Appendix E

SPECIAL REPORT

JUNE 2015

Western Governors' Drought Forum

Chairman's Initiative of Nevada Gov. Brian Sandoval

WESTERN GOVERNORS' ASSOCIATION

westgov.org/drought-forum

GOV. BRIAN SANDOVAL
WGA Chairman

Dear Friends of the West,

During my year as chairman of the Western Governors' Association, I have led a regional discussion on a pervasive issue that impacts all of the western states: drought. Through the Western Governors' Drought Forum, we have created a framework for states, industry and communities to share best practices and policy options for drought response.

Most western states depend on just a few months of snowfall in the mountains to supply water for people, businesses and wildlife over the course of a full year. Consequently, it is crucial to share strategies on drought response before, during and after drought occurs.

Our Drought Forum discussions have shown that westerners are experts at innovating in response to water supply variability. They have also shown the importance of communicating across sectors and state lines to best respond to drought. Western states will continue to thrive, even with the threat of drought, so long as we work together and make the most of the water we have.

This report is not the culmination of the Drought Forum; rather, it is designed as a guide to more detailed information available online. It also identifies policy issues which WGA will further explore in the coming years.

I invite you to continue the dialogue sparked by the Drought Forum with your own communities and colleagues. Western Governors will use the Drought Forum online resource library to inform our efforts and discussions about drought over the coming years. It is certainly a conversation that I plan to continue and expand within Nevada.

JIM OGSBURY
WGA Executive Director

When Governor Brian Sandoval told me he wanted to focus on drought during his time as Chairman of the Western Governors' Association (WGA), I could not have been more enthusiastic.

Drought is an issue that fits squarely within the mission of WGA. While the topic is not unique to the West, for the past several years the map of drought conditions in the U.S. has seemed like a target with a bulls-eye on the western states. Given that much of the region is naturally arid, the consequences of western drought are especially acute. There is room for real innovation in drought management and response. Drought is bipartisan. And WGA has been a leader on drought policy for well over a decade.

That leadership significantly expanded under Gov. Sandoval's direction. Over the past year, the governors received input from a broad cross-section of experts, including such diverse voices as electricity providers, dairy farmers, state engineers, mining experts, environmental advocates, federal partners and water providers for the largest cities in the West. WGA went to five western states in five months to hold in-depth conversations about drought, only to turn around and hold five additional webinar discussions. We learned a great deal during that time. One takeaway: despite the region's long experience with water scarcity issues, there is still room for innovation in drought management and a need for ongoing dialogue.

I am proud of what we have accomplished so far with the Drought Forum, but our work is not done. The Drought Forum online resource library on WGA's website will remain active and updated with new content in the years to come. We intend to keep the library stocked with valuable information for the governors as they continue to work through the complexities of drought.

If you have not yet done so, please send your best practices and case studies to help us build this resource. The Drought Forum is an ongoing discussion and we want to be sure your perspective is included.

Thank you to those who contributed to and supported the Drought Forum over the past year. We hope to partner with you again as we continue to work on this issue in the years to come.

Respectfully,

EXECUTIVE SUMMARY

Recent drought throughout the West has affected economies and communities in ways both visible and hidden. Fallowed fields, bare streambeds and near-empty reservoirs provide stark reminders of drought's effects, but they do not tell the full story. Drought has also resulted in lost tourism revenues, increased fire risk, decreased quality of wildlife habitat, unemployment and livestock losses.

Through the Western Governors' Drought Forum, WGA has collected best practices, case studies and the insights of western leaders on drought response and management. These resources are collected in the Drought Forum online resource library, which is accessible at westgov.org/drought-forum.

This report is designed as a roadmap for the online resource library, pointing to specific drought management strategies and information available on the web. The report is arranged around seven key themes that have emerged from the Drought Forum thus far, including:

Data and Analysis – Data on snowpack, streamflow and soil moisture is essential to understanding drought and its evolution. Though a great deal of information already exists, water managers could benefit from enhanced drought data collection and real-time analysis at a higher resolution.

Produced, Reused and Brackish Water – Technologies exist to use produced, reused, recycled and brackish water—industrial, municipal and groundwater sources traditionally considered to be marginal or wastewater. Adoption of these technologies has been limited by inadequate data, regulatory obstacles, financial barriers, public attitudes and logistical uncertainties.

Forest Health and Soil Stewardship – Better land management practices for forests and farmland may help improve water availability and soil moisture retention. Employing these management strategies can help water resource managers and farmers make the most efficient use of the water they have.

Water Conservation and Efficiency – Public awareness of drought has drawn increased attention to water conservation strategies for municipal, industrial and agricultural purposes. Cities and farmers are implementing water-saving technologies and reducing water use to mitigate the effects of drought.

Infrastructure and Investment – Infrastructure to store and convey water is crucial to drought management, but

Western Governors' Drought Forum

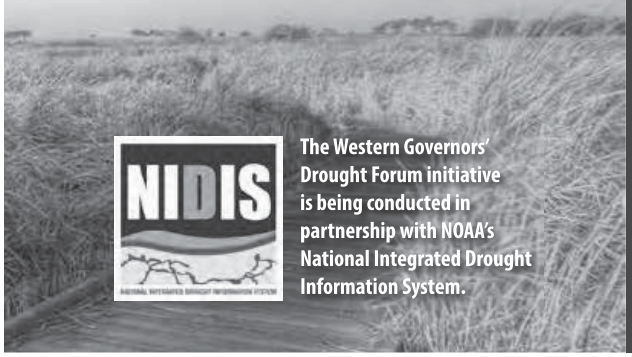
maintenance and expansion of that infrastructure is often difficult to fund. Westerners are looking for ways to make the most of existing infrastructure, while seeking creative solutions to develop new infrastructure with limited resources.

Working within Institutional Frameworks to Manage Drought – Legal and regulatory frameworks can sometimes limit the ability of state, local and federal agencies to respond quickly to drought conditions, but many are working to create innovative, flexible policy solutions within existing legal structures.

