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

Kings River Experimental Watersheds

Because 55 to 65 percent of California's developed water comes from small streams in the Sierra Nevada, it is important to understand the role the snowpack has in the distribution and quantity of stream discharge (streamflow). In the southern Sierra, more than 80 percent of precipitation falls December through April. However, owing to the delay in snowmelt, there is a lag in runoff until the spring. At higher elevation sites, the spring melt does not peak until May or even June. This makes mountain water available to California during the summer months. The Kings River Experimental Watersheds (KREW) sites demonstrate that precipitation in the form of snow generates greater yearly discharge in a given watershed. The difference in discharge between the KREW Providence site and Bull site is as much as 20 percent per year.

Research Area

KREW is a watershed-level, integrated ecosystem project for headwater streams in the Sierra Nevada. Eight watersheds at two study sites are fully instrumented to monitor ecosystem changes. Stream discharge data, just one component of the project, have been collected since 2002 from the Providence site and since 2003 from the Bull site.

What is Stream Discharge?

Discharge is the amount of water leaving each watershed within the stream channel. It is represented as a rate of flow such as cubic feet per second (cfs), gallons per minute (gpm), or acre-feet per year. Discharge varies greatly in the KREW watersheds. Late summer flows may range from 5 to 30 gpm. However, during periods of spring snowmelt, we may see continuous flows as high as 6,000 gpm lasting for a month or more. A single rainstorm on December 31, 2005, produced peak flows of 16,000 gpm on some of our lower elevation watersheds. Because of this large range of values for discharge, KREW uses a double flume system to accurately measure flows of all magnitudes (fig. 1). A flume is a uniform fiberglass channel placed in the natural stream channel.

The KREW has automated instrumentation to continuously measure water height in each flume. Discharge can be calculated from the water height on each stream because the cross-section area of each flume is known. Discharge data are collected at 15-minute intervals all year. This high frequency of data collection allows for an accurate representation of rapid changes in discharge that occur during storm events. Because stream discharge is a key factor in determining stream contaminant and sediment loads, it is important that very accurate discharge data are obtained. In addition, monitoring the change in discharge before and after watershed improvement treatments is critical for understanding the effects of management activities on downstream systems (fig. 2).

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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.

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Figure 2—Hydrologist checking discharge at a large flume during spring snowmelt.

Snow and Yearly Discharge

More than 60 percent of the yearly discharge of the KREW watersheds comes during a 3-month period in the spring. During this

