



Multiple Stressors on Central Arizona Water Resources



A Report of the Water Stressors Workshop*



I. Background: Decision Making Under Uncertainty in a Desert City

The earth's changing climate may profoundly affect a wide range of societal activities and environmental functions. At the same time, climate change is one of a large number of influences on such activities and functions. For example, while climate change may influence the behavior and frequency of extreme weather events, the impacts of such events depend mostly on socioeconomic vulnerability, which in turn reflects a range of variables such as demographics, development patterns, economic growth and wealth distribution, and local environmental conditions. While a warming climate may lead to migration of tropical disease vectors, vulnerability to disease also depends on social and environmental factors other than climate. While climate change may influence ecosystem function, human activities such as urban development, resource extraction, and agriculture also strongly affect ecosystems.

Given the multi-causal nature of most predicted climate impacts and the large uncertainties typically associated with efforts to quantify the relations between a particular cause (e.g., global temperature rise) and an impact (e.g., coastal inundation), one obvious approach to guiding policy decisions is to look for areas of *relative* strength in relations between causes and impacts, and to focus research in support of decision making in such areas. In other words, unless climate impacts on a particular aspect of society are understood relative to other factors acting on that same aspect, neither effective research priorities nor effective policy priorities can be established.

As part of its ongoing effort to understand how climate change relates to other influences on society and the environment, the Science Policy Research and Assessment on Climate (SPARC; sciencepolicy.colorado.edu/sparc/) — in collaboration with the Decision Center for a Desert City (DCDC; dcdc.asu.edu) and the Consortium for Science, Policy, and Outcomes (CSPO; www.cspo.org) — convened a workshop of interdisciplinary experts to discuss the relative importance of various stressors on the water supply for the Phoenix, Arizona metropolitan area. This report summarizes the principal results of that workshop, held on November 2-3, 2006 at Arizona State University (see Agenda in Appendix 1).

Major urban centers have arisen in deserts since the dawn of human history. Successful management of water supply and demand has been a necessary attribute of all such cities. In the southwestern United States, water resource management has become increasingly complex as pressures on existing supply continue to mount. Projected population growth, rising water demand for economic development, the need to preserve and enhance aquatic ecosystems, and a variable and changing climate are

* This report represents the workshop organizer's interpretation of the major issues raised during the workshop. It is not meant to reflect or suggest a consensus among workshop participants on either the framing or the relative importance of any of these issues.

part of the complex dynamics that affect the regional hydrologic system. Nowhere is the complexity of water management more crucial than in the desert landscapes of central Arizona where limited water supply restricts the structural solutions to its management. The capacity of the region to successfully meet its interrelated challenges while managing its water resources in a sustainable manner will benefit from an understanding of the relations among the various factors that help determine supply of and demand for water.

II. The Water Stressors Workshop

The Water Stressors Workshop brought together expertise relating to water supply, demand, and quality, from diverse fields such as hydrology, climatology, ecology, anthropology, chemistry, public policy, economics, and law (see Participant Bios in Appendix 2). The goal of the workshop was to move toward an integrated understanding of the multiple factors affecting water supply and demand. Prior to the workshop, participants were given a white paper that laid out a method and preliminary ranking of stressors on the Phoenix area water supply, with a particular focus on assessing the potential for demand management to help meet growing water needs in the context of changing climate (“Decision Making under Uncertainty: Ranking the Multiple Stressors on Central Arizona Water Resources;” www.cspo.org/working/WhitePaper_Final.pdf). Workshop deliberations responded to and built upon the white paper. The workshop provided an opportunity for experts from a number of disciplines to comment on the draft white paper and refine its preliminary ranking of stressors on the water resources of Central Arizona. The workshop (www.cspo.org/working/AZ_Water_resources.htm) was held on November 2-3, 2006, at the Decision Center for a Desert City (DCDC) at Arizona State University. It was sponsored by SPARC and DCDC (both funded by the National Science Foundation), the Consortium for Science, Policy and Outcomes, and the V. Kann Rasmussen Foundation.

II. Emergent Themes

While participants in the workshop did not substantially dispute the initial ranking of stressors, they also offered diverse additional perspectives for understanding the dynamics of the system. This section describes themes that emerged during the discussion as critical to the water system that were not adequately addressed in the initial ranking.