Communication and Collaboration – Communication among states, federal agencies, water providers, agricultural users and citizens is a crucial component of effective drought response. Open dialogue and information-sharing helps water users understand the challenges drought poses for other stakeholders, facilitating the opportunity for a unified response to drought.

This report and the accompanying online resource library will be foundational tools for governors as they weigh drought management strategies in the future. They will provide governors and water managers with robust resources to draw from to meet current drought challenges, as well as a medium for thought-provoking discussions to help policymakers plan for future periods of water scarcity.

WGA will continue the Drought Forum discussion in the coming years, updating the online resource library with new content. WGA will also maintain the framework for sharing drought best practices with ongoing webinars and meetings related to the key themes of this report.



The Western Governors' Drought Forum initiative is being conducted in partnership with NOAA's National Integrated Drought Information System.

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Nevada Gov. Brian Sandoval announced the creation of the Western Governors' Drought Forum on the boat ramp of the Lahontan Reservoir in northern Nevada, which suffered from exceptionally low water levels in 2014 due to drought.

WGA Chairman's Initiative

The First Year of the Western Governors' Drought Forum

The backdrop to Gov. Brian Sandoval's announcement of the Western Governors' Drought Forum illustrated the challenge posed by drought: Nevada's Lahontan Reservoir, where low water levels caused by drought had forced the closing of all boat launches and a 75 percent decrease in visitation in 2014 as compared to the previous year.

"The impact of drought in the West is clear to everyone here," Gov. Sandoval said at the September 2014 rollout event. "But it extends far beyond Lahontan Reservoir. California is experiencing 'exceptional drought.' And 'extreme drought' conditions continue in much of Nevada, Arizona, New Mexico, Colorado, Kansas, Oklahoma and Texas."[1]

That regional impact spurred Gov. Sandoval to make the Drought Forum his cornerstone initiative as the Western Governors' Association Chairman. Gov. Sandoval set a goal to provide a framework for sharing best management practices on drought for state and industry leaders across the West.

Oklahoma Governor Mary Fallin, right, offered a keynote at a workshop in her state about managing drought in the energy sector. Michael Teague, the state's Secretary of Energy and Environment, also spoke.

The initial year of the Drought Forum was a multifaceted effort to build that framework through in-person workshops, a webinar series and an online resource library. In addition, WGA solicited case studies and best practices, highlighting innovations in drought response from across the region.

Workshops in Oklahoma, Arizona, California, Nevada and New Mexico examined the effects of drought on specific economic sectors by gathering leading thinkers from industry, non-profits, academia, and state, local and federal government. Through these sessions, WGA identified the management challenges drought poses, as well as strategies and policy options for effective drought response.

The Governors played a significant role, in part by hosting and participating in workshops. **Oklahoma Gov. Mary Fallin** spoke in Norman, noting that the state had suffered $2 billion in losses from the drought of 2011-2012. The Governor cited her signing of the Oklahoma Water for 2060 Act, which establishes a goal for the state to use no more fresh water in 2060 than it did in 2012.[2]

Gov. Sandoval highlighted the bipartisan nature of the Drought Forum by speaking alongside **California Gov. Jerry Brown** at the Sacramento workshop. "I think the drought will test our imagination and our science, our technology and our political capacity to collaborate," Gov. Brown said.

The workshops also helped WGA discern themes for closer attention in a free five-part webinar series that broadened the Drought Forum audience by attracting a total of more than 1,200 registrants. The webinars are now available in the online resource library.

Drought Forum Meetings and Webinars

WORKSHOPS

Managing Drought in the Energy Sector
Hosted by Gov. Mary Fallin (OK)

Drought Impacts and Solutions in the Manufacturing, Mining and Industrial Sectors
Hosted by then-Gov. Jan Brewer (AZ)

Drought Impacts and Solutions in the Agricultural Sector
Hosted by Gov. Edmund G. Brown (CA)

Drought Impacts and Solutions in Water Supply
Hosted by Gov. Brian Sandoval (NV)

Drought Impacts and Solutions for Recreation and Tourism
Hosted by Gov. Susana Martinez (NM)

WEBINARS

Once Marginal, Now Crucial: The Growing Demand for Re-used, Produced, and Brackish Water

Community Outreach and Consumer Technology for Municipal Water Use

Tip of the Spear: The Horizon for Drought Data and Technology

Managing Forest Health for Water Resources

One Size Doesn't Fit All: Why Variation in Hydrology and Legal Structures means that Drought Looks Different across the West

California Gov. Jerry Brown offered opening remarks at the Drought Forum workshop n agriculture he hosted at his office in the California state capitol building.

Reflections of Drought in the West

Drought in the western states is often depicted through stark images: fallowed fields, exposed riverbeds, near-empty reservoirs and the broad "bathtub ring" at Lake Mead behind Hoover Dam. But drought is present in other, less obvious ways as well: elevated water temperatures in streams and rivers, for instance, and waning soil moisture levels not visible to the naked eye.

Conversations about western drought have traditionally focused on agriculture. In some western states, agriculture accounts for more than 90 percent of consumptive water use.[3] Over a quarter of all farm acres in the West are irrigated, and the value of irrigated crops is markedly higher than dryland crops.[4] So when water supplies are limited and farmers receive less water than their usual allocation, agricultural producers have to adjust how they do business. In some cases, the short-term response means letting some fields go fallow in favor of higher-value crops or selling more livestock than in an average year in order to moderate costs for the animals' feed. In other cases, western farmers have found ways to use water more efficiently, as is illustrated in detail in the *Water Conservation and Efficiency* section of this report.

For urban water users, the sting of drought in past decades has been softened by water storage and water providers who have proactively planned to ensure reliable supplies. The severity of the multiyear drought in California removed that cushion for some, such as citizens of

The South Lake Dam in California's Sierra Nevadas shows signs of drought conditions affecting many states in the west.

