



United States Department of Agriculture  
Forest Service  
Pacific Southwest Research Station

# The Importance of Streamflow in California's Southern Sierra Nevada

## Background

Studies show that 55 to 65 percent of California's developed water comes from small streams in the Sierra Nevada, thus it is important to understand the role of climate and snowpack on streamflow. In the southern Sierra, more than 75 percent of precipitation falls from December through April. However, snowmelt starts in April and usually produces peak streamflow in May. At high elevations, the spring melt often continues into June providing mountain water for summer months. The Kings River Experimental Watersheds (KREW) study demonstrates that snow-dominated locations generate a greater yearly streamflow than rain alone. The difference in streamflow between the KREW Providence Creek site, a rain-dominated lower elevation site, and the Bull Creek site, a snow-dominated higher elevation site, on average is 58 percent per year.

KREW is a watershed-level, integrated ecosystem project for headwater streams in the Sierra Nevada. Two study sites are equipped with instruments to monitor ecosystem changes at eight headwater streams. Streamflow data, just one component of the project, has been collected since October 2002 from the Providence Creek site, located at an elevation of 4,910-6,950 ft., and since 2003 from the Bull Creek Site, at 6,720-8,150 ft. elevation.

## What is Streamflow?

Streamflow is the amount of water within the stream channel leaving a watershed. It is expressed as a rate of flow such as: cubic feet per second (cfs) or gallons per minute (gpm). The daily average of streamflow varies during the year ranging from 90-540 gpm. However, during periods of spring snowmelt, average daily flows range from 350-980 gpm. A single rainstorm on December 19, 2010, produced peak flows of 16,500 gpm on some of the lower elevation watersheds. Due to the high variability in streamflow, KREW uses a double flume system to accurately measure flows (fig. 1). A flume is a uniform fiberglass channel placed in the stream. Automated instruments at 15-minute intervals continuously measure water height in each flume. The streamflow can be calculated from the water height of the stream and the cross-sectional area of each flume. This high frequency of data collection allows for an accurate representation of rapid changes in flow that occur during storm events; accurate streamflow is a key factor in determining stream pollution contaminant and sediment loads. In addition, monitoring the change in streamflow before and after watershed treatments (i.e. tree thinning and understory prescribed burns) is critical for understanding the effects of management activities on downstream systems. KREW data are also useful for computer modeling to better understand and predict future streamflow with different vegetation, climate, or air pollution stress.



Figure 1—KREW's double flume system. The large flume (background) accurately captures high flows, and the small flume is successful at measuring lower base flows.

## Snow and Yearly Streamflow

More than 60 percent of the yearly flow from the KREW watersheds comes during a three-month period in the spring. During this time, temperatures rise enough to allow the snow stored on the watersheds to melt. At the Providence Creek site, the spring runoff period typically lasts from March to May (fig.2). The Bull Creek site has colder temperatures and a deeper snowpack so spring runoff typically is April through June although snow can last well into July in some years. Streamflow during the snowmelt period can be as much as 6.5 times the late summer flows. The amount of snowfall in each watershed is an important factor in the total yearly flow for each stream. A water year (WY) starts on Oct. 1 and continues through Sept. 30 of the following year.

