WRITTEN TESTIMONY OF
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HEARING ON THE EFFECTS OF WATER QUALITY ISSUES IN THE LOWER COLORADO RIVER

BEFORE THE
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COMMITTEE ON NATURAL RESOURCES
U.S. HOUSE OF REPRSENTATIVES

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Chairwoman Napolitano, Ranking Member McMorris Rodgers, Arizona Representative Grijalva and other members of the subcommittee, thank you for the opportunity to speak with you today on water quality issues in the Lower Colorado River.

My name is Jonathan Overpeck. I am the founding co-director of the Institute of the Environment at The University of Arizona, where I am also a professor of geosciences and a professor of atmospheric sciences. I have published more than 130 papers on climate and the environmental sciences, and recently served as a coordinating lead author for the U.N. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment (2007). I have been awarded the US Department of Commerce Bronze and Gold medals, the Walter Orr Roberts award of the American Meteorological Society and a Guggenheim Fellowship for my interdisciplinary research. I also serve as principal investigator of the Climate Assessment for the Southwest (CLIMAS), an interdisciplinary Regional Integrated Science and Assessment (RISA) project funded by NOAA. In this capacity, and others, I work not only on generating climate system knowledge, but also on supporting use of this knowledge by decision-makers in society.

There is a perfect storm on the horizon that will pose major threats to the Colorado River Basin, its ecosystems and its people. This perfect storm has both natural and human causes, and it requires urgent and sustained action by the federal government, states, universities and their partners to ensure that the basin, and all that depends on it, weathers the storm. There are *three principal threats* to the sustainability of the Colorado River Basin: (1) population growth and over allocation of water, (2) the very real potential for decades-long drought and (3) continued climate change. All three have happened in the past, or are ongoing, and the most recent science suggests all three are even more serious threats for the future. *Two broad solutions* are required: (1) mitigation of climate change via the reduction of greenhouse gas emissions and (2) a much enhanced, stakeholder-driven capacity to adapt to unavoidable future climate variability (i.e., drought) and climate change. Neither solution is alone sufficient, and both are necessary. Special attention should be placed on ensuring that the abundant renewable energy potential (i.e., solar and wind) of the Colorado River Basin region is developed without jeopardizing the land and water resources that are needed for non-energy purposes, including climate change adaption.

The Water Allocation Threat

The futures of the Lower Colorado Basin and Upper Colorado Basin are closely intertwined, both in terms of challenge and opportunity, by their semi-arid climate and co-dependence on Colorado River water. A focus on the Lower Colorado River Basin is incomplete without consideration of the entire Colorado River Basin.

The seven states of the Colorado River Basin (AZ, CA, CO, NM, NV, UT, WY) include some of the most rapidly growing parts of the nation (Figure 1), as well as some of the nation's largest cities, Indian reservations and agricultural areas. Populations are projected to expand even more in the next 30 years (e.g., double in Arizona, and grow even more in absolute terms in California). Limited natural recharge of groundwater makes the Colorado River region highly dependent on surface river flow for water. Agreements in the 20th-century allocated an average annual total of 16.5 million acre feet (MAF) among the basin states and Mexico, but recent scientific studies indicate the actual long-term average flow is no more than 14.6 MAF. Even in the absence of any climatic threats, the seven states of the Colorado River Basin have a serious water problem.