Outingdale, California, where water curtailments in May 2015 forced the local water provider to truck in water for residents, limiting customers to just 50 gallons of water per person each day.[5] Even for cities and states that are nowhere near such dire straits, public awareness of drought has dramatically increased due to reporting from media outlets and public outreach campaigns from water providers and states, such as Oregon's #ORdrought social media campaign.[6]

Drought impacts wildlife habitat and the environment as well. Elk, mountain lions and bears have been sighted outside of their traditional habitat, at lower elevations and closer to population centers, in search of water and food during drought conditions.[7] Aquatic habitat can diminish with low flows and the water that remains in the stream is often warmer, leading to poor conditions for some fish

California Gov. Edmund G. Brown Jr., center, and Department of Water Services Director Mark Cowin, right, watched as Frank Gehrke, chief of the California Cooperative Snow Surveys Program, discussed snow survey results on April 1, 2015, at an elevation of 6,800 feet in the Sierra. It was the first recorded early-April measurement that found no snow at the Phillips Station, an indication of the drought's severity. Courtesy of California Department of Water Resources

species. Low streamflow and reduced precipitation also bodes poorly for some native vegetation.

Drought creates dry conditions that can lead to devastating wildfires. Dry vegetation as a result of low precipitation, low soil moisture and high temperatures creates conditions for particularly hot fires that spread quickly and are difficult to control.[8] This may be further exacerbated by standing dead trees killed by pine bark beetles infestations.[9]

Wildfire can have significant impacts on air quality and can, in some cases, affect a state's ability to comply with Clean Air Act (CAA) standards. Soot and ash contribute to particulate matter (PM) pollution, as does dust and exposed dirt released by low soil moisture levels.[10] This PM can affect human health in a variety of ways, from airway irritation and coughing, to aggravated asthma conditions, to decreased heart and lung function. Wildfire also increases ground-level ozone, as fire releases nitrogen oxides and volatile organic compounds.[11] These factors contribute to the regulatory challenge for states to meet federal National Ambient Air Quality criteria pollutant standards (commonly referred to as NAAQS) required by the CAA.

Low water levels in reservoirs can lead to reduced capacity for hydroelectric power generation, a source of more than a fifth of the power generated in the Mountain and Pacific West.[12] Hydropower generators have a minimum "power pool" threshold needed to reliably generate electricity.

Drought is a contributing factor to dust storms such as this 2013 storm in southeastern Colorado. Courtesy of Jane Stulp, Stulp Farms

Drought's role in air quality

Drought can mean a decline in air quality, most commonly due to dust caused by low soil moisture or particulate matter released by wildfires. Despite vast improvements in land management practices since the devastating Dust Bowl of the 1930s, dust from dry soil remains difficult to prevent during drought conditions. The result can be enormous dust storms like those experienced in southeastern Colorado in 2013 and captured in this photo by Jane Stulp of Lamar, Colorado. Learn more about how drought impacts air quality in the Drought Forum Science Brief, *How Drought Affects Air Quality*. Find that and more in the Drought Forum online resource library at westgov.org/drought-forum.

When reservoirs fall below that level, electricity generation costs increase. Prior to California's devastating multiyear drought, 14 percent of the state's power came from hydroelectric generation. The drought decreased that figure to 6 percent in 2014.[13]

Drought affects other parts of the energy sector, as well. Oil and natural gas extraction requires water. Coal mining operations use water to both remove coal from underground seams and to cool the machinery required to transport and process the product. All thermoelectric power generation requires water for cooling processes. Renewable energy generation requires water as well: utility-scale solar power generation requires water for both electricity generation and for cooling.

For recreation destinations, winter and summer alike, drought can have consequences for visitation and public perception. Water shortages during Colorado's intense drought of 2002 resulted in an estimated $1.7 billion decrease in recreation revenue.[14] Drought impacts river recreation, in particular; rafting, fishing, kayaking, and other water-related activities help drive an estimated $25.6 billion of economic activity in the Colorado River Basin, and reliable flows are essential for these activities.[15] Ski resorts use proactive public messaging and advanced snowmaking technology to ensure that visitors know their slopes are open, even if precipitation has been below-average.

Key Themes

Data and Analysis

"There is an adequate amount of technology available to accurately monitor and manage water usage and drought, but much of this technology is stuck at a very high level of decision making and is not trickling down to the state or local level."

– Jay Famiglietti, Senior Water Scientist, NASA Jet Propulsion Laboratory, California Institute of Technology

Water managers measure drought through multiple factors, including mountain snowpack, soil moisture, streamflow, temperature and precipitation, reservoir levels and reported impacts. These measurements and reports enable water managers and users to piece together a picture of drought conditions.

Drought scientists pull this information together in a user-friendly map called the U.S. Drought Monitor that shows drought severity across the nation. Each week, collaborators affiliated with the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture, and the National Drought Mitigation Center at the University of Nebraska-Lincoln analyze the latest information on water and other variables to generate this map, depicting four levels of drought severity. Additional information about the creation of the U.S. Drought Monitor is available in a Drought Forum Science Brief in the online resource library.

Additional resources for understanding and predicting drought are available at drought.gov, the online home of the National Integrated Drought Information System (NIDIS). NIDIS is a federal interagency program managed by NOAA that was authorized by Congress in 2006, and reauthorized in 2014, with support from WGA. The program is designed to provide decision-makers with the best available information and tools to prepare for drought, assess its potential impacts and mitigate its consequences.

Western Governors' Drought Forum participants expressed a desire for continued (and, in some cases, increased) drought data, collection and analysis. In an informal survey of Drought Forum participants and partners, WGA found that the U.S. Drought Monitor, the National Resources Conservation Service's (NRCS) snow survey, and the National Weather Center outlooks for temperature, precipitation and drought were the products most frequently used to track drought by state, local and federal government employees, business professionals, water managers and others in the West.[16] Groundwater data, predictive climate models for drought and analytical tools that allow users to compare multiple datasets over time were all cited by respondents as ongoing needs.

Detailed data on water use—including residential, agricultural and industrial uses—help states and water providers manage their resources. The common refrain, "if you can't measure it, you can't manage it" was used

Mapping Drought with the U.S. Drought Monitor

The U.S. Drought Monitor is a weekly map detailing the intensity of drought conditions across the nation.

Eleven climatologists from partner organizations take turns as the lead author of the Drought Monitor, synthesizing the data across timescales and geographic locations. Several states and federal agencies rely on the Drought Monitor to help determine if drought declarations are needed on a state or local basis.

