

J. Lukas

“New perspectives on hydroclimatic variability in the Upper Colorado River Basin.”

Upper Colorado Basin Endangered Fish Recovery Program Annual Researchers’ Meeting, Grand Junction, CO.

### **February 2, 2010**

E. Gordon and L. Dilling

“An Empirical Approach to Defining Success in Climate Adaptation.”

Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS) Meeting, Champaign, IL.

### **February 23, 2010**

K. Averyt

“Potential Impacts of Climate Change on Water & Energy Resources in the Western US.”

Electric Power Research Institute Workshop, Albuquerque, NM.

### **February 25, 2010**

J. Deems

“Dust on Snow: early snowmelt in the Colorado River.”

Aspen Center for Environmental Studies Naturalist Nights, Aspen, CO.

### **March 4, 2010**

K. Averyt

“The Energy-Water Nexus and Climate Change.”

Carpe Diem Meeting: Energy & Water in the West, San Francisco, CA.

### **April 23, 2010**

J. Lukas

“Tree-ring paleohydrology and planning for future conditions.”

American Water Resources Association – Colorado Chapter Annual Symposium, Golden, CO.



**April 29, 2010**

K. Cozzetto

“Drought Vulnerability on BLM Lands in the Southwestern U.S.”  
Dept. of Interior Conference, Portland, OR.

**May 12, 2010**

K. Cozzetto

“Downscaled Precipitation Projections for the Four Corners Region”  
San Juan Public Lands Center Workshop: Adapting to Climate Change in the San Juan National Forest, Durango, CO.

**May 18, 2010**

J. Lukas

“Tree-ring reconstructions of streamflow and climate.”  
Grand Mesa, Uncompahgre, and Gunnison National Forests Climate Training Pilot Study Workshop, Delta, CO.

**September 13, 2010**

J. Lukas

“Lessons from the *TreeFlow* project, 2000-2010: Working to bring paleohydrology into the mainstream of water resource management.”  
Utah State University Dendrochronology Workshop, Logan, UT.

**October 5, 2010**

G. Guentchev

“Statistical significance of the model-observed differences in precipitation variability for the historical 1951-1999 period.”  
Colorado River Hydrology Group meeting at CADSWES, Boulder, CO.

**October 7, 2010**

J. Barsugli and L. Mearns

“What do climate models really tell us and how do we use them?”  
MSI Conference on Managing for Resiliency in the San Juan Mountains—Adaptation and Planning for Climate Change, Silverton, CO.

**October 7, 2010**

K. Cozzetto

“Downscaled Precipitation Projections for the San Juan Mountains Region.”  
MSI Conference on Managing for Resiliency in the San Juan Mountains—Adaptation and Planning for Climate Change, Silverton, CO.

**October 7, 2010**

J. Deems

“Dust impacts on snowmelt timing and water yield in the Upper Colorado River Basin.”  
MSI Conference on Managing for Resiliency in the San Juan Mountains—Adaptation and Planning for Climate Change, Silverton, CO.



**October 7, 2010**

I. Rangwala

“Current and expected temperature trends in the San Juan Mountains.”

MSI Conference on Managing for Resiliency in the San Juan Mountains—Adaptation and Planning for Climate Change, Silverton, CO.

**October 14, 2010**

E. Gordon

“The Western Water Assessment: Ongoing Research and Opportunities for Collaboration.”

Western Association of Agricultural Experiment Station Directors W2190 Group Meeting, Fort Collins, CO.

**October 29, 2010**

J. Deems

“Dust impacts on snowmelt timing and water yield in the Upper Colorado River Basin.”

Cryospheric and Polar Processes Seminar, NSIDC, Boulder, CO.

**November 3, 2010**

K. Averyt

“Complicating the Complicated: Adding Climate Change to the Energy & Water Mix.”

Cross Currents: Water and Energy Challenges in the 21st Century, Boston, MA, USA.

**November 5, 2010**

J. Lukas and B. Rajagopalan

“Paleohydrology of the Lower Colorado River Basin – Project Overview and Status.”

Colorado Water Institute Advisory Board Meeting, Denver, CO.