A. Water Quality

Participants identified water quality as an important aspect of water supply systems and one which should be explored further in the context of stressors on Central Arizona water resources. Deteriorating quality from synthetic chemical, mineral, and biological contamination can potentially reduce availability of water for some uses. The salt content of surface and groundwater sources is becoming a major contamination challenge in the Phoenix area. Salinity derives from a number of sources, among which is the concentration of naturally occurring salts in areas with high evaporation rates. Repeated agricultural use further increases the concentration of salts as water

evaporates from fields, leaving all of the salts in the remaining water and soil. Additional anthropogenic sources include agricultural runoff, fertilizers, and water softeners. While technology exists to address growing salinity contamination, associated costs and energy consumption are currently prohibitive.

In addition to increasing salinity, biological contamination can reduce the availability of usable water. Microbes (e.g, *E. coli* and *Cryptosporidium*) originating from animal and human wastes are known to be present in both surface and ground water. Development of more integrated approaches that couple water quantity and quality will provide critical knowledge for improving resilience towards adapting future water needs.

B. *Agriculture and Resilience*

Agriculture has long been seen by planners as a source of resiliency in the Arizona water system, with water from agriculture available for future municipal needs as the population grows and agricultural lands are converted to housing or otherwise retired. In Arizona's dry and highly variable climate characterized by periodic droughts, maintaining regional agriculture may be critical to resilience of the entire water system. During droughts, agricultural water can be diverted to more pressing needs. Agriculture currently serves as an emergency water bank, buffering the supply against annual fluctuations in water availability. If agriculture were to be largely replaced with domestic and industrial uses of water, those sectors would suffer shortages during periods of drought. The location of agriculture is critical to the effectiveness of the agricultural buffer because transporting water from distant agricultural lands will require expanding current infrastructure. Thus, it becomes important to have a serious debate about balancing the usage of water for long-term agricultural use and urban growth while assessing the vulnerability of water resources. Other sources of resiliency must also be explored and developed.

C. *Lack of Urgency*

Overall workshop participants felt that water supplies in the Phoenix Active Management Area (AMA) will likely be sufficient to meet demand for the next 25 years, which was the period assessed in the white paper. Yet most participants also believed that serious problems are likely to emerge in the longer term, especially if measures to ensure sustainable water management practices were not implemented to meet growing demand in the coming decades. Numerous potential causes of longer term problems were raised, including climate change and associated changes in the regional hydrologic cycle, climate variability, declining water quality, depletion of groundwater supplies, changes in policy environment, increases in upstream demand, and loss of water system resilience due to retiring of agricultural lands. There was no consensus on the relative likelihood or magnitude of these various long-term problems. Nevertheless, many participants evinced a sense of frustration that these threats did not impart the urgency necessary to develop policies in the near-to-medium term that could help ensure long-term sustainability.

The question of how to impart greater urgency to policy makers proved vexing. One idea that seemed appealing to many participants was to ensure that water experts

were ready with feasible policy recommendations that could be presented to relevant decision makers when events such as droughts, water quality problems, or legal conflicts created a greater sense of urgency, and thus an openness to policy innovation. The role of technological innovation in addressing long-term problems was not discussed.

D. Climate Change as a Motivating Factor of Urgency

A group of participants proposed using climate change as a method of motivating water managers to have a greater sense of urgency regarding the future of water resources in Central Arizona. Projected impacts of climate change on the Central Arizona water supply, and the uncertainty surrounding them, can be used to focus discussions on growth, lifestyle, and associated water demand in the Phoenix area. While climate change may not be currently viewed as a strong physical stressor, the social consensus that is developing around it could be used as a social opportunity to instigate change among institutions that are resistant to change. A potential drawback of this approach may be a loss of credibility if warnings of climate change impacts do not come to fruition.

E. Uncertainty around Climate Change

Future changes to climate, particularly on a local scale, are fraught with uncertainty – related to the non-linear response of natural systems, the models used to make predictions of future climate, and the behavior of society. The low resolution of Global Circulation Models (GCMs) leads to large errors and high degrees of uncertainty when they are used to generate regional and local scale predictions. Many hydrologic processes occur on spatial scales smaller than GCMs are able to resolve. Some participants suggested that more regionally based models could provide better predictions by reducing uncertainty. In addition to the uncertainty associated with climate change, other sources of uncertainty can be found in how people and institutions will react to changes in water availability and how the Native American tribes in Arizona will manage their water allocations.