Learn more about how the Drought Monitor is created in the Drought Forum Science Brief, *Creating the U.S. Drought Monitor*. Find that and more in the Drought Forum online resource library at westgov.org/drought-forum.

by Drought Forum participants to describe the need for water use data for both surface water diversions and groundwater pumping. Water managers require this data to confidently develop demand projections, whether or not drought conditions prevail. For water utilities, this information can inform strategies to implement conservation programs and adjust rate structures. For states, water use data provides a better sense of diversions, consumption and return flow of water, which is used by some states to facilitate water transfers and deliveries.

Several participants also emphasized the value of soil moisture monitoring—an important tool that helps scientists determine the severity of drought conditions.

"The way that data are produced and recorded at the local level is irreplaceable. Satellite monitoring and model-based estimates are important but a full portfolio of observations is needed," Roger Pulwarty, Director of NIDIS said. "In the West, the sparseness of data on important drought metrics like *in situ* soil moisture measurements needs to be addressed."

Soil moisture information currently collected by federal, state and local entities will soon be assimilated through the National Soil Moisture Network, a collaborative effort of NIDIS, NRCS and the US Geological Survey. Though presently in a pilot stage, the program is designed to one day provide real-time soil moisture data through an online network.[17] Additionally, the National Aeronautics and Space Administration (NASA) is producing global soil moisture maps with its new Soil Moisture Active Passive observatory which launched in January 2015.[18]

Drought Forum participants also cited a need to increase the integration of water data resources to help better interpret water conditions. "Data stove-pipes exist because different agencies collect information for varying purposes—water quality and quantity data, for example, are often collected by different agencies with different objectives," said Jeri Sullivan Graham, Brackish Water Work Group Coordinator for the New Mexico Energy, Minerals and Natural Resources Department. "Combining and interpreting these data thus becomes challenging."

Existing water data sources are often available online, but state and local water managers may be unaware of the availability or location of these resources. "An overwhelming amount of data already exists regarding drought," said John Andrew, Assistant Deputy Director of the California Department of Water Resources. "The issue lies in making it accessible to those who need it, when they need it."

Tip of the Spear:
Webinar on the Horizon for Drought Data and Technology

Historic data on snow and water levels provide a frame of reference for current monitoring of drought conditions. WGA convened a webinar discussion on the ways that basic data is being used in conjunction with the latest modeling and satellite technology to inform drought management decisions. Find that webinar and more in the Drought Forum online resource library at westgov.org/drought-forum.

Improvements in predictive capability and measures of reliability for drought forecasting are also needed. Ongoing research to better understand the relationship between snowpack, rainfall, groundwater recharge, soil moisture and temperature could potentially improve predictions of water availability. Though scientists can forecast weather up to 10 days in advance, predictive capability for drought conditions a few months out is primarily a condition of El Niño Southern Oscillation (ENSO) climatic events. More work is needed to fully understand how ENSO-neutral periods relate to drought. In addition, research on climatic variability at both the decadal scale (for example, the Pacific Decadal Oscillation) and the seasonal scale would help scientists to better understand the dynamics of drought development.

The Western States Water Council — an organization of high-level state water managers from 17 continental western states and Alaska — is developing a platform called the Water Data Exchange (WaDE). This online tool will allow users to access state data on water allocation, supply, and demand through a single web portal. Once launched in December 2015, WaDE will help water planners across the West better understand water resources by providing them with a state-driven framework and state-managed data. This functionality will provide an additional mechanism for future Drought Forum discussions regarding water resource data.

Produced, Reused and Brackish Water

In response to limited and variable water availability, industry leaders are testing new technologies to harness water supplies once considered marginal. For sources such as re-used, recycled, produced and brackish water, technologies are emerging to use these sources, but implementation is not always simple. Treating these sources can be expensive and may require special environmental considerations. In some instances, regulatory uncertainty and lengthy permitting requirements can limit adoption.

"Produced water, flow back water, in the energy discipline have historically been viewed as a waste—a nuisance—something to be managed," Ken Knox of Noble Energy said on the Drought Forum webinar, *The Growing Demand for Re-Used and Brackish Water*.[19] "But the disposal, the treatment, the recycling of those wastewaters is now at the forefront of development of energy throughout the United States, North America, and frankly, the world."

Produced water, when treated, has the potential to be reused for irrigation, stock watering, dust control or energy production onsite. But some energy representatives say that such opportunities are limited by the time it takes to obtain permits as well as regulatory complexity and uncertainty at varying levels of government.

Water treatment technologies exist for processing produced water on-site at the wellhead, according to Ed Steele of the General Electric Global Research Center. It is, however, very expensive to treat to recharge standards. Difficulties can arise with storing the water immediately after treatment. "Recharging aquifers with treated water would eliminate inefficiencies resulting from evaporative losses," said Steele. "However, this concept faces considerable regulatory and legal liability challenges."

Some business leaders and electricity providers are looking to "fit-to-use" water for their operations. Fit-to-use water is treated to the point that it can be used for certain industrial processes. For example, power provider NV Energy uses treated wastewater from hotels and casinos in the small town of Primm, Nevada, along with an advanced dry cooling system, to cool a 500-megawatt generating station. While a typical water-cooled 500-megawatt plant may use up to 2,500 acre feet per year, a dry-cooled plant like the one in Primm uses roughly 200 acre feet per year.[20]

Brackish water is a semi-saline source that can be treated for potable use by reverse osmosis. The process can be costly due to the energy used in processing and the costs of disposing the waste products that result from treatment. This high financial barrier can be a deterrent for municipalities, which have traditionally provided water to customers at relatively low prices.

Some water providers and state water managers are pursuing seawater desalination, which poses similar challenges as brackish water desalination in addition to its own unique challenges. Ocean water desalination plants can more easily dispose of brine waste resulting from the desalination process by discharging into the sea, but these plants tend to attract opposition because of the potential threat they may pose to marine life and habitats near the water intake and brine release sites. In addition, it is costly to treat and pump water uphill from the shoreline to residences at a higher elevation.[21] Information about the Carlsbad desalination project under construction in San Diego is available on the Drought Forum webinar: *One Size Doesn't Fit All: Why Variation in Hydrology and Legal Structures means that Drought Looks Different across the West*.

