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WHEN IS DROUGHT NOT A DROUGHT?

DROUGHT, ARIDIFICATION, AND THE "NEW NORMAL"

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Words are important. In current Colorado River water management, perhaps no word is used (and misused) more than *drought*. To most people, the word *drought* contains two concepts. The first is the lack of available water, primarily a function of below normal precipitation, but often exacerbated by management and water-use practices. Second is the notion that the condition is temporary—a deviation from a norm that is expected to eventually return. *Aridity*, in contrast, refers to a dryness that is permanent, and is a function of natural (and presumably stable) climatic conditions. While it is fair to say that the Colorado River Basin is in a period of *drought* (in that recent precipitation has lagged slightly below the long-term averages), and that much of the basin is *arid* (or *semi-arid*), neither term is adequate to accurately describe emerging conditions in the Colorado River Basin. For that, perhaps the best available term is *aridification*, which describes a period of transition to an increasingly water scarce environment—an evolving new baseline around which future extreme events (droughts and floods) will occur. *Aridification*, not drought, is the contingency that should guide the refinement of Colorado River management practices.

The Shifting Baseline

Among the most obvious and alarming symptoms of the changing physical environment is the decline in runoff efficiency—i.e., how much streamflow results from precipitation. Several recent studies have confirmed that, compared to last century, a given level of winter snowpack today results in less river runoff than in the past (Udall and Overpeck, 2017; Woodhouse and Pederson, 2018; Woodhouse et al., 2016; McCabe et al., 2017; and Pitzer, 2017-18). As an example, compare the 1950s drought and the ongoing 21st century drought (see Figure 1). The former had significantly less precipitation, yet the observed reductions in streamflow are quite similar. Why? In large part, the answer is that the basin has become hotter, which modifies several facets of the hydrologic cycle that lie between precipitation and runoff, including evapotranspiration and sublimation rates, the timing of snowmelt, and soil moisture characteristics. These changes are not primarily the result of reduced precipitation and are not temporary—the typical characteristics of drought—but rather are associated with a warming trend that will continue. Thus, while much of the recent decline in runoff can rightly be characterized as drought, the remaining component is a very different and highly troubling shift in runoff efficiency largely tied to warming—a recipe described as "hot drought."

Other research contributes further to our understanding of the changing physical environment. Climate models used in recent studies generally project "wetter" conditions (i.e., more precipitation) than preceding efforts (Ayers et al., 2016). However, this provides little reason for optimism. High uncertainties surround these new projections, and increasing temperatures are likely to overwhelm any possible increases in precipitation. Future risks clearly skew dry—possibly with temperature-induced runoff declines of 35% or more by the end of the century (Udall and Overpeck, 2017; Vano et al., 2014).

These studies also often project a shift in precipitation to the north, with sub-basins such as the Green becoming more important contributors to streamflow, while the arid conditions of the Lower Basin creep northward through the San Juans and the Colorado River sub-basin (Dominguez et al., 2012; Niraula et al., 2017). This trend is already evident and shifts runoff away from infrastructure and population centers established under the flawed assumption that historic patterns of climate and runoff were stable.