## Snow and Yearly Streamflow

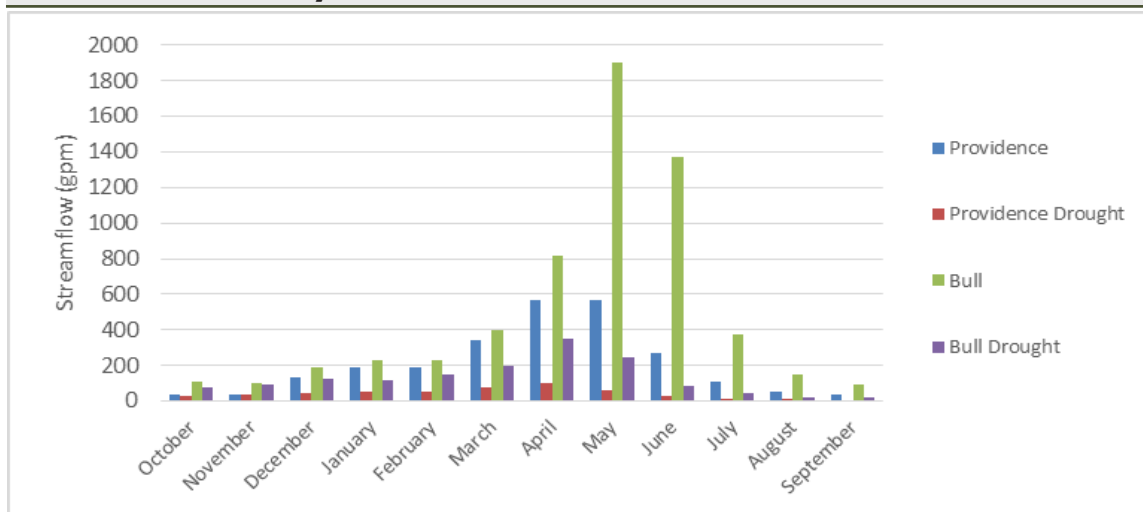


Figure 2: Average monthly streamflow (gallons per minute) comparing wet years (2004-2011) and drought years (2012-2015). Note the large percentage of yearly flow during the spring snowmelt period. Average values are based on four watersheds at each site.

In WY 2005, 2006, and 2011 approximately 40 percent of the yearly precipitation that fell on the Providence Creek site was measured as streamflow. The remainder was evaporated back to the atmosphere, used by trees and vegetation, or stored in soil and groundwater (fig. 3). However, in those same water years, the Bull Creek site watersheds had streamflow equivalent to 55 percent of the yearly precipitation. This 15percent difference in streamflow is because much of the precipitation that falls at the Bull Creek site is snow while the warmer Providence Creek site receives more rain which can soak into the soil and be used by vegetation that is not dormant. Some of the difference is also because of coarser soils which drain faster at the Bull Creek site. A prolonged drought started in 2012 in California; this caused a significant decrease in streamflow. At the Providence Creek site the streamflow was only 10 percent of the average yearly precipitation from 2012-2015 while at the Bull Creek site it was 20 percent; vegetation was stressed during these years, especially at lower elevations where tree mortality occurred.

## Implications to California

As climate changes in the Sierra Nevada, scientists predict more precipitation to fall as rain than snow. This will likely result in earlier start of spring snowmelt making less water available during the summer months. In addition, rain is absorbed by mountain soils and vegetation more easily than snow, so the expected increase in the percentage of rain may reduce the total yearly streamflow. This could leave less water for the downstream foothills and Central Valley of California. Researchers at KREW are evaluating climate change effects on headwater systems; the Providence Creek site is an example of how the Bull Creek site may function in the future.

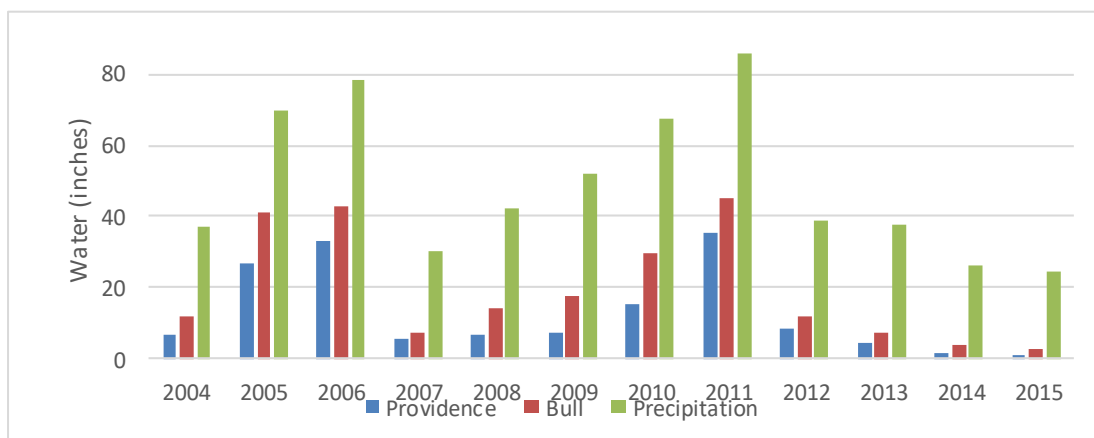


Figure 3: The amount of precipitation that leaves the watersheds as streamflow varies by year and elevation. The higher elevation Bull Creek site produces about 20 percent more flow than the Providence site.

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