**November 8, 2010**

T. Painter, J. Deems, J. Belnap, and B. Udall

“Response of Colorado River runoff to dust radiative forcing in snow.”

NASA Headquarters Brown Bag Seminar Series, Washington, DC.

**November 9, 2010**

T. Painter, J. Deems, J. Belnap, and B. Udall

“Response of Colorado River runoff to dust radiative forcing in snow.”

Briefing at US Global Change Research Program, Washington, DC.

**November 9, 2010**

T. Painter, J. Deems, J. Belnap, and B. Udall

“Response of Colorado River runoff to dust radiative forcing in snow.”

Briefing at NOAA Headquarters, Silver Spring, MD.

**November 10, 2010**

T. Painter, J. Deems, J. Belnap, and B. Udall

“Response of Colorado River runoff to dust radiative forcing in snow.”

Briefing of Assistant Secretary for Water and Science, US Department of Interior, Washington, DC.





**November 29, 2010**

J. Deems

“Dust impacts on snowmelt timing and water yield in the Upper Colorado River Basin.”  
Heinz Foundation Colorado Plateau Workshop, Durango, CO.

**December 13, 2010**

T. Painter, J. Deems, J. Belnap, A. Hamlet, C. Landry, B. Udall

“Response of Colorado River runoff to dust radiative forcing in snow.”  
American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 13, 2010**

K. Nowak, B. Rajagopalan, M. Hoerling and E. Zagona

“Multi-decadal variability of Colorado River basin streamflow.”  
American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 13, 2010**

S. Skiles, T. Painter, A. Barrett, C. Landry, J. Deems, A. Winstral

“Interannual Variability in Radiative Forcing and Snowmelt Rates by Desert Dust in Snowcover in the Colorado River Basin.”  
American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 14, 2010**

K. Averyt, J. Macknick

“Water Requirements for Energy Production Technologies: A Collaborative Effort to Support Integrated Resource Planning.”  
American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 14, 2010**

E. Gordon and E. Pugh

“A Conceptual Model of Water Quantity Impacts from Insect-Induced Tree Mortality in Coniferous Forests: Implications for Colorado River Basin Water Management.”  
Poster presented at the American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 16, 2010**

E. Gordon and R. Klein

“The Colorado Climate Preparedness Project: A Systematic Approach to Assessing Efforts Supporting State-Level Adaptation.”  
Poster presented at the American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.

**December 17, 2010**

J. Barsugli

“What's a billion cubic meters among friends: The impacts of quantile mapping bias correction on climate projections.”  
American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.



**December 17, 2010**

B. Rajagopalan, K. Nowak, J. Prairie and E. Zagona

“Managing Colorado River Water Resources In a Nonstationary Climate.”

American Geophysical Union, 2010 Fall Meeting, San Francisco, CA.



## APPENDIX B: WWA Appearances in Media

### January 23, 2010

Colorado: Climate change raises concerns for state's recreation industries, *Grand Junction Sentinel*  
<http://www.ecoearth.info/shared/reader/welcome.aspx?linkid=149518&keybold=global%20AND%20warming%20AND%20skiing>

Joe Barsugli

### January 23, 2010

Panel gathers in Glenwood to discuss climate change, *Glenwood Springs Post Independent*  
<http://www.postindependent.com/article/20100123/VALLEYNEWS/100129954>

Joe Barsugli

### January 24, 2010

Experts weigh threat to Colorado economy from Climate Change, *Summit Daily News*  
<http://www.summitdaily.com/article/20100124/NEWS/100129903>

Joe Barsugli

### March 14, 2010

Research: water imports no shield against drought, *Pueblo Chieftain*  
[http://www.chieftain.com/news/local/article\\_f3042ff5-91a9-591f-ab0c-a20b31d00740.html](http://www.chieftain.com/news/local/article_f3042ff5-91a9-591f-ab0c-a20b31d00740.html)

Jeff Lukas and Joe Barsugli

### April 2010

Dry Times, *5280 Magazine*  
<http://www.5280.com/magazine/2010/04/dry-times>

Brad Udall

### April 14, 2010

How did it get here, *Snowmass Sun*  
<http://www.snowmasssun.com/article/20100414/NEWS/100419986>

