Southwest faces diminished stream flows, new water policies

By Melissa Lamberton

Growing populations, energy production, and agriculture all tap water from Southwest rivers. Now, climate change is staking its own claim, challenging western states and water managers to reconsider long-standing policies on how water is allocated and used.

University of Arizona law professor Robert Glennon says this marks an "era of reallocation." In his book *Unquenchable: America's Water Crisis and What to Do About It*, released in April, Glennon calls for new ways of valuing water that recognize the resource as limited.

"There is no new oasis out there where we can magically come up with new water," Glennon said in an April interview. "We in the West traditionally allowed anyone to put another straw in the glass. It's a recipe for disaster."

In an effort to avert disaster, Glennon and other water experts are increasingly looking toward innovative solutions for the future, including incorporating new legal measures to ensure states share a certain volume of river water, pricing water appropriately, and reallocating existing water rights.

Figure 1. This image captures the water level in Lake Mead. In the last 100 years, the Colorado River flow has averaged 15.1 million acre-feet per year. Climate change threatens to reduce this amount. Photograph is courtesy of Bureau of Reclamation.

Higher temperatures diminish flows

Climate change will not affect all rivers alike. Kevin Trenberth, a scientist at the National Center for Atmospheric Research in Boulder, Colo., co-authored a study that examines changes in the amount of water that reaches the sea from rivers around the world. The study appeared in the *American Meteorological Society's Journal of Climate* in May.

About 10 percent of the world's largest 200 rivers showed an upward trend in 1948–2004 data, typically in northern latitudes where snowmelt and precipitation have increased. Forty-five of the 200 rivers—about 23 percent—had diminishing trends, particularly in subtropical and tropical regions. One of those regions is the Southwest, which falls into the subtropical range, roughly 20 to 35 degrees latitude.

Trenberth's study shows lessening flows in the Colorado River, which serves a growing population in seven U.S. states and Mexico. "Dams and human withdrawals complicate the picture everywhere and are certainly an important factor for the Colorado," Trenberth said. "But the study suggests climate change is also a significant driver."

The Colorado River primarily is fed by snowmelt, which seeps from high elevations to add a swell of cold water in spring. A 2007 National Research Council study explained how a warming climate decreases snowpack in the mountains and leads to earlier snowmelt. Higher temperatures also cause more evaporation. The result, the NRC study concluded, is likely altered hydrologic cycles and reduced flows in western rivers.

The effect of warming temperatures on precipitation in the Southwest is harder to predict. Some scientists, including Trenberth, suggest climate change will bring fiercer summer thunderstorms with fewer soaking winter rains. Other models predict different precipitation changes. Most scientists agree that higher temperatures alone will reduce runoff in western rivers, with precipitation changes likely to exacerbate the problem.

Various models calculate reductions in the Colorado's flows, with several of the most well-regarded models projecting declines of 10 to 30 percent by mid-century. The Colorado River is particularly vulnerable to climate change because its flows have already been over-allocated for human use, Trenberth noted.

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Interstate compacts

Even small reductions in a river's flow can have a serious impact on interstate policies. Rivers that flow over state borders, like the Colorado, Rio Grande, Klamath, and Pecos, are divided among users through complex agreements called compacts. Some of these compacts are flexible and capable of resolving conflicts, while others may be ill-equipped to deal with climate change, said Edella Schlager, a University of Arizona associate professor of public administration and policy.

Schlager heads up a National Science Foundation study that examines 14 western interstate compacts. How these compacts will respond to climate change will vary from state to state, Schlager said. The Costilla Creek Compact, for example, allocates water between Colorado and New Mexico by percentages. If river flows are reduced, the shortage will be spread among the two states. In the South Platte Compact, however, Colorado guarantees a minimum flow to the downstream state, Nebraska.

"The burden of climate change, in a water allocation rule like that, rests on the upstream state," Schlager said.

The Colorado River, not included in Schlager's study, is governed by a complex series of allocation rules collectively known as the Law of the River. The law's cornerstone is the 1922 Colorado River Compact, which divided 16.5 million acre-feet of water among the users, not including evaporation loss. One acre-foot is about 326,000 gallons, enough water to satisfy the needs of about four people for one year.

The compact allows the states in the Colorado River's upper basin—Colorado, Utah, New Mexico, and Wyoming—to consume 7.5 million acre feet per year. The rules also require the upper basin to deliver 7.5 million acre-feet to the river's lower basin—Arizona, New Mexico, Nevada, and California—plus another 1.5 million acre-feet to Mexico. Although there is some flexibility in the law—the required amount can be delivered yearly or averaged over a decade—the upper basin is obliged to cut back its water use, if needed, to make the delivery.