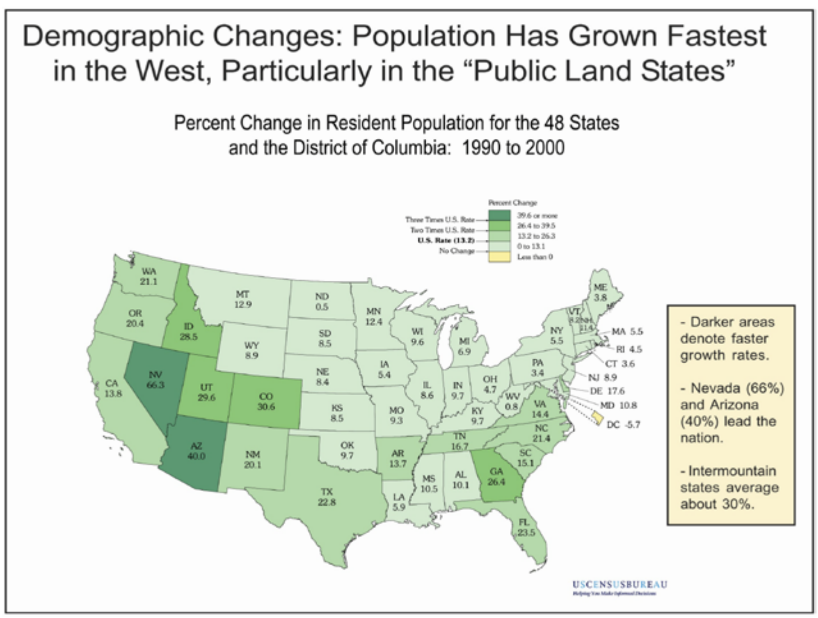
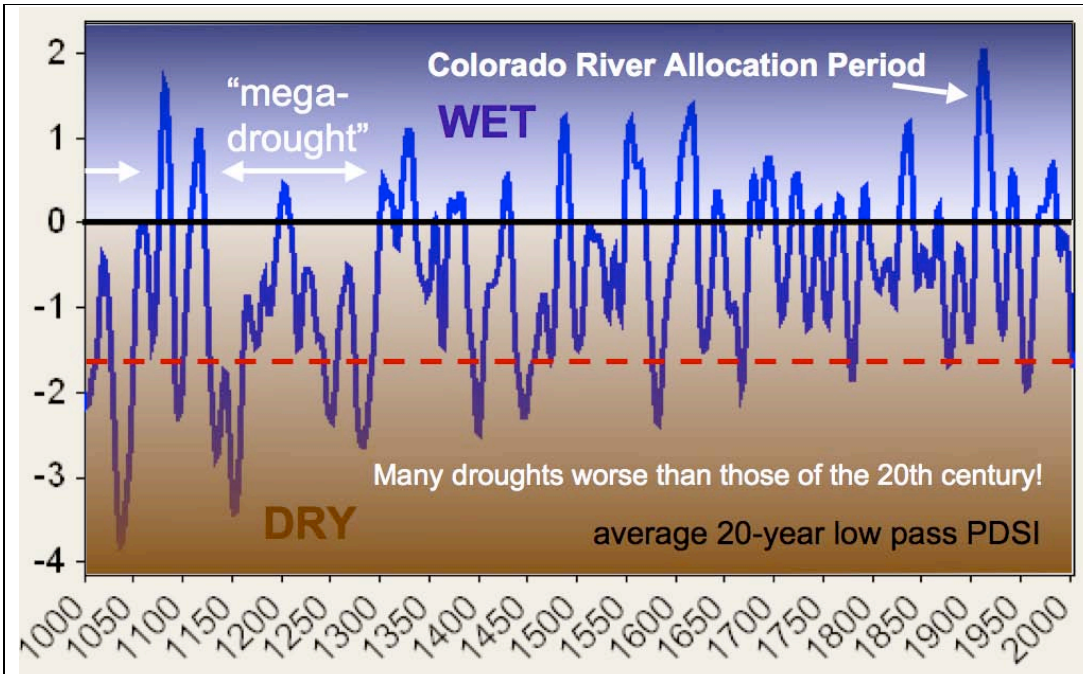


Figure 1. *Population change during the last decade of the 20th century. The darker the shading, the greater the rate of population growth. Continued rapid increases are projected for the seven Colorado Basin states, with two Lower Colorado Basin state (AZ and NV) in competition to be the fastest growing in the country. Source: U.S. Census Bureau.*

