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Shifts in Local Climate Adaptation Strategies over the 2015-2017 Water Years: A Case Study in the Truckee-Carson River System

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*This fact sheet reports results from **Water for the Seasons,** a collaborative modeling research program that partners researchers with water managers representing the diverse water-use communities in the Truckee-Carson River System of California and Nevada. Through systematic and iterative interactions, key water managers and researchers work together to assess climate resiliency and examine strategies to adapt to climate-induced water supply variability. This five-year (2014-2019) research program is funded by a Water Sustainability and Climate program grant from the National Science Foundation (#1360506) and the U.S. Department of Agriculture (#2014-67003-22105).*

Introduction

Mountain snowpack remains one of the fastest changing features in a warming climate (USGCRP, 2017). In the northern Sierra Nevada, for example, these changes include less snow accumulation, more rain than snow, and earlier snowmelt runoff. Such changes alter streamflow timing (Hatchett et al., 2017; McCabe, Wolock, & Valentin, 2018; Mote, Li, Lettenmaier, Xiao, & Engel, 2018) and available water supply.

In the Truckee-Carson River System, a collaborative modeling research program brings together researchers and water managers to assess climate resiliency (Singletary & Sterle, 2017; Singletary, Sterle, & Simpson, 2016). As part of this assessment, researchers frequently meet with local water managers in order to understand managers' **adaptation strategies.** These strategies seek to moderate harm or exploit beneficial opportunities in response to: extreme droughts and floods, year-to-year water supply variability, and changes in long-term climate conditions (Adger, Arnell, & Tompkins, 2005; Smith et al., 2000). As part of these discussions, managers often describe implementation **barriers** that constrain or impede their adaptation efforts (Eisenack et al., 2014; Moser & Ekstrom, 2010). This fact sheet summarizes key findings from three waves of interviews conducted with the

same key water managers during the 2015, 2016 and 2017 water years (a water year is Oct. 1 – Sept. 30). Local managers represent the interests of diverse and competing municipal, industrial, agricultural, environmental and regulatory water-use communities across the river system.

Snowpack conditions, as one indicator of water supply, varied over the three-year data collection period, as illustrated in Figure 1. Water years 2012 through 2016 featured unprecedented drought conditions characterized by historic low Sierra Nevada snowpack and anomalously warm temperatures (Williams et al., 2015; Belmecheri et al., 2016; Mote et al., 2016). However, the winter of 2016/2017 brought numerous atmospheric river storm events resulting in record precipitation, historic Sierra Nevada snowpack and winter and spring flooding (California-Nevada Climate Applications Program, 2017). Comparison of interview data collected during coincident to this period provides insight into year-to-year shifts in local adaptation strategies and implementation barriers (Sterle & Singletary, 2017).

The Truckee-Carson River System

The Truckee (3,060 square-mile area) and Carson (3,966 square-mile area) Rivers originate as snowpack in the Sierra Nevada of eastern California and terminate in the Great Basin of northwestern Nevada. Areas in the headwaters receive over 70 inches of precipitation per year, typically falling as snow between November and April above 6,000 feet.

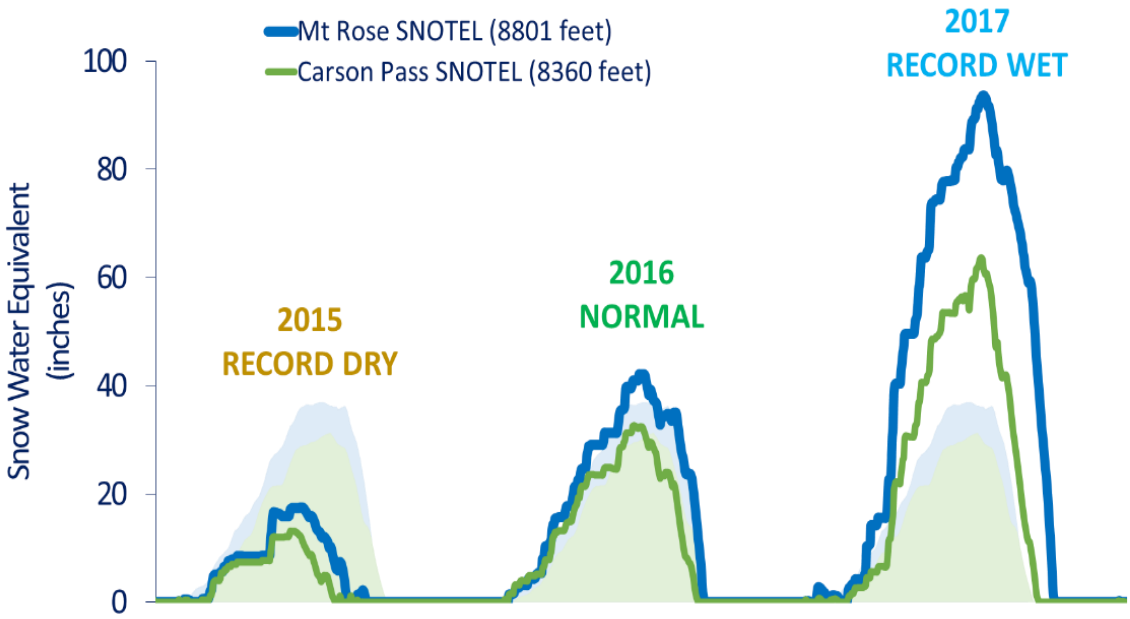

Figure 1. Recent water years in the Truckee-Carson River System. Shading is 1981-2010 average snow water equivalent, defined as the water content of snowpack. Data sources: NRCS SNOTEL Data and Water Supply Outlook Reports.