F. Price

The subject of price was raised multiple times during the discussion, both in terms of whether the current price structure for water in Central Arizona accurately reflects the actual costs of using that water and in terms of whether politically plausible increases in water prices would impact water user behavior. The price of water is not a meaningful signal regarding water availability because policy interventions (e.g., subsidies) impact how much consumers actually pay for water. The price signaling mechanism is broken, some participants believed; while water has never been a free market commodity, the feedback signal between water availability and price in some states is much stronger than in Arizona. There was discussion regarding whether price could be used as a policy lever, rather than as a signal. Price structures are a political issue and there are ideological disputes about opening up water to market forces. Raising water prices might lead to decreased usage, but also may preclude some users from acquiring sufficient water to meet their basic needs, evoking concerns about

equity. An additional concern was that water prices need to be considered in context; energy prices also impact water availability, which in turn affects the price of both agricultural and non-agricultural goods. Price was also seen as a limitation in addressing water quality issues. Technologies exist to reduce contamination by chemicals, salt, and microbes, but they are not viable at current water prices. The relationship between water price, water quality, and technological innovation is dynamic and will change in unpredictable ways.

G. Legal/Policy Framework

Workshop participants thought it important to put the results of the sensitivity analysis into the context of the existing legal and policy framework. Many of the decisions regarding water management and use are constrained by the laws and policies that govern them and thus, the legal and policy framework is important when looking at stressors on the water system. The “Law of the River,” consisting of 12 major and several minor federal and state laws, treaties, court decisions, and compacts, governs Colorado River water rights. Each state has different rights to access river water. Due to Arizona’s junior status, water supply could be severely curtailed if a water crisis is experienced on the Colorado River. The legal framework for allocating water is ossified in the political system and not driven by markets. Another developing legal issue is the need for legal structures to buy/lease water rights from agriculture. Participants emphasized that it is critical to establish systems by which water could be diverted from agriculture during dry years for municipal use without putting farmers out of business. Were farmers to go bankrupt and the water permanently reallocated to other uses, that buffer would not be available during subsequent droughts and the resilience of the whole system would be reduced.

H. Importance of Institutions

Participants suggested that an analysis of stressors with the intent of informing policy must address the role of institutions in water management. Central Arizona water policies are embedded in multiple layers of institutions, including private interests, multiple states, and federal agencies. For example, one of the stressors the white paper ranks is agricultural water use inefficiency, one component of which is the practice of planting water-inefficient crops with low profitability. Participants argued that merely identifying these practices as inefficient is not helpful without an analysis of why these seemingly unwise practices persist in competitive markets. An analysis that includes discussion of subsidy structures and the importance of agricultural markets, they suggested, would be more helpful in guiding management practices. Numerous institutions were deemed to be worth mentioning in the analysis, including developer groups, utilities, states, the Colorado River Law, and federal agencies. Each of these institutions has unique priorities, is interested in different time scales, advocates for different constituencies, and has legacies that inform current and future practices. Participants took particular interest in thresholds that will affect Arizona’s water supply from the Colorado River under current law if there are shortages. A reduction in Colorado River flow will not lead to a linear reduction in Arizona’s share; rather, a small decrease in flow could result in much more dramatic decreases in Arizona’s share of

river water. Participants felt that these and other institutional complexities should be addressed in the ranking.

IV. Implications for Holistic Analysis of Stressors on Central AZ Water

The Phoenix, Arizona water system is complex and coupled to larger scale atmospheric, surface, subsurface, and social processes. Workshop participants emphasized that a ranking of stressors on the system needs to include an analysis of this complexity where possible and an acknowledgement of it when it is too complex to analyze. A ranking that fully explored all these factors would be unwieldy in complexity and length and, therefore, of little value for policy makers.

Despite their concerns, however, participants agreed that climate change will be a relatively minor stressor on the system for the next two decades. Inefficient use and water quality are much more pressing considerations for water managers and merit additional research attention. Although concern about climate change may motivate people to have discussions about growth, development, and the water system, beyond that, there are significant other factors that can have more direct impacts on the water resources where discussion should occur for appropriate policy action. The discussion at the workshop suggests that challenges to the system will be multi-causal and will include interactions of many stressors. Climate change cannot be considered apart from this complex context and it is unclear how current knowledge about regional climate can add to the quality of decision making about the Phoenix area water supply, except that it highlights the extent of uncertainty about the future.