The "Megadrought" Threat

Two major climate issues threaten the Colorado River Basin with even larger water problems, problems that threatens the very sustainability of the region. The *first climate* *threat* is natural: we now know from tree-ring and other research that the Colorado River Basin is likely more prone than any other part of the U.S. to decades-long drought, often referred to as "megadrought." Droughts of the last century, including the devastating Southwest drought of the 1950s, as well as the even hotter drought that has plagued the Lower Colorado Basin since 1999, pale in comparison to longer droughts that routinely plagued the Southwest U.S. over the last 2000 years. For example, the period AD 1130 to 1300 was characterized by 170 years of frequent severe drought in much of the western U.S., particularly in the Colorado River Basin (Figure 2). Thus, even though the drought since 1999 has caused the major reservoirs on the Colorado River to decrease from full to half full in only a couple of years, this drought is minor in a long-term context.



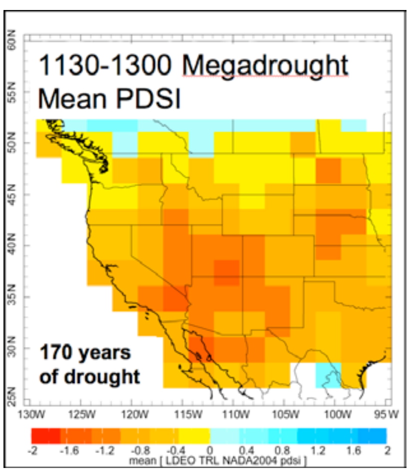


***Figure 2**. (Above) Record of hydrologic variability in the headwaters of the Lower Colorado River Basin over the last 1000 years as reconstructed using a network of tree-ring data. Wet is up (blue) and down (brown) is dry; the red dashed line indicates the level of drought associated with the recent 21st century drought. Note the record "wet" period that coincided in time with the 1920's allocation of Colorado River water among basin states, as well as the major droughts prior to 1900. (Left) Map showing the average hydrologic conditions (orange colors indicate drought) during the AD 1130 to 1300 "megadrought." Data source: Cook et al., (2004) Science v. 306, 1015-1018.*

The most troubling aspect of the megadrought threat is that climate scientists currently lack the ability to predict such drought with confidence. What *is known* with confidence, however, is that the Lower Colorado Basin is regularly hit by multi-year, and even multidecade drought, and that it is likely that the region will experience such devastatingly severe droughts in the future. It is also no comfort that the longest droughts appear to have occurred during previous periods of above-average Northern Hemisphere temperature, as during medieval times.

The Climate Change Threat

The *second climate threat* is likely human-caused. Climate change is warming up and drying out the Colorado River Basin. Temperature increases over the last 100 years are among the largest during this period in the United States (Figure 3), and these increases are causing snowpack to melt earlier, resulting in decreasing river flow. Even more troubling, climate models agree with the recent climate observations that show an ongoing trend toward less late winter precipitation, and thus lower river flow. It appears that human impacts on the climate system are causing all-important late winter storms to track further northward than in the past, drying out the Lower Colorado Basin region as a result.

