Sierra Nevada freshwater runoff could drop 26 percent by 2100

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Looking to the north towards Mt. Whitney and the Sierra Nevada from Mt. Langley, California. Credit: Mel Stoutsenberger/Wikipedia

Freshwater runoff from the Sierra Nevada may decrease by as much as one-quarter by 2100 due to climate warming on the high slopes, according to scientists at UC Irvine and UC Merced.

Accelerated plant growth at higher elevations caused by increasing

temperatures would trigger more water absorption and evaporation, accounting for the projected runoff declines, the researchers add.

A diminished river flow will only add to the burden of providing resources to the thirsty farms and homes that rely on it. The state is currently experiencing a severe drought, and some reservoirs and groundwater levels are at all-time lows.

The study findings appear this week in the early online edition of *Proceedings of the National Academy of Sciences*.

"Scientists have recognized for a while that something like this was possible, but no one had been able to quantify whether it could be a big effect," said UCI professor of Earth system science Michael L. Goulden of the decreased runoff. "It's clear that this could be a big effect of climate warming and that water managers need to recognize and plan for the possibility of increased water losses from forest evaporation."

According to the researchers, runoff from mountain ranges is vulnerable to temperature hikes that lengthen growing seasons and result in more vegetation growth at high elevations. Snow-dominated mountain forests that are currently dormant in winter with cold temperatures have lower vegetative density and less evapotranspiration than downslope forests in the snow-rain transition zone, which have year-round growing seasons. Evapotranspiration is the combination of water evaporation from land and the loss of water through plant-leaf transpiration.

Goulden and UC Merced's Roger C. Bales investigated the potential influence of a warming climate on evapotranspiration in the Kings River Basin in California's Sierra Nevada and found resulting changes in the amount of freshwater mountain runoff available to serve surrounding communities.

They gauged water vapor emission rates and combined those measurements with remote sensing imagery to determine relationships among elevation, climate and evapotranspiration. According to the data, freshwater mountain runoff is highly sensitive to expanded vegetation growth.

The authors found that greater vegetation density at higher elevations in the Kings basin with the 4.1 degrees Celsius warming projected by climate models for 2100 could boost basin evapotranspiration by as much as 28 percent, with a corresponding 26 percent decrease in river flow.

Further, the relationships among evapotranspiration, temperature and vegetation density were similar across a broader area of the Sierra Nevada, suggesting that the impact of climate change on evapotranspiration and freshwater availability could be widespread.

"Most people have heard about the giant forests around Yosemite and Sequoia national parks, but these areas have not been a focus of this type of research. Understanding of Sierran hydrology has improved recently with the National Science Foundation's Critical Zone Observatory, and data collected there allowed us to look at the problem from several perspectives," Goulden said. "All of our analyses pointed in the same direction: An upslope expansion of forest with warming would cause a large increase in evaporative water loss and lead to reduced water availability."

More information: "Mountain runoff vulnerability to increased evapotranspiration with vegetation expansion," by Michael L. Goulden and Roger C. Bales. *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1319316111

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