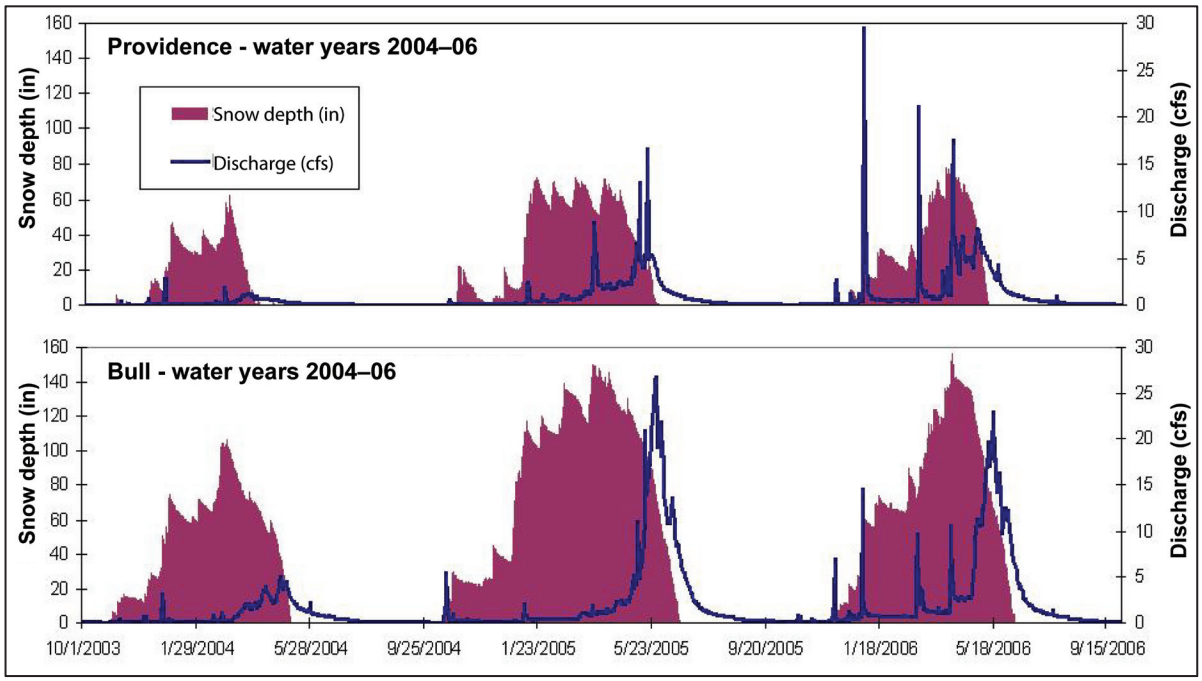

Figure 3—Discharge (cubic feet per second) and snow depth (inches) over a 3-year period. Note the large percentage of yearly discharge during the spring snowmelt period.

time, temperatures rise just enough to allow the snow stored on the watersheds over the winter months to begin to melt. At the Providence site, the spring runoff period typically lasts from March to May. At the Bull site, which is at a higher elevation and receives a deeper snowpack, spring runoff is typically delayed until April through June; snow can last well into July some years (fig. 3). Streamflows during the snowmelt period can be as much as 30 times the late summer flows.

The amount of snow that falls in each watershed is an important factor in the total yearly discharge for each stream. In California, a water year (WY) starts on October 1 and continues through September 30 of the following year. In water years 2005 and 2006, approximately 40 percent of the yearly precipitation that fell on the Providence site was measured as stream discharge. The remainder was evaporated back to the atmosphere, absorbed by trees or vegetation, or stored as groundwater (fig. 4). However, in those same water years, the Bull site watersheds had discharges equivalent to more than 60 percent of the yearly precipitation. Although differences in vegetation, topography, and soil play a large role in this difference, it also results from the larger amount of precipitation that falls as snow on the Bull site. The Providence site is located within the rain-snow transition boundary; most of the precipitation comes as snow, but a few of the warmer winter storms fall as rain on these watersheds. This provides more opportunity for soils and vegetation to take in water that would otherwise leave the watershed as discharge during extended periods of snowmelt.

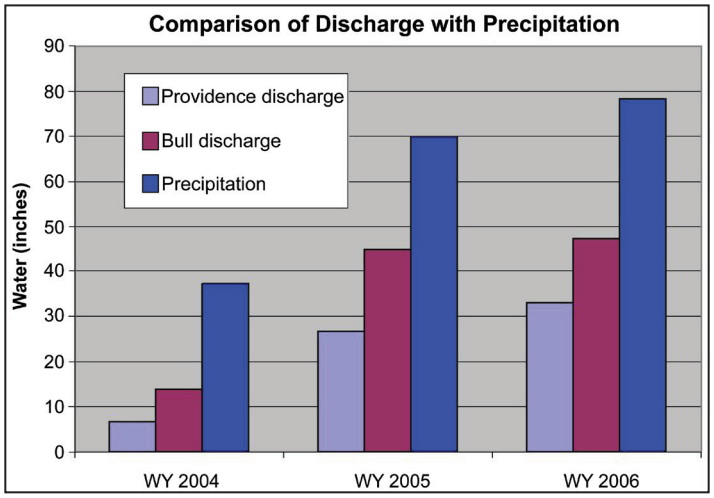

Figure 4—The amount of precipitation that leaves the watersheds as stream discharge varies by year and elevation. The higher elevation Bull Creek site, produces about 20 percent more discharge than the Providence site. WY = water year

Implications to California

As the effects of climate change are better understood, scientists predict more precipitation to fall as rain within the Sierra Nevada. This will likely result in earlier occurrences of spring snowmelt making less water available during the summer months. In addition, because rain is absorbed by mountain soils and vegetation, more easily than snow, the expected increase in the percentage of rain that falls in the Sierra Nevada may negatively affect the total yearly discharge. This could leave less water available for the rest of California. Researchers at KREW are evaluating climate change effects on these small headwater systems. The Providence site is an example of how the Bull site may function in the future.

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