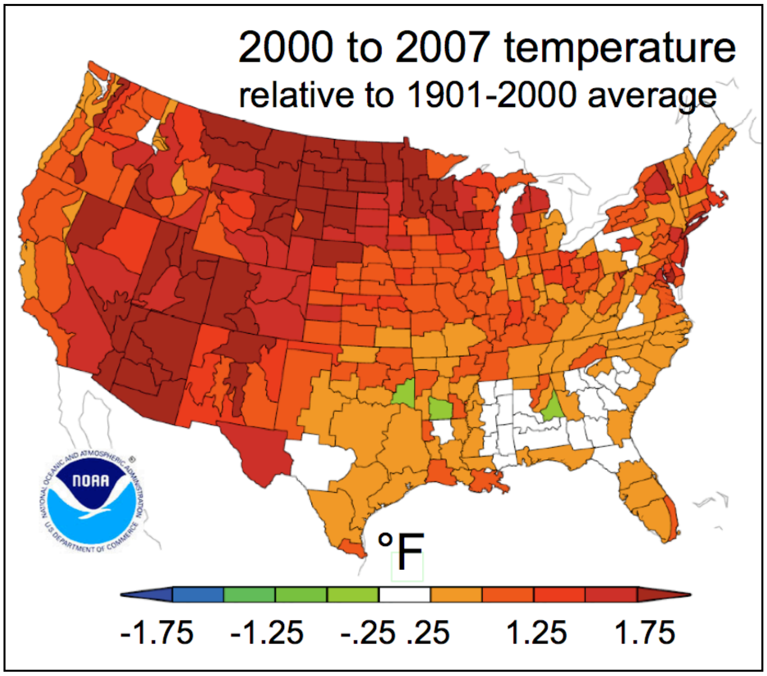


Figure 3. *Average 21st century temperatures relative to the average temperatures of the 20th century. The Lower Colorado River Basin has warmed as much or more than any other region of the lower 48 states. Map from M. Hoerling, NOAA.*

Climate warming and drying is also combining to cause unprecedented vegetation death and wildfire in the region with largely unknown consequences for runoff amounts and water quality. For example, the ongoing reduction of vegetation cover in the Four-Corners area of the Southwest is allowing more desert dust to be blown into the mountains of Colorado, where the dust appears to cause a further reduction in snowpack and river flow. Climate, hydrologic and ecological science all indicate that the Colorado River Basin will likely become more prone to increasingly hot droughts and is thus rapidly becoming one of the nation's "hotspots" for climate change impacts.

Climate change is likely to drive many aspects of change in the Lower Colorado River Basin other than just warming, less snow and reduced river flow. Climate change is also likely to cause an increase soil dryness (Figure 4), as well as an increase in drought frequency. Although it is too early to tell if climate change is the mechanism behind the most recent drought in the Colorado River Basin, there appears to have been a global increase in drought frequency as predicted by theory and models. Paradoxically, a warmer atmosphere will also likely cause precipitation to be more intense when it occurs. This increase in intensity has been observed across the U.S., and in the Lower Colorado River Basin, it means more potential sediment and pollution mobilization (e.g., of historic mine waste) in the future. Moreover, the acceleration of snow melt in late winter by a warming atmosphere is likely to increase the chance of flooding, as is the switch from snow-dominated to rain-dominated precipitation in late winter. Although this will likely mean more turbid river water, the details of how it will impact ecosystems and people are not known.