Jeff Deems

### April 20, 2010

Dust, snow make for problematic mix for skiers, *Denver Post*  
[http://www.denverpost.com/sports/ci\\_14917371](http://www.denverpost.com/sports/ci_14917371)

Jeff Deems

### July 22, 2010

Running dry on the Colorado [Excerpt], *Grist Magazine*  
<http://www.grist.org/article/2010-07-21-running-dry-on-the-colorado-excerpt>

Brad Udall



**July 19, 2010**

Dust Takes a Toll, *High Country News*

<http://www.hcn.org/issues/42.12/dust-takes-a-toll>

Imtiaz Rangwala and Jason Neff

**June 25, 2010**

Researchers call for 'no-regrets' approach to climate warming, *UA News*

<http://uanews.org/node/32480>

Brad Udall

**September 15, 2010**

Expedition Voices: Brad Udall Likens Lake Mead to a Glass Half Empty, *Blue Legacy*

<http://www.alexandracousteau.org/current-expedition-blue-planet-2010/colorado-river/expedition-voices-brad-udall-likens-lake-mead-gla>

Brad Udall

**October 2010**

The Colorado River Runs Dry, *Smithsonian Magazine*

<http://www.smithsonianmag.com/science-nature/The-Colorado-River-Runs-Dry.html>

Brad Udall

**October 14, 2010**

A Climate-change Crossroads, *The Silverton Standard*

<http://www.silvertonstandard.com/news.php?id=237>

Imtiaz Rangwala

**October 14, 2010**

The Death of Rivers, *The Why Files*

<http://whyfiles.org/2010/state-of-the-rivers-ruinous/>

Brad Udall

**October 18, 2010**

Morning Newscast, *Aspen Public Radio*

[http://www.aspenpublicradio.org/news\\_archive\\_detail.php?story=802](http://www.aspenpublicradio.org/news_archive_detail.php?story=802)

Brad Udall and Jeff Deems



## APPENDIX C: Summary of Western Water Assessment Advisory Board Meeting

April 27–28, 2010

*Major Points and Concerns for WWA to Address Listed in Blue*

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### **Purpose of WWA and the RISA Program**

- Objective of the RISA program is decision support
- RISAs develop networks of users to help us understand what people's needs are
- RISAs work not only on integrating scientific disciplines, but also on integrating the needs of different users to develop usable science
- RISAs could provide a coordination role for climate services, but that can't be their only role
- WWA helps its users "get the science"
- RISAs cannot be all things to all people, cannot spread themselves too thin
  - *Where does WWA draw the line so we don't spread ourselves too thin?*

### **National and NOAA Climate Service**

What thoughts do the Advisory Board members have on all of the climate service activities and how RISAs fit in?

- RISAs can play a coordination role
- There should be a clearing center mechanism so that it's not just an accident to find information
- RISAs have been linking science and research decision-making, only now are agencies beginning to fill in applied science in the middle
  - *Where does WWA fit on the continuum between LCCs and CSCs that are being stood up in the region?*
  - *How do we integrate among these activities?*
  - *What about a Super-RISA and what would that look like?*

### **Internal Grant Process**

- *To what extent does the advisory board want to be involved in this process?*
- *To what extent do we want to bring others into this process?*

### **Colorado River Theme**

#### *Scientific Issues Raised*

- Differences about assumptions in CARWAS and CADSWES work with respect to agricultural demand stresses
- Resequencing of paleo and loss of variability signal
- CO River researchers' work can be integrated into other issues that might not be climate-related, such as urban growth, ecosystem issues, etc.
- Concerns of an unnecessary focus on the Colorado River. What happens in the Platte impacts what's going to happen in the CO. What happens in Northern California impacts what will happen. This is an institutional issue—river systems are interconnected. Single-minded focus on CO River is going to be a problem down the road.





- *To what extent does WWA need to address other basins? (This was a concern in the re-bid feedback as well)*

#### *Gaps & Needs Identified*

- Encourage WWA to further integrate into other issues that might not be climate-related, such as urban growth, ecosystem issues, etc.
- WWA needs to help figure out what are we doing now that is keeping us from what we need to do in the future?