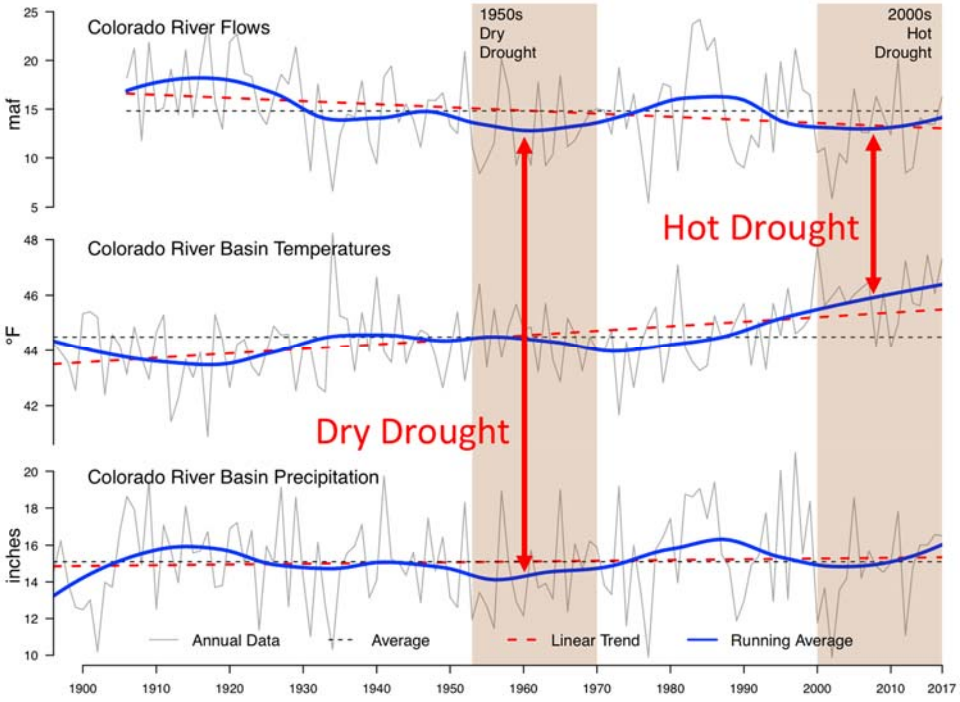

Figure 1. The Changing Nature of Colorado River Droughts (Udall and Overpeck, 2017)

Also creeping upward, in terms of probabilities, is the regional threat of megadrought. From tree-rings, we know that such events have happened infrequently in the past, but risks are increasing rapidly (Meko et al., 2007). Measuring the likelihood of future megadroughts in terms of low soil moisture, one major study suggests that the risk of an event lasting 35 years or more later this century is a near certainty (Cook et al., 2015). This finding further reinforces the prospect that ongoing regional desiccation should be viewed a strong and persistent trend rather than a singular, extreme event.

Warming is not the only human-influenced landscape level change that is affecting runoff levels. One increasingly important phenomenon is "dust on snow"—i.e., the phenomenon that snowfields in the Rockies are more frequently being painted with fine layers of dust that absorb sunlight and thus accelerate snowmelt. Winds now coat the Rockies with five to seven times the dust as seen in the early 19th century, in part due to land disturbances such as grazing that break up soils in the Colorado Plateau and Great Basin. The result, on average, is an earlier (by three-weeks) start to the snowmelt season, and a projected five percent decrease in runoff (Painter et al., 2010). The impact is most pronounced in high dust years (such as 2009 and 2013), generating early season snowmelt peaks that can overwhelm the ability of managers and infrastructure to cope (Deems et al., 2013; Painter et al., 2017). Earlier and smaller runoffs influence the basin in many undesirable ways, threatening water supplies, fueling a longer fire season, robbing (and warming) late season streamflows, and drying out soils in advance of the next runoff season.

An "Aridification Contingency Plan"

Many productive negotiations and reforms are currently underway in the region, including prominently the "drought contingency plans" (DCPs) under development in both the Lower and Upper Basins. In the short-term, it is vitally important that those efforts continue to move forward. Longer-term, the net result of these and future negotiations (such as those regarding the expiration of Interim Guidelines in 2026) must be to address the changing baseline and extreme event probabilities associated with ongoing aridification. Devising an "aridification contingency plan" of this sort is a big and multi-faceted challenge that may necessitate considering management options currently off-the-table in basin negotiations.

Perhaps more importantly, moving forward means abandoning the mindset that current changes to climatic and hydrologic regimes are a temporary phenomenon. We are not likely to ever return to *normal* conditions; that opportunity has passed (Milly et al, 2008). Rather, there are two possible *new normals*. First is a continuation (and likely acceleration) of the current drying trend and the accompanying increase in variability, an outcome largely "baked into" the system by existing atmospheric greenhouse gas concentrations. A second, and better, *new normal* would be to establish regional hydrologic conditions at a steady new level—a step change—that results from the stabilization of atmospheric greenhouse gas concentrations at some new equilibrium. Achieving this second outcome will require many actions taken across the globe, and in sectors beyond water management. Nonetheless, the Colorado River management community can still be a leader in promoting and contributing to such actions. There is much to gain in the basin by leading on these larger issues, as well as by exploring local opportunities—such as dust suppression—to slow or halt ongoing environmental changes. It is time for water managers to both adapt for the profound changes the future holds and to advocate within the political sphere for a reduction in greenhouse gas emissions. A very modest starting point is to admit words such as *drought* and *normal* no longer serve us well, as we are no longer in a waiting game; we are now in a period that demands continued, decisive action on many fronts.

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