[1] For further details on water managers who participate in the research program, see Extension publication, *Assessing the Climate Resiliency and Adaptive Capacity of the Truckee-Carson River System: Results of a Survey of Local Organizations (SP-16-03)* (Singletary, Sterle, & Simpson, 2016).

Storm systems are depleted of moisture as they pass over the Sierra Nevada, resulting in a rain shadow effect in the middle and lower river reaches in northwestern Nevada. Surface water and groundwater supplies are used to meet urban water demand. Surface flows provide nearly all water supply for irrigated agriculture as well as environmental flows to support habitat for the endangered (Cui-ui) and threatened (Lahontan cutthroat trout) fish species in Pyramid Lake.

Truckee River surface flows, diverted via the Truckee Canal, join Carson River flows to supply water to the Newlands Irrigation Project area, the nation's first desert reclamation project (est. 1906), and to provide water for environmental use on the Stillwater National Wildlife Refuge (Wilds, 2014).

Annual Interviews with Key Local Water Managers

Over the 2015, 2016 and 2017 water years, researchers asked local water managers the following open-ended interview questions:

(1) What are the water-related challenges that your organization faces?
(2) What strategies has your organization adopted to adapt to these challenges?
(3) In implementing these strategies, what barriers (if any) do you face?
(4) What science information would be useful to help support your local adaptation efforts?

Responses were coded and analyzed using constant comparison analysis (Rossman & Rallis, 2016) to identify recurrent themes over the three-year period. NVIVO, a qualitative data analysis software, was used to produce word clouds that illustrate managers' most frequently mentioned terms (Leech & Onwuegbuzie, 2011).

Shifts in Adaptation Strategies and Barriers

Table 1 summarizes key themes identified across all water managers and word clouds. In summary, despite the 2017 water year that brought historic snowpack, managers still faced ongoing water supply and management challenges following the unprecedented drought years. To adapt, managers described continued drought adaptation efforts to enhance and diversify water supply and to expand data collection to monitor climate impacts, including increased groundwater monitoring.

Referring to recent conditions as the "new normal climate" for which they should be planning, managers referred less often to climate uncertainty as a barrier in implementing their desired adaptation strategies. Instead, managers referred to existing water management institutions as a barrier to adaptation and requested researchers use their modeling tools to evaluate alternative water management strategies for the river system. For example, managers shared interest in exploring how fixed date-based river and reservoir operations developed based on historical climate records may be revised to absorb earlier snowmelt runoff and streamflow timing.

Table 1. Key themes resulting from annual interviews with key water managers during the 2015, 2016 and 2017 water years, with supporting word clouds to illustrate frequently mentioned terms.

2015: "The Point of No Return"

Drought Continues to Challenge Already Scarce Water Supply

- Fourth consecutive drought year (2012-2015) exacerbates water supply challenges and affects routine operations

Adaptation Strategies Being Explored

- Manage water demand to conserve scarce supplies and prioritize restoration projects to enhance climate resiliency

2016: "A Normal Snowpack Lost to a Hot Spring"

Warmer Temperatures Exacerbate Water Scarcity

- Earlier snowmelt reduces summer streamflow and increases evaporation and irrigation water demand

Emergent Barriers to Adapt to: "For what conditions are we planning?"

- Climate uncertainty emerges as a barrier, constraining local climate adaptation

More Focused Adaptation Efforts

- Monitor changes to surface water and groundwater, soil moisture, and ecosystem health
- Explore modifications to existing water management to enhance water supply

2017: "Mother Nature Delivered"

Wet Years Bring a Different Set of Challenges

- Historic snowpack and atmospheric storm events that brought winter and spring flooding require concerted communication and coordination among water managers to mitigate flooding damage

Climate Uncertainty No Longer the Greatest Barrier to Adapt

- Recent climate variability experienced over the 2015, 2016 and 2017 water years defines the "new normal"

Use Science and Modeling to Inform Adaptive Water Management

- Simulate locally identified water management alternatives that may enhance water supply
- Harness improved relationships with researchers and other managers to explore systemwide implications

In addition, managers requested that researchers continue to generate hypothetical yet plausible climate scenarios similar to recently observed climate conditions. Specifically, conditions include warmer than normal winter and spring temperatures bringing more rain than snow, strong atmospheric river storm events, and earlier snowmelt runoff that exacerbates water supply scarcity during late summer when water demand is greatest.

The word clouds presented in Table 1 offer further insight into local managers' changing perspectives over the three years of interviews. For example, in 2015, "changing," "managing" and "drought" were frequently referenced terms. However, in 2016, despite a normal snowpack year (see Figure 1), "drought" was referenced more often, indicating that one normal water year did not sufficiently rebound water supply. Following the 2017 water year, "strategy" was referenced more often, supporting the claim that recent water supply variability merits an understanding of how alternative water management strategies might help overcome implications of the "new normal" climate indicative of extreme drought and flooding, in addition to warmer temperatures.[2]

Next Steps

As part of this five-year collaborative modeling case study, researchers and managers continue to work together to evaluate the climate resiliency of the river system. Researchers will utilize hydrologic and operations modeling tools to quantify potential benefits of locally identified alternative water management strategies, including revisiting fixed date-based reservoir operations in the Truckee River Basin and exploring storage potential through managed aquifer recharge in the Carson River Basin. The collaborative modeling framework featured in this research project helps to ensure that local knowledge is utilized to inform research activities, and that the research results are relevant and useful to local water managers.

[2] For additional data to support this comparative analysis, refer to Sterle & Singletary (2017) and Sterle et al. (Accepted).

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