#### *WWA Involvement in Policy*

- The work that Doug Kenney is doing (Governance Study) has to be done, but it could be a dangerous place for WWA to go
- WWA should be looking at support for decision-making, stay immune from politics
- The best role for WWA is to push conversations into risk-based analysis
- A good role for RISAs when policies are contested is to provide an array of consequences for decisions
- Distinction between making policy and influencing policy with information you have available and can translate for decision-maker use or between policy hypotheticals and policy influencing. WWA should focus on the former.
- A good planner informs the decision-maker but is indifferent to the decision
  - *How far down this progression (Governance Study) is the appropriate mandate for WWA?*
    - A good role for RISAs where policies are contested is providing an array of consequences for decisions

#### **Ecosystem Theme**

##### *Needs & Gaps Identified*

- Missing a hydrologic foundation within the research in this theme and general applications for impact on streamflow monitoring
  - *To what extent does WWA research need to focus on water connections?*
- Denver Water is more worried about catastrophic fire will be the larger problems (compared with MPB)
- Concerned about public safety hazard of falling trees
- Paleo-hydrology/climate, etc can be a lens for how to analyze historical impacts from MPB

##### *WWA Issues*

- *The work in this theme presents an excellent opportunity for WWA to link into DOI initiatives (LCCs and CSCs) as a mode for expanding WWA mission; so how do we make this happen?*

#### **Emerging Initiatives**

##### *Science Issues*

- Note that coal doesn't suffer as much efficiency loss from switching to air cooling than CSP does, can use a hybrid water-air cooling

##### *Needs & Gaps Identified*



- WWA activities include an impressive number of things, but what seems to be missing is study of specific measures to adapt. This effort to come up with specific adaptation measures (CO Climate Preparedness Project) is an important one
- Aggregate information into a baseline and revisit in a few years and at end of 5-year cycle to see evolution of thinking in region

#### WWA Issues

- *Where does the tribal climate services work go from here?*

#### Services vs. Prototyping

- IWCS has turned into a service, would like to find someone else to take it over. But it absorbs significant resources
- Develop relationships, two schools of thought between WWA as prototyping and delivering services to stakeholders. What happens next? What if we develop products and interaction and funding runs out?
- There has to be a receptive body for taking products from WWA, and that's been a problem
  - *What do we do with the SW Casts?*
  - *What do we do with the IWCS?*
  - *What is our long-term strategy and how do we push back to NOAA on transfer to services?*

#### Communication & Marketing/WWA Core Activities

- We (advisory board) know what you (WWA) are working on—can there be a place we can go to see what's going on?
- Do you have a communications plan where you ID stakeholders?
- Curious whether you guys have thought about who you're trying to reach, how to design useful website that everyone can use? If issue is communicating information that you're amassing, worth thinking about in a more systematic way. Think about it as an activity, otherwise no one is going to know about it.
  - *Does WWA need to develop a marketing strategy or communication plan?*
- NOAA is supposed to help the RISAs integrate their activities into the NOAA Climate Service in Climate Portal
- RISAs have a more targeted audience vs. the rest of NOAA Climate Service
- Experimenting with a content management system that allows individual PIs to update with caveat that you don't get money if you don't update twice a year
- RISAs have done a great job of getting out to stakeholders. Can have website or focused conversations, which I think WWA does, may be more important than trying to update website
- Supporting decision-makers is the frame for all the research you do and how you organize the website
- RISAs should have good websites to disseminate information
  - *What is the priority of the website redo?*
  - *How do we update website content?*
- You've got great support among your board and in the room, but who else out there should be using your services? Yes, I recognize you have a limited budget, but building a bigger client base is a way to get more resources for your work. Generally, RISAs are woefully under-known in the West; RISAs could do a better job working together to describe their services beyond current users



- Entire discussion has been phrased in terms of decision-makers. That's frame for all of the outreach you do, how you organize the website
  - *How can we use webinars to communicate with stakeholders and the advisory board? What will be the plan for this?*