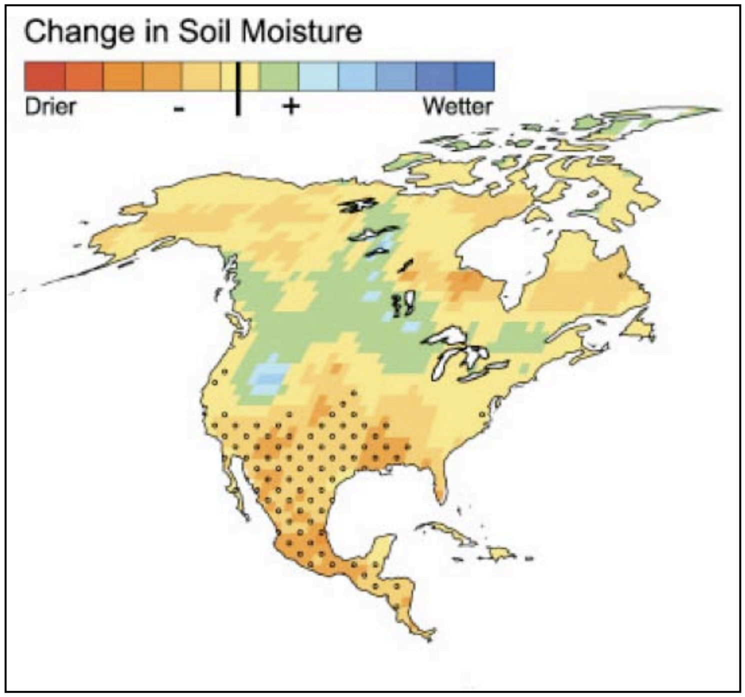


Figure 4. *Average change in soil moisture projected by many climate models for the end of the 21st century assuming only small reductions in greenhouse gas emissions. Yellow and orange colors indicate those areas that are projected to dry on average, and stippling indicates those areas where model agreement is greatest. In other words, the Lower Colorado River Basin is among the most likely regions to see a drying out of soil and vegetation in the future. From Overpeck (2009) Southwest Hydrology v. 8(2): 24-30, after IPCC 2007.*

Future Climate Impacts and the Bottom line for the Lower Colorado

The bottom line is that the Lower Colorado River and surrounding region are likely among the most threatened coupled human-ecological systems in the nation. What has been predicted has already started. What *is* known is that there will likely be less water to go around even before human population increases and the potential for megadrought are factored in. What *is not* known is exactly how much less water, the timing of change, or the details of how many aspects of a more arid Lower Colorado River Basin will be affected by the drying. For example, even though *all recent projections* of future Colorado River flow into the Lower Basin indicate less flow is likely, projections range from roughly -5 to -45 percent less river flow by mid-century, assuming modest reductions in global greenhouse gas emissions (Figure 5).

Less water on average, combined paradoxically with more intense rainfall and greater chances for flooding, means that water quality will likely become an ever-increasing challenge for the Lower Colorado River Basin. Warmer temperatures will also increase evaporation, and when combined with a greater need for water recycling, water quality will become more difficult to maintain (e.g., the water used in agricultural applications will become less fresh). Moreover, reduced water availability will likely also drive greater demand for water reuse in urban settings and also heighten concern over water quality that goes with water reuse.

Similarly, continued warming and drying of the Lower Colorado River Basin is likely to place increased stress on natural ecosystems. In-stream water needed for maintaining healthy aquatic ecosystems will become more challenged by other water uses as river flow continues to decrease. The prospects for upland ecosystems in the Lower Colorado River Basin also look dim with continued climate change, warming, drying of soil, increased drought frequency, and removal of soil by wind. In addition to continued increases in plant death and wildfire, it will be increasingly necessary to manage for change rather than to preserve existing ecosystems. New land management paradigms must be developed and tested.