A handful of western water providers are mixing recycled wastewater with traditionally-sourced water for human consumption, venturing closer to "potable reuse"—a practice colloquially known as "toilet-to-tap." The towns of Big Spring, Texas, and Cloudcroft, New Mexico, have both implemented technology to treat wastewater forpotable use after mixing with surface water supplies.[22]

Once Marginal, Now Crucial: *Webinar on the Growing Demand for Re-used, Produced, and Brackish Water*

WGA delved into the growing interest in reused, brackish, and produced water with a webinar available in the Drought Forum online resource library. Listen to the discussion of how state and industry leaders are using sources once considered useless as an alternative means of water supply in the Drought Forum online resource library at westgov.org/drought-forum.

Despite its limited adoption in the West, many Drought Forum attendees mentioned it as a partial solution to drought. For other communities, negative public perceptions about treated wastewater—what participants called the "yuck factor"—remains a deterrent regardless of the water's quality.

Many communities that have not opted for direct potable reuse are reusing water for other purposes. Scottsdale, Arizona, for example, uses reclaimed water for irrigation purposes for 23 golf courses served by its water treatment plant. Remaining treated water is used to recharge the groundwater aquifer.[23]

Forest Health and Soil Stewardship

"The forests are not as healthy as they used to be. In the last decade, over two million acres have burned. We need to protect our watersheds so they act like a sponge, not a parking lot."

– Charlie Ester III, Manager, Water Resource Operations, Salt River Project, Arizona

Land management practices may mitigate drought conditions by increasing runoff into stream systems and retaining moisture in the soil. Some water managers are taking an active role in forest management to improve water availability. The Salt River Project (SRP) in Phoenix, Arizona, has partnered with the National Forest Foundation to create the Northern Arizona Forest Fund. Through that program, SRP is thinning forests, using prescribed burns, and restoring riparian habitat to invest in the health of watersheds.

A recent analysis of forest management techniques indicated that runoff in thinned forests could be up to 20 percent higher than in un-thinned forests.[24] Unmanaged forests are thirstier, says study author Marcos Robles and his colleagues, because forests today are two to 44 times denser than they were prior to settlement by non-Tribal populations.[25] While the initial findings are promising, implementing thinning at a larger scale is cost-prohibitive when only the water runoff effects are considered. "The increases in water yields, in and of themselves, are probably not enough to warrant the level of investment that would be required to reach the scale that's needed to see those runoff benefits," Robles said. However, the investment merits consideration, "when you package it with the reduced fire risk and erosion and sedimentation and the cost of cleanup."

Managing Forest Health for Water Resources:
Webinar on the Connections Between Forestry and Water Availability

WGA convened water and forest management leaders from the U.S. Forest Service, the City of Santa Fe, N.M., and The Nature Conservancy on a webinar to discuss proactive forest management methods that reduce wildfire risk and add security to municipal water portfolios. Find that webinar and more in the Drought Forum online resource library at westgov.org/drought-forum.

Some farmers are looking to make the most efficient use of their water resources by improving soil health. Soils with high organic matter are better at retaining water. Daniel Fullmer of the National Young Farmers Coalition remarked upon the dramatic difference in water retention between soils with 1.5 percent and 2.5 percent organic matter. The best farmers are able to achieve 11 percent organic matter, according to Fullmer – twice the levels of undisturbed forests.[26]

The use of these water-conscious forest- and soil-management practices have significant implications not only for water supply, but also for other key resource management priorities in the West. Healthy, robust forests are more resistant to insect and disease predation as well as wildfires. Well-managed soil is more nutrient-dense and aerated, which is conducive to plant growth. Therefore, implementing land management practices can promote drought-resilient landscapes and mitigate the cascading effects of drought on ecosystems.

Water Conservation and Efficiency

Drought Forum participants—industry leaders and state water managers alike—talked about making the most efficient use of available water. Water re-use, technologies to reduce consumption, and increasing flexibility in transferring water all play a role in western water management in the face of drought.

Some industry leaders who participated in the Drought Forum noted an increased attention to water planning

in business decisions, even if that factor might have been considered minor prior to recent droughts. Nate Hines has observed this trend in his irrigation design business, Hines Inc. "We have developers coming to us saying water is our number one or number two cost right now—how can you help us make this work?" Hines said. "The increasing costs of water and drought are driving behavioral changes and retrofitting efforts."

Land developers are thus considering water-saving equipment, efficient irrigation and drought-resistant landscaping when designing a new facility, rather than waiting until the end of development for this analysis. For example, Hines cited the example of a 4,000-acre development in Texas that had been planned to use water-intensive bluegrass; ultimately, native prairie grasses were chosen due to the water saving benefits.

Water-conscious consumers are encouraging the food and beverage industry to use less water, giving rise to "water footprint" monitoring. Businesses are increasingly rethinking their operations, down to the geometric design of the steeping and malting containers for brewing beer, for example.[27]

Some municipal water providers—including those in

Cities Help Water Users See Just How Thirsty they Are

Cities are investing in technologies to help water users understand their own water consumption. Park City, Utah, uses an advanced metering infrastructure (AMI) capable of tracking water usage in real time. This has helped the Park City Water Department identify and deliver over 150 leak alerts to residents, 70 percent of which were addressed within 10 days of the notification.

The City of Roseville, California, includes charts on water users' billing statements that compare household water use to neighbors and similar water users. This strategy employs competition and behavioral psychology to conserve water. The statements also include customized suggestions for how to use water more efficiently.

Other technologies allow users to view their water consumption using smart phone apps. Learn more about this topic by visiting the Drought Forum online resource library at westgov.org/drought-forum.

Some farmers use drip irrigation to apply water efficiently, close to the plant root zone. Agricultural water conservation achieved by drip irrigation helps farmers save water, but implementation of drip should account for local hydrological conditions.