### **Decisionmaking& Use of Information**

- When NOAA is reporting on major achievements for RISAs, they are looking at outcomes rather than outputs. CO Climate Report was an excellent output, but what decisions did that inform and can you show us what outcomes were informed?
- There's an ongoing challenge to measure how this information is being used
  - *What does WWA continue to do with all our products?*
- New avenue for WWA to think about. A lot of talk about decision support. But how do decision-makers make decisions in the face of all of this uncertainty?
- Agree with looking at the science of planning
- Bring science even with its ugly uncertainties into the decision-making process. WWA may not be the place to do that, but something should
  - *Who in WWA is doing this and how do we build this?*

### **Advisory Board Mechanics**

- The question of WWA mission focus is unresolved right now. Do you want that advice from the board or does the board expect WWA to provide that?
  - *What is the purpose of the advisory board?*
  - *Do we want policy wonks or do we want people who can get money on the Advisory Board?*
- I really enjoyed it, liked seeing it in one place. Considered adding reps from other agencies like USGS, BLM, USFS, etc.?
  - *What types of sectors are not represented?*
  - *On what issues should WWA engage the advisory board in terms of support for funding?*
- ½ day meeting is too short, liked the presentations
- Can bring in others who would be interested in the research you had to show.
- Could convey some of this via webinar
- Bring others in, would help in terms of leveraging PIs you're funding with seed grants
- Maybe do this for all the stakeholders, not just those on the advisory board?
- You need influential champions to say what you're doing is important. The board should be willing to take political action with respect to \$
- Don't try to cover everything, highlight few specifics they want to get across. Don't need to cover everything, esp. for twice a year meetings
- Could have a meeting like this once a year and another ½ year meeting
- Hold in Utah or Wyoming with their invited guests or intro to those folks
  - *When is the next meeting, how long is it?*
  - *How will we continue to engage the Advisory Board throughout the year?*
  - *To what extent does our engagement of the Advisory Board also transfer to all stakeholders?*

### **Utah & Wyoming**

- It has always been a three-state RISA. For better or worse, that's the way it is, you should consider improving representation in those other two states
- NIDIS shares this need with you, need to do a better job of engaging stakeholders in UT and WY



- *Can we leverage NIDIS funds?*
- *Regional expansion vs. sectoral expansion: What are the trade offs and priorities?*
- *To what extent do we engage the state climatologists?*
- In Wyoming, the need is a way to get the science and products you're generating here to people in WY. As far as money is concerned, I don't need you to hand me the money but we can work together to find the money. Rather than having it be a burden, let's leverage it so it's not hurting the program you've already established.
- What CLIMAS decided to do was split our core office resources and shift some of it to NM to fund the state climatologist and give them enough resources for a ½ time graduate assistant. The model hasn't worked particularly well.
- Before finding \$, need a strategy for moving forward. Idea of going to both states, having meetings, ask stakeholders what they think of what WWA can provide. How can we help you? Here are our constraints, let them shape what we do. Starting point to identify those relationships.
- Big shindig getting everyone together, putting together bits and pieces. WWA talk to State Water Forum. Talk to WY Water Ass'n Annual Meeting. Get people involved in newsletters that come out from Ngo, trade groups. You have to overcome that no one knows who you are. Build up the trust.
  - *What is our strategy for engagement in Wyoming? What sectors and what people? What is the mechanism for engagement?*
  - *What is our strategy for engagement in Utah? What sectors and what people? What is the mechanism for engagement?*
  - *What is our plan if we don't get the additional funding for Utah and Wyoming?*
  - *How do we avoid setting up expectations we may not be able to meet?*
- Who's willing to validate what you're doing and say it's important? Needs to go beyond academia or political world, has to reach to someone else.
  - *What are initial stakeholders in Utah and Wyoming?*

### **Funding**

- If you were not to win a DOI RFP for a climate service center, what are the other funding sources? It would seem to me that there should be a lot of opportunities for matching funds, NSF money, EPA climate money, that the research projects shouldn't be things that you guys are funding totally. And if you had someone whose job it was to get grants, that might actually increase the pot.
- Money for climate change right now in federal gov't. Need to ID where it is and who you can partner with.
  - *Do we need a fundraiser? What is our outside funding strategy?*
  - *How can we better work with Congress to gain NOAA support?*
  - *How do we use our limited funds to prioritize geographic expansion, research agenda, and core activities?*