Acknowledgements and Disclaimer

This material is based upon work supported by the National Science Foundation under Grant No. SES-0345604 (SPARC) and Grant No SES-0345945 (DCDC). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. This report represents the workshop organizer's interpretation of the major issues raised during the workshop. It is not meant to reflect or suggest a consensus among workshop participants on either the framing or the relative importance of any of these issues.

Appendix 1



Water Stressors Workshop

ASU Decision Center for a Desert City
Brickyard Orchid House, Room 175
21 East Sixth Street, Suite 126B
Tempe, AZ



AGENDA

Thursday November 2, 2006

- 3:00pm disOrientation – *Chuck Redman, Arizona State University*
- 3:30pm Introductions – *Dan Sarewitz, Arizona State University*
- to the workshop
- to each other (1 minute each)
- 4:30pm Presentation of the CSPO Draft **Decision Making Under Uncertainty: Ranking of Multiple Stressors on Central Arizona Water Resources** – *Netra Chhetri, Arizona State University*
- 5:00pm Responses to the Draft Ranking
Bonnie Colby, University of Arizona
Abe Springer, Northern Arizona University
Morteza Abbaszadegan, Arizona State University
- 5:45pm Q&A with Panel
- 6:00pm Adjourn

Friday November 3, 2006

- 8:30am Charge to the Group – *Dan Sarewitz*
- 8:45am Breakout Session I
- rank potential stressors on water resources
- rank effectiveness and feasibility of potential policy interventions
- rank areas of knowledge strength and research needs
- 10:30am Break
- 10:45am Breakout Groups Report Back
- 11:30am Discussion

12noon	Lunch
1:30pm	Charge (part deux) – <i>Dan Sarewitz</i>
1:45pm	Breakout Session II – revise rankings
3:30pm	Break
3:45pm	Breakout Groups Report Back
4:30pm	Discussion
5:00pm	Wrap-up
5:30pm	Adjourn

Sponsors:

Science Policy Assessment and Research on Climate (SPARC)

<http://sciencepolicy.colorado.edu/sparc/>

SPARC conducts research and assessments, outreach, and education aimed at helping climate science policies better support climate-related decision making in the face of fundamental and often irreducible uncertainties.

Decision Center for a Desert City (DCDC)

<http://dcdc.asu.edu/>

DCDC's research establishes relationships between climatic conditions and water decision making.

Consortium for Science, Policy and Outcomes

www.cspo.org

The mission of the Consortium for Science, Policy and Outcomes is to ensure that science and technology move forward in harmony with broader public goals and aspirations.

National Science Foundation

www.nsf.gov

V. Kann Rasmussen Foundation

www.vkrf.org

Appendix 2

Water Stressors Workshop Participant Bios

Morteza Abbaszadegan

Arizona State University

Morteza.Abbaszadegan@asu.edu

Morteza Abbaszadegan joined the Civil and Environmental Engineering department at ASU in 1999 having spent more than six years as a Microbiology Research Manager in private industry. His research interest is in health-related water microbiology.

Brad Allenby

Arizona State University

Braden.Allenby@asu.edu

Brad Allenby is currently Lincoln Professor of Engineering and Ethics, and Professor of Civil and Environmental Engineering, and of Law, at Arizona State University, having moved from his previous position as the Environment, Health and Safety Vice President for AT&T in 2004.

Jessica Block

Arizona State University

jlblock@exchange.asu.edu

Jessica Block is a senior research scientist for ASU's Decision Theater (DT). She holds a Masters degree in geology from ASU where she was also an associate in the Integrative Graduate Education and Research Training (IGERT) in Urban Ecology. At the DT, she helps bridge the gap between science and policymaking for Decision Theater clients through immersive visualization of environmental information.

Bob Bolin

Arizona State University

bob.bolin@asu.edu

Bob Bolin's academic background is in sociology and geography with a focus on socio-environmental transformations. His research at ASU has focused on questions of social vulnerability and environmental justice.

Anthony Brazel

Arizona State University

abrazel@asu.edu

Anthony Brazel is a professor of geography at Arizona State. He has conducted regional and local-scale research on climate and energy/water budgets in the high mountains of Alaska, Colorado, and the Himalayas, in the Southwest desert and Mexico, and in the Phoenix metropolitan region.

