

New research predicts California droughts will worsen

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Future droughts in California are likely to bite deeper and last longer than the one now gripping the state, according to new research into the potential effects of climate change.

Scientists from the Scripps Institution of Oceanography and the U.S. Geological Survey used computer climate modeling tools to estimate the effects of warmer temperatures in future decades. In particular, they studied the effect on California's mountain snowpack, the largest source of fresh water in the state, which refills thousands of water-storage reservoirs each spring via snowmelt.

The results show that by 2050, the median snowpack present on April 1 each year could be one-third smaller than the historical median, and by 2100 it could be two-thirds smaller. Such a dramatic loss of snowmelt would produce less runoff to refill reservoirs each summer, potentially making droughts an ever-present condition.

The research also shows that by 2100, there is only a 10percent chance that California mountains will see a snowpack equal to the median that accumulates today.

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The research was conducted by some of California's leading climate researchers, and has not yet been published or peer reviewed. It was presented Thursday at the Bay-Delta Science Conference in Sacramento.

"The water contained in the snowpack is declining pretty steadily through the 21st century," said Dan Cayan, director of the California Climate Change Center at Scripps in San Diego and the study's lead author. "According to the models, we're already detecting these changes in snowpack."

California water management officials are bracing for these potential changes. On Thursday, the state Department of Water Resources released a revised [California Water Plan](#), a comprehensive strategy to protect the state from water shortages and floods that looks out to 2050. A major focus involves managing the effects of climate change.

"Unless we take strong action, we won't have the existing water be reliable for the future," said John Laird, secretary of the California Natural Resources Agency, which oversees DWR. "Over time, conservation as a way of life in California is something that simply has to be done."

State officials released the plan just days before California voters weigh in on Proposition 1, a \$7.5billion water bond pushed by Gov. Jerry Brown. If passed, the measure would authorize bonds for a range of water projects, including dams, groundwater replenishment, water recycling, flood protection and habitat restoration.

DWR's water plan lays out 350 strategies aimed at boosting water supplies and improving conservation. Key among them is better connecting existing water systems. For instance, the plan calls for reconnecting rivers with their historic floodplains so that, when floods occur, the water can be held on the land to recharge groundwater wells.

In many cases, this would mean breaching levees. It also could mean difficult changes in land use, said DWR Director Mark Cowin.

"For many decades, one of the challenges we've had is that agencies that carry out responsibility for water management are not necessarily connected to the local agencies that are responsible for land use," Cowin said.

“That needs to change.”

Cayan’s research into climate change would seem to support this direction. The research found that the Sierra Nevada, source of most of California’s crucial snowmelt, could warm by an average of 3degrees Celsius (or 5.4degrees Fahrenheit) by 2100. This could mean less of the mountain range gets snowfall in winter but gets rain instead. That would result in less snowmelt to refill reservoirs, and a need for more ways to capture rainfall during winter.

The research shows that each 1degree Celsius of warming results in a loss of about 23 percent of the snowpack typical today. Cayan called the findings “fairly robust,” noting the results are based on 32 different climate simulations, an unusually large number.

“The western slopes of the Sierra are among the most vulnerable to temperature change in the U.S.,” Cayan said. “What we’re seeing here is a sort of slow and constant march toward warmer temperatures, and that’s tending to depress the snow water that’s stored in the snowpack.”

Because of the way reservoirs are operated today, it is difficult to capture all the runoff from rainfall that occurs in winter. Most large reservoirs are required to maintain a certain amount of empty space at all times during winter to ensure there is room available to capture potential floodwaters. In the days and weeks after every storm, water is slowly released downstream to maintain that empty space.

A relatively new concept called “forecast-based operations” could be applied instead, which would allow reservoirs to hold more water in storage when storms are not expected. But it has been slow to evolve and is not yet formally in use at any major California reservoir.

Changing reservoir rules is not simple, because the state’s reservoirs serve many purposes. The changes could increase flood risk, alter wildlife habitat and diminish recreational opportunities.

Folsom Lake in the Sacramento region is a case in point. Its dam is in the midst of a billion-dollar project to construct a new spillway to handle larger floods. As part of the project, the U.S. Army Corps of Engineers is rewriting the reservoir operations manual that governs how water releases are managed. The rewrite began in 2010 and is not expected to be finished until 2017. That rewrite is expected to cost \$11million.

Corps officials say they aren’t yet sure if forecast-based operations will become part of the new rulebook. They are studying the accuracy of historical weather forecasts to determine whether meteorology can safely play a role in operating a major flood-control dam.

The basic problem is that weather forecasts still are not 100percent accurate. It is difficult to predict how a major Pacific storm will affect a relatively small watershed, such as the American River, which drains into Folsom Lake. A storm could shift direction slightly as it makes landfall, missing the watershed entirely. Water released from Folsom Dam to prepare for that storm would then be lost. The opposite is also possible: If a big storm hits the watershed unexpectedly when the reservoir is full, flooding could result.

DWR’s Cowin said a broader rethinking of California water systems is needed to account for climate change as well as population growth. The state’s population, at 38million, already exceeds all other Western states combined. By 2050, it is projected to increase 30percent, to about 50million people.

Serving all those people in a warmer future would mean changing the rulebook at every reservoir, along with increasing water supplies through conservation, wastewater recycling, groundwater storage and other measures.

All this will cost money. The California Water Plan estimates the state needs to invest \$200billion over the next decade simply to maintain current levels of service, and another \$500billion in future decades to make improvements. Those numbers include all levels of government spending, from local water districts to the federal

government.

“That sends a pretty clear signal that water is going to cost more for Californians in the future,” Cowin said. “I think that’s a reality we’ll all have to get used to.”

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