Tree-ring data spanning more than 1,200 years have since estimated the river's annual flow to average 14.65 million acre-feet. In a 2007 amendment to the Law of the River, the U.S. Bureau of Reclamation

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Figure 2. Periodic drought plays a major role in water management in the Southwest U.S. For example, in 2002 the Colorado River flow was 5.4 million acre-feet, slightly more than one-third of the 1906–2005 average. Image courtesy of University Corporation for Atmospheric Research.

Stream flows, continued

developed an environmental impact statement that considers how climate change might influence management of the Colorado. Kathy Jacobs, director of the Arizona Water Institute and a major contributor to the project, said the new guidelines allow for joint operation of two reservoirs—the upper basin's Lake Powell and the lower basin's Lake Mead—to improve flexibility during shortages.

Climate change is also likely to burden river ecosystems because rivers themselves are last in line for water. All of the compacts were developed prior to the 1970s, and "none of them consider environmental values," Schlager said.

The compacts are based on the prior allocation rule, which states that the first person to divert water for a "beneficial use" has a priority right. Historically, leaving water in a riverbed was not considered a beneficial use, nor did it fulfill the requirement to physically divert water from the stream. The system was developed in western mining camps, where miners needed to divert large quantities of water to wash gold and silver from the hillsides. The rule later was adopted for irrigation and domestic water use.

The benefits of preserving in-stream flows have only recently gained recognition. "Healthy rivers are critical to us as a people," Glennon said. "It's the legacy of the area. It's what people originally settled here for."

Solutions for adapting

States are generally unwilling to reopen hard-won water compacts for renegotiation. If climate change reduces river flows, states will likely try to adapt within the existing framework.

"It's really hard to overstate the value of water and how states treasure their water resources," Schlager said. "They're reluctant to do anything to place their water resources at risk."

Most western compacts, she said, currently lack compliance mechanisms to ensure upstream states deliver the promised water when flows are low. She suggests states should incorporate compliance measures into their compacts, such as third parties to oversee river management or a pool of water in an upstream reservoir controlled by the downstream state.

Schlager also advocates for investments in sophisticated hydrological models to track river changes. Hydrologic monitoring is critical, she said, because many of the compacts have complicated allocation rules that rely on knowing exactly how much water is in the river. Climate change is likely to alter the rhythm of rivers' flows, making it more difficult for upstream states to meet their delivery requirements. States need to implement an information system that all the users agree on, so that when disagreements arise they will be able to pinpoint how much climate change is to blame for diminished flows, or whether the upstream state also bears responsibility, Schlager said.

"There might be opportunities for states to cooperate, given that they're facing a new hydrologic regime," she said. "The only way to really survive is to work together to provide a common response."

Glennon also sees a need for extensive monitoring systems, but he envisions this coming mostly from the federal level. He calls for fundamental changes in the way water is viewed in the West, outlining new mechanisms for controlling water use that would supersede existing policies. For example, farmers currently receive about 80 percent of the water resources in western states, Glennon said. He suggests reallocating water from low-value uses, like alfalfa and cotton, to high-value uses, like the Intel Corporation, which requires large quantities of ultra-pure water to manufacture microprocessors. Glennon writes that an acre-foot of water used to grow alfalfa generates about $264, while an acre-foot used to manufacture Intel chips generates $13 million.

Glennon also suggests using market forces to discourage wasting water. In the U.S., he said, one-third of all water companies have decreasing block rates, so the more you use, the less it costs per gallon. Other companies simply offer a flat rate. He envisions policies that recognize a human right to water for basic necessities, coupled with increasing block rates so that the larger water consumers pay more.

"We think of water like air—something that's inexhaustible and limitless," Glennon said. "We have so undervalued the resource that most of us pay more for cell phone service and cable television."

In addition, developers should have to purchase and retire an existing water right in exchange for permission to build, rather than simply adding a new straw to the glass, Glennon said. The usual engineering solutions—more dams, diversions, or pipelines—are not going to work anymore, he said. Instead of searching for new sources, he advocates for ways to conserve the existing supply.

In his book, Glennon also writes of a growing movement in western states to develop "water trusts," organizations that protect in-stream flows by purchasing water rights. Water trusts provide incentives to farmers to conserve water for environmental uses and ensure that if a farmer chooses to leave water in the stream—perhaps to improve fishing or protect an endangered species—another farmer cannot claim the water by diverting it.

"This is a crisis, but not a catastrophe," Glennon said. "It's a time when we still have options. Now we need the courage and political will to act."

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