Aliya Buttar

Arizona State University

Aliya.Buttar@asu.edu

Aliya is a research intern at the Consortium for Science, Policy, and Outcomes. She is a senior seeking her degree in Biology and Society and French and will be attending the University of Nevada School of Medicine next fall.

Netra Chhetri

Arizona State University

Netra.Chhetri@asu.edu

Netra is a Post Doctoral Research Associate at the Consortium for Science Policy, and Outcomes at ASU. His work focuses on understanding the sensitivity of ecosystems to multiple stressors such as population growth, land-use change, pollutant loading, persistence of water-intensive agricultural systems, and climate variability and change.

Uven Chong

Arizona State University

Uven.Chong@asu.edu

Uven is a research intern at the Consortium for Science, Policy, and Outcomes. Uven is a third year undergraduate student seeking a degree in Mechanical Engineering. In addition to CSPO, Uven works on air pollution flow research projects with ASU's Environmental Fluid Dynamics Research Lab.

Niklas Christensen

Herrera Environmental Consultants

nchristensen@herrerainc.com

Niklas Christensen is a surface water engineer working for Herrera Environmental Consultants in Seattle, Washington. He received a B.S. in Atmospheric Science and a Masters in Engineering from the University of Washington in 1996 and 2002, respectively. He has worked on climate change issues in the Colorado Basin, as well as on groundwater/arsenic interactions in Sweden and Bangladesh.

Bonnie Colby

University of Arizona

bcolby@ag.arizona.edu

Bonnie Colby is a professor of Natural Resources Economics and Public Policy. Some of her current projects involve nonmarket valuation of natural amenities, analyzing transactions costs generated by regulatory policies, evaluating the reallocation of water resources among economic sectors, economic tools to resolve environmental conflicts, and identifying strategies to promote efficient allocation of risk associated with variability in water supply and water quality.

Bethany Cutts

Arizona State University

Bethany.Cutts@asu.edu

Bethany Cutts is a Ph.D. candidate in the School of Life Sciences. She studies the influence of interactions between water education organizations on program development and public knowledge levels.

Judith M. Dworkin

Sacks Tierney P.A.

judith.dworkin@sackstierney.com

Judith Dworkin is the managing partner in the Scottsdale law firm of Sacks Tierney P.A. Her practice is devoted primarily to water resources and Indian law issues. Among Ms. Dworkin's current clients and legal projects is the implementation of the Arizona Water Settlements Act of 2004.

Joe Feller

Arizona State University

Joseph.Feller@asu.edu

Joe Feller works on environmental and natural resource issues, with an emphasis on public land management and water law. He has been a leading advocate for reform of livestock grazing on public lands in the western United States and has represented environmental interests in litigation before administrative boards, federal district courts and courts of appeal, and the United States Supreme Court.

Gregg Garfin

University of Arizona

gmgarfin@email.arizona.edu

Gregg Garfin is project manager for the Climate Assessment for the Southwest (CLIMAS) project, a NOAA-funded integrated assessment designed to identify and evaluate climate impacts on human and natural systems in the Southwest, and to identify climate services useful in assisting decision makers in coping with climate-related risks.

Patricia Gober

Arizona State University

gober@asu.edu

Pat Gober is a Professor of Geography at Arizona State University. She is co-Director of the National Science Foundation's Decision Center for a Desert City which studies water management decisions in the face of growing climatic uncertainty in Greater Phoenix.

Lori Hidinger

Arizona State University

Lori.Hidinger@asu.edu

Lori is the Program Manager for the Consortium for Science, Policy and Outcomes. In addition to managing the operations of CSPO, she participates in the development of new projects and on the research team for the Science Policy Assessment and Research on Climate Project.

Jim Holway

Arizona State University

jim.holway@asu.edu

Jim Holway is the Associate Director for Solutions of the Global Institute of Sustainability at Arizona State University. Prior to joining ASU in 2005, Jim served as Assistant Director of the Arizona Department of Water Resources.

Chip Howard

Turf Science, Inc.

turfsci@cox.net

Chip Howard received his Ph.D. in Turfgrass Science from Penn State and is a certified professional agronomist and professional crop scientist. He is the principal specialist at TurfScience, an Arizona-based technical firm serving clients nationwide for many years in matters relating to turfgrass industry.

Helen Ingram

University of California - Irvine

hingram@uci.edu

Helen Ingram is a professor of Planning, Policy, and Design and Political Science at the University of California, Irvine. Additionally, she is the Drew, Chace and Erin Warmington Chair in the Social Ecology of Peace and International Cooperation.