Las Vegas and Los Angeles—are encouraging residents to reduce water use by offering rebates for turf removal in favor of less-thirsty landscaping. Utilities are also showing customers how much water they use in comparison to their neighbors through easy-to-interpret graphical information on bills and smart phone apps.

Western farmers are finding ways to use water more efficiently. Some farmers have increased their water efficiency by laser-leveling fields, lining canals, or implementing drip irrigation. In the Oklahoma Panhandle, farmers have adjusted irrigation methods, reduced tillage and switched to less consumptive crops. These agricultural producers have reduced water use for crop irrigation by 60 percent over the past 10 years while retaining the same amount of irrigated cropland and increasing the market value of agricultural products sold. A case study of the Panhandle Regional Water Plan is featured on the Drought Forum online resource library.

Agricultural irrigation often affects other parts of the water system. For areas with high permeability and interchange between surface water and groundwater, return flows from agricultural water use make their way to local streams and underground aquifers. When water used in irrigation is reduced—or becomes more precisely delivered to plant root zones through the use of drip irrigation—it can sometimes result in less water for downstream users or instream flows. Several Drought Forum participants said that while measures to increase agricultural efficiency are quite useful in some areas, return flows and groundwater recharge should be taken into account where appropriate.

Increased urban water efficiency also helps western cities become more drought resilient and meet a significant portion of water demands for expanding populations. For example, Denver Water has invested in rebates to replace toilets with more efficient models and has led an outreach campaign to encourage customers to conserve water in household use and landscaping. As a result of these and other efforts, Denver Water's December 2014 demand was nearly the same as in December 1973, even though its customer base expanded by over 350,000 users in that period.[28]

Infrastructure and Investment

Water infrastructure development and maintenance is crucial to water management, especially during drought. Deputy Secretary of Interior Michael Connor emphasized this point during his participation in the Drought Forum. "The Bureau of Reclamation (USBR) was originally intended to support states and develop water infrastructure. Today, the mission isn't to reclaim the West as much as it is to sustain the West," Connor said. "The West is still extremely fragile and sensitive to water scarcity; how we operate and manage reservoirs is crucial to dealing with drought."

Federal programs such as the USBR's WaterSmart program and the Environmental Protection Agency's state revolving funds support repairs and modernization of existing infrastructure. In some instances, however, federal and state investment capacity is limited, so local governments shoulder more of infrastructure costs than they have in the past. Public-private partnerships and long-term local bonds can offer alternative funding mechanisms for local governments.

Drought conditions have put a spotlight on water infrastructure needs that already existed, in many cases. "So much of our water conveyance infrastructure is extremely outdated," said Ron Thompson, General Manager of the Washington County Water Conservancy District in Utah. "At the state level there is good work being done in planning, but at the local level, they lack the resources to adequately update and replace infrastructure. Policy and regulations are barring water managers from dealing with this issue."

Cities facing impending water shortages may require large capital investments to provide water security for their citizens. Southern Nevada Water Authority (SNWA), the water provider for the Las Vegas metro area, will soon complete a third intake for drawing water from Lake Mead in the event that the water level drops below the two existing water intakes in the reservoir. The three-mile long project required an $817 million investment, seven years of construction and a custom-built tunnel-boring machine.[29] SNWA also plans to build a low lake level pumping station that will be used if Lake Mead falls below the water level required for existing pumping facilities.[30]

Working within Institutional Frameworks to Manage Drought

For western state water managers, the frequency and severity of recent droughts have demanded a closer look at the ways water is currently managed. For example, California, Idaho and other states have streamlined frameworks for temporary transfers of water rights that allow more flexibility to move water relatively quickly.

Some Drought Forum attendees expressed the belief that states need to increase flexibility in water transfers to better address drought conditions, especially for transfers from agricultural use to instream flows for environmental purposes. Others expressed a desire for states to make permanent transfers of water easier. WGA produced a detailed report in 2012, *Water Transfers in the West*, which provides information on policy options for states to streamline the facilitation of water transfers and improve outcomes for all stakeholders.

Groundwater management poses additional challenges and opportunities for states in periods of drought. Groundwater basins can be managed to allow sustainable groundwater use with replenishment programs like ones managed by the Central Arizona Project throughout central and southern Arizona. During prolonged, severe droughts, however, drawing on a groundwater "savings account" may have its limitations as well. Nevada State Engineer Jason King recognized the stresses caused by pumping supplemental groundwater as a backup supply when surface water is unavailable. The state's lead water manager said he may need to start considering curtailment of those rights in order to maintain the health of the aquifer.

Drought Forum participants also acknowledged the difficulties posed when water conservation measures allow water users to fully "consume" the water in a water right, decreasing return flows to the water system. Some called for water managers to consider policies that would encourage conserved water to be stored or left in-stream rather than put to new uses; others argued that the use of the conserved water is a necessary incentive for water saving strategies.

Communication and Collaboration

"Early communication about an impending water shortage – and the resulting groundwater pumping curtailments – allows stakeholders to transfer water usage to higher value crops, minimizing economic impacts of drought on agricultural producers."

– Jason King, State Engineer, State of Nevada

Water systems—including infrastructure, hydrogeology and ecological networks—are dynamic and interconnected. Water management choices by one user or community can have consequences for others downstream, or in other economic and environmental sectors.

Pat Mulroy, Senior Fellow at the Brookings Institute and former General Manager of the Southern Nevada Water Authority, described a need for those who rely on water from the Colorado River to think of themselves as "citizens of a basin."

"The years of competition and litigation over water need to come to an end," Mulroy said. "Water resource management has to be strategic, built upon partnership and rational thought."

Throughout the Drought Forum discussions, participants commented on the connections between water users and emphasized the need for collaboration and communication. A frequent theme was the importance of communications among state engineers and farmers, utilities and ratepayers, and federal, state and local agencies with overlapping jurisdictions.

For instance, the California Department of Water Resources worked closely with federal managers at the USBR to operate their respective water infrastructure systems in concert during drought conditions in 2014. The continuous communication and collaboration allowed them to minimize regulatory roadblocks impeding the transfer of water to where it was needed most.