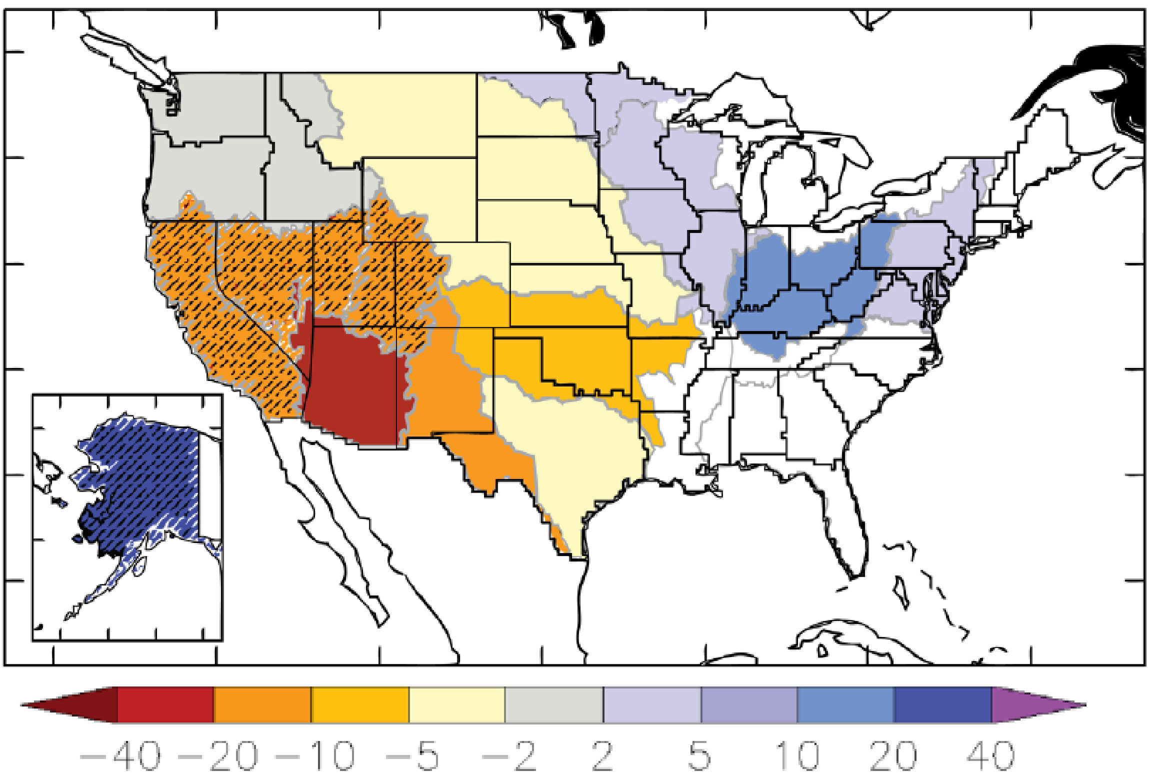


Figure 5. *Percent change in average in river basin runoff volume projected for the middle of this century (relative to the period 1900 to 1970 average). Color denotes percentage change for a climate change scenario assuming only modest reductions in global greenhouse gas emissions (current emissions are significantly higher than this emission scenario). (After Milly et al., 2005). The major water basin with the most potential change is the Lower Colorado River Basin, colored red above. Unpublished research suggests the Colorado River flow entering the Lower Colorado River Basin is most likely to be reduced by 20 percent given the same reduced greenhouse gas emissions*

scenario, but also that there is an associated 30 percent chance (even without potential megadrought factored in) that all Colorado River Basin storage (i.e., 60 MAF of reservoir storage) could go dry by 2050. (Rajagoplan et al., personal communication).

Solutions to Averting Crisis on the Lower Colorado River

Two actions are necessary to avert a water crisis in the Lower Colorado River Basin. *First*, global emissions of greenhouse gases, and especially carbon dioxide, must be reduced significantly. Reductions of greenhouse gas emissions by 2050 to levels 80 percent below 1990 levels is a good target. The Lower Colorado River Basin is blessed with the greatest solar power potential in the nation and also has significant wind assets that can be tapped to curb emissions. *Second*, a ***federal stakeholder-driven science and services program*** is required to provide the *actionable knowledge* and *knowledge access* for decision makers across the basin so they can plan and act to reduce vulnerability. This vulnerability could result from continued population increases, the potential for more severe drought, and the myriad of climate change impacts that will occur even as the most damaging impacts are averted via aggressive reductions in GHG emissions.

Not only would such a science and services program help avert future water conflict among states, Native Nations and Mexico, it would also provide the capacity to deal with other implications of continued population increases, drought and climate change: threats to the region's ecosystems, public health, agriculture, ranching, air and water quality, and much more. The same science and services program would also help optimize greenhouse gas emissions reduction levels while ensuring that the build out of low-carbon energy in the sun- and wind-rich basin states is implemented in a manner that does not exacerbate water or land management problems in the basin.

The needed stakeholder-driven science and services program should build on the successful NOAA-funded Regional Integrated Sciences and Assessments (RISA) model of university-based *regional stakeholder-driven interdisciplinary science and services*. The new program should be focused on the entire Colorado River Basin, and should be implemented via funding administered by the three RISAs active in the basin, and with strong oversight by lead water, ecosystem and other stakeholders in the basin. The funds would be allocated to RISAs and partners in the basin states, as well as to universities, federal labs and other partners outside the basin who can help meet the stakeholder-driven needs of the Colorado Basin region. Resourcing at a level of $20 million per year for 10 years would be appropriate this effort.