Katharine Jacobs

Arizona Water Institute

jacobsk@email.arizona.edu

Kathy Jacobs is the Executive Director of the Arizona Water Institute, a consortium of the three state universities (Arizona State University, the University of Arizona, and Northern Arizona University) focused on water-related research, education and technology transfer relating to water supply sustainability.

Chris Martin

Arizona State University

Chris.Martin@asu.edu

Chris Martin is a professor of environmental horticulture at Arizona State University. His research interests involve basic and applied research at the landscape and whole plant level with special emphasis given to the study of the interactions of plants and people in cities.

Mark Neff

Arizona State University

Mark.Neff@asu.edu

Mark is a Ph.D. student in the School of Life Sciences at ASU and works with the Consortium for Science, Policy & Outcomes. He studies ecology and climate research policy.

Dev Niyogi

Purdue University

dniyogi@purdue.edu

Dev Niyogi is an Assistant Professor of Applied Climatology in Departments of Agronomy and Earth and Atmospheric Sciences at Purdue University, and the Indiana State Climatologist. His research focus is on assessing and representing the effect of vegetation on regional-scale environmental processes, an important component of environmental forecasting and regional climate change assessment studies.

Megan O'Shea

Arizona State University

Megan.Unger@asu.edu

Megan is a research assistant at the Consortium for Science, Policy, and Outcomes. She is pursuing a Masters of Science degree in Geological Sciences through CSPO and the School of Earth and Space Exploration (SESE) at ASU.

Thomas Painter

University of Colorado

tpainter@nsidc.org

Tom Painter is a research scientist at the National Snow and Ice Data Center at the University of Colorado, Boulder. His research interests include snow radiative forcing and melt associated with dust and soot, alpine surface radiation, snowmelt hydrology, snow radiative properties,

integration of remote sensing and distributed snow models, remote sensing of snow cover properties, spatial distribution of desert surface properties, and robotic instrumentation.

Jennifer Pitt

Environmental Defense

jpitt@ed.org

Jennifer Pitt leads Environmental Defense's effort to protect and restore the Colorado River delta. Her recent publications include "Conservation Priorities in the Colorado River Delta, United States and Mexico" and "Conservation Before Shortage," a proposal for managing the Colorado River in times of drought.

Albert Rango

USDA Agricultural Research Service

alrango@nmsu.edu

Al Rango is a member of the Water Science and Education Center at New Mexico State University and is a research hydrologist for the USDA-ARS Jornada Experimental Range and the USDA-ARS Jornada Basin LTER. His primary research interests include remote sensing, snow hydrology, rangeland remediation, watershed management, and climate change effects.

Charles Redman

Arizona State University

charles.redman@asu.edu

Chuck Redman is the Director of ASU's new School of Sustainability and the Co-Director of the Decision Center for a Desert City. His interests include human impacts on the environment, sustainable landscapes, rapidly urbanizing regions, urban ecology, environmental education, and public outreach.

Daniel Sarewitz

Arizona State University

Daniel.Sarewitz@asu.edu

Dan Sarewitz is a Professor of Science and Society, and the Director of the Consortium for Science, Policy & Outcomes at Arizona State University. He is interested in the ways that science policy rhetoric and decision making are related to real-world outcomes.

V Kerry Smith

Arizona State University

Kerry.Smith@asu.edu

Kerry Smith is a Professor in the Department of Economics at Arizona State University. His research interests are in agricultural and resource economics.

Abe Springer

Northern Arizona University

Abe.Springer@nau.edu

Abe Springer is an Associate Professor of Geology at Northern Arizona University and he is the NAU Water Coordinator for the Arizona Water Institute. Dr. Springer and his students study local and regional groundwater flow systems and the ways in which they are impacted by humans.

Dave White

Arizona State University

Dave.White@asu.edu

Dave White is an Assistant Professor in the School of Community Resources and Development at Arizona State University. Dave's research focuses on the intersection of science, policy, and management for natural resources on public lands.

Marvin Waterstone

University of Arizona

marvinw@u.arizona.edu

Marvin Waterstone is a professor of Geography and Regional Development at the University of Arizona. His current interests focus primarily on the intersections of discourse and power, and the uses of social theory. In addition, he maintains an active research and teaching program in issues of environmental and resource management and the human dimensions of global change.