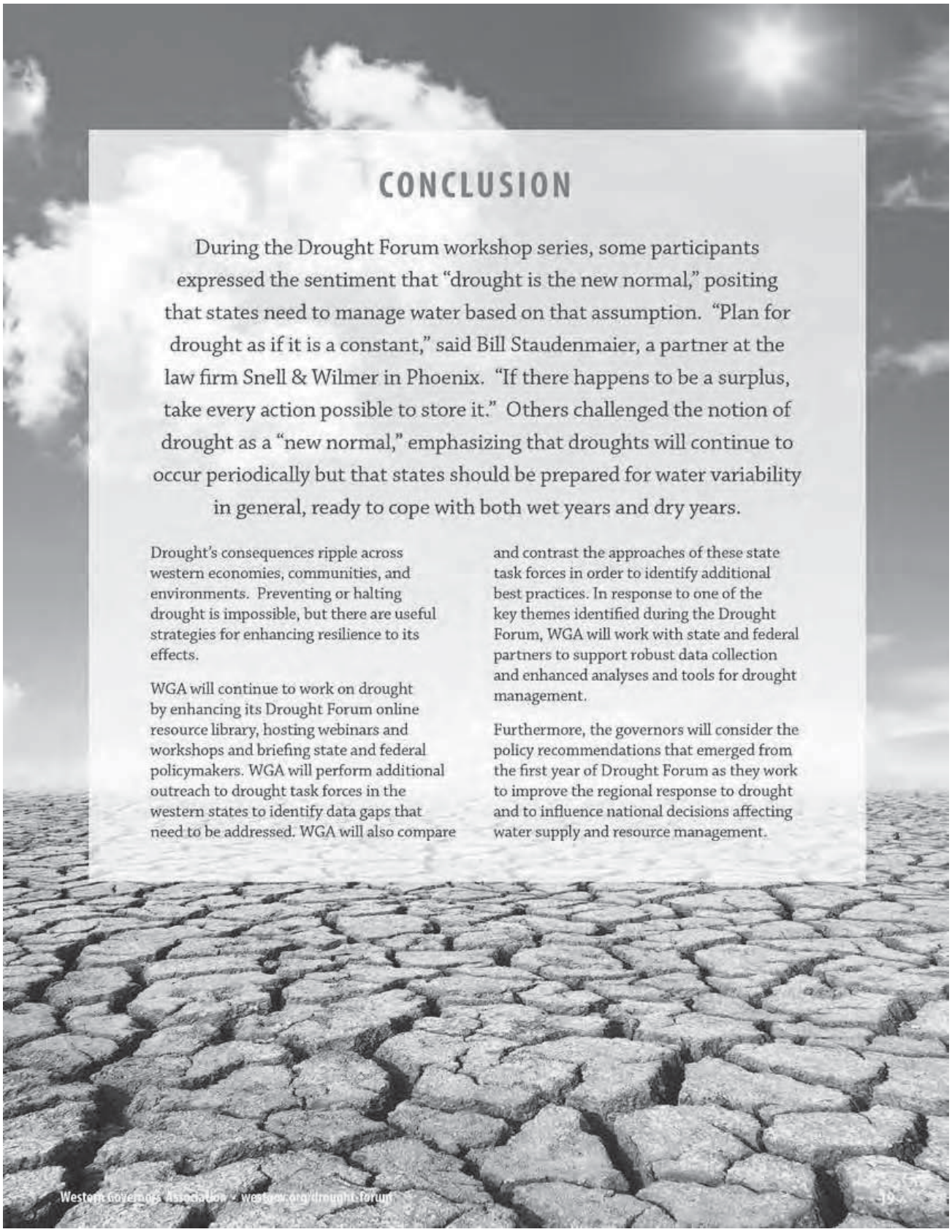
Communication among states' officials, federal agencies, water providers and citizens is another crucial component of drought response. Nevada state officials focused on the need to increase citizen awareness of drought conditions and conservation opportunities. "Citizen awareness is critical to the success of any drought or conservation measure," said Cassandra Joseph, Senior Deputy Attorney General for Government and Natural Resources in Nevada. "It is difficult to achieve, but it is absolutely imperative that the general public understands the importance of water resource management."

Water providers have traditionally communicated with residential customers about water use through monthly bills, but some utilities are now providing water information through an online interface using websites and smart phone apps that allow users to monitor their own water use more frequently. The Drought Forum online resource library includes a case study and a webinar entitled *Community Outreach and Consumer Technology for Municipal Water Use* with additional information.

Outreach to recreational water users such as rafters and kayakers regarding water releases from reservoirs helps to maintain tourism and quality of life during drought. "When reservoir operators and recreational interests share data and coordinate their needs, we can manage against the threat of low flows on our rafting and angling attractions, and sustain our local tourism and recreation economies through a drought," Nathan Fey, Colorado River Program Director for American Whitewater, said.

Cross-Agency Collaboration in Addressing Record Drought in California

The drought in California led state and federal agencies to craft a unified plan in 2014 to balance the competing water needs in the state. Principals from six agencies communicated on a daily basis, forming a collaborative drought operations team able to address issues in real time. The partners took steps to streamline water transfers and schedule water deliveries in ways that helped conserve fish habitat. Watch a video in which state and federal partners describe the collaborative plan at the Drought Forum online resource library at westgov.org/drought-forum.



CONCLUSION

During the Drought Forum workshop series, some participants expressed the sentiment that "drought is the new normal," positing that states need to manage water based on that assumption. "Plan for drought as if it is a constant," said Bill Staudenmaier, a partner at the law firm Snell & Wilmer in Phoenix. "If there happens to be a surplus, take every action possible to store it." Others challenged the notion of drought as a "new normal," emphasizing that droughts will continue to occur periodically but that states should be prepared for water variability in general, ready to cope with both wet years and dry years.

Drought's consequences ripple across western economies, communities, and environments. Preventing or halting drought is impossible, but there are useful strategies for enhancing resilience to its effects.

WGA will continue to work on drought by enhancing its Drought Forum online resource library, hosting webinars and workshops and briefing state and federal policymakers. WGA will perform additional outreach to drought task forces in the western states to identify data gaps that need to be addressed. WGA will also compare and contrast the approaches of these state task forces in order to identify additional best practices. In response to one of the key themes identified during the Drought Forum, WGA will work with state and federal partners to support robust data collection and enhanced analyses and tools for drought management.

Furthermore, the governors will consider the policy recommendations that emerged from the first year of Drought Forum as they work to improve the regional response to drought and to influence national decisions affecting water supply and resource management.

Western Governors'

A central goal of the Western Governors' Drought Forum is to create an online library that includes an ever-growing collection of resources to guide future planning and decision-making about drought in the West.

Visit the Drought Forum website: **westgov.org/drought-forum**

MEETINGS

Workshops hosted by Western Governors in Oklahoma, Arizona, California, Nevada and New Mexico gathered experts from government and industry to discuss drought's impact in various sectors – agriculture, water supply, recreation and tourism, energy, mining – and share policy solutions, case studies and best practices.

On the web:

Meeting summaries, photos, agendas, lists of attendees.

WEBINARS

The Drought Forum Webinar Series provides in-depth discussions with experts on topics that arose during the Drought Forum's regional workshops. Topics include the growing demand for re-used water, new drought data and technology, why drought looks different across the West, and how forest health is related to municipal water resource security.

On the web:

Watch the webinars.

Drought Forum

Western Governors' Association

SCIENCE BRIEFS

We've created a series of science briefs that dive deeper into how drought resources are developed and how drought impacts the daily lives of westerners. The briefs examine topics such as the work that goes into developing the weekly Drought Monitor to how drought impacts air quality.

On the web:

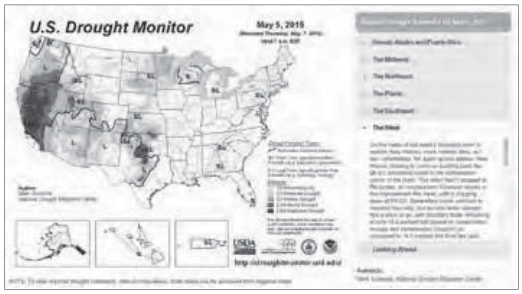
Read, download science briefs.

DATA & RESOURCES

The seasonal drought measurement and forecast "equation" includes temperature, precipitation and soil moistur. While the equation seems straightforward, these terms are dependent on a number of interrelated elements that vary across spatial and temporal scales. The impact each of these elements has on drought conditions – and predictions – varies given the time of year and the region in question.

On the web:

Find tools that help gauge drought's impact on the West.



CASE STUDIES

California and federal agencies are collaborating to allocate scarce water supplies while balancing the needs of water users and protecting against devastating financial loss. The San Antonio Water System employs customer outreach that has resulted in a voluntary reduction of 40 percent in *per capita* consumption. WaterSmart software yields an average reduction in water use of 5 percent within a year of its use.

On the web:

Watch videos of Case Study presentations.

The Western Governors' Drought Forum initiative is being conducted in partnership with NOAA's National Integrated Drought Information System

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END NOTES

[1] Since the September 2014 rollout event, a wet spring has ameliorated or eliminated drought conditions in parts of the Southern Great Plains and Rocky Mountain region. Despite this much needed moisture for parts of the interior West, severe drought has made its up way up the Pacific Coast; both Oregon and Washington are currently under gubernatorial drought declarations.

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[4] Schaible, Glenn, and Marcel Aillery. "Western Irrigated Agriculture: Production Value, Water Use, Costs, and Technology Vary by Farm Size." U.S. Department of Agriculture Economic Research Service. Sept. 2, 2013.

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[9] The impact of bark beetles on wildfire conditions across the West is variable and dependent on other conditions like soil moisture and temperature, but some studies suggest that it still is a factor in determining wildfire risk. For reference please see: Hicke, Jeffrey A., Morris C. Johnson, Jane L. Hayes, and Haiganoush K. Preisler. "Effects of Bark Beetle-caused Tree Mortality on Wildfire."Forest Ecology and Management 271 (2012): 81-90. Wertz, Joe. "The Cost of Oklahoma's Drought: $2 Billion in Two Years." State Impact, A Reporting Project of National Public Radio. Dec. 4, 2012.

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[13] Bender, Sylvia, Deputy Director of the California Energy Commission—Energy Assessments Division. Personal correspondence, April 24, 2015.

[14] Estimate includes $200 million in losses to outfitters and $800 thousand in lost revenue from fishing licenses. Hayes, M.J., M.D. Svoboda, C.L. Knutson and D.A. Wilhite (2004). Estimating the economic impacts of drought. 14th Conf. Appl. Climatol.

[15] Southwick Associates, prepared for Protect the Flows. "Economic Contributions of Outdoor Recreation on the Colorado River & Its Tributaries." May 3, 2012.

[16] Western Governors' Drought Forum survey. Administered May 6, 2015 – May 20, 2015. Total of 25 respondents. Results on file with WGA.

[17] Maloney, Wayne. "Want to Know about Soil Moisture on your Farm? Soon, There May be an App for That." US Department of Agriculture. March 2, 2015.

[18] "NASA Launches Groundbreaking Soil Moisture Mapper." National Aeronautics and Space Administration – Jet Propulsion Laboratory. January 31, 2015.

[19] In energy production, "produced" water is an industrial wastewater that is released to the surface during energy extraction. "Flow back" water is that which is injected during hydraulic fracturing, then returns to the surface.

[20] Geraghty, Kevin, Vice President, Energy Supply, NV Energy. Personal correspondence, June 4, 2015.

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[25] Scientists have long debated the role forests play in water availability, often within the context of afforestation and deforestation. While the scientific community has not come to consensus about the relationship between forestry practices and water runoff, several Drought Forum participants expressed interest in this developing field of research—especially because of the benefits forest management has for wildfire risk reduction and ecological health. For more information about the scientific debate, see: Ellison, David; Martyn N. Futter; and Kevin Bishop. "On the forest cover–water yield debate: from demand- to supply-side thinking." Global Change Biology (2012) 18, 806–820.

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