**WARMING TRENDS AND GROUNDWATER RECHARGE IN WESTERN MOUNTAINS, WITH IMPLICATIONS FOR GROUNDWATER AND SURFACE-WATER RESOURCES**

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Groundwater is a vital resource in the western USA. In 2000, 26% of all western water uses (excluding power generation) and 28% of irrigation were supplied from groundwater. Western ecosystems also depend on these resources, especially in riparian and phreatophyte stands. Groundwater is also an important contributor to surface-water resources: groundwater inflows make significant contributions to western streamflow, sustaining flows during long dry seasons and contributing significant fractions even during intense rainfall and snowmelt episodes.

Because mountains are generally wetter and cooler than adjacent basins, groundwater in the West is derived mainly from mountain precipitation. Because large, sustained infiltrations of water are required to break through the region's thick unsaturated zones, because much mountain precipitation is deposited as snow, and because snowpacks store and then release precipitation from several storms at once, snowmelt provides more recharge in western mountains than does rain. Isotopic studies in western settings have suggested that 50 to 90% of recharge is from snowmelt. Recent temperature analyses based on the composition of dissolved gases in groundwater from the Chiricahua Mountains (AZ) show that recharge in the central portion of the range is derived only from above seasonal snowlines.

As the western climate warmed in recent decades, precipitation came more frequently as rain rather than snow, snowpacks thinned, and snowfed streams flowed earlier in the year. These trends would be accentuated under projected 21$^{st}$-century climates. Snowline elevations may be expected to rise and thus snow-covered areas would decline in western mountains. If so, mountain-block recharge also may be expected to decline, as recharge areas shrink and as snow available for snowmelt infiltration dwindles. Declines in recharge triggered by warming may seriously impact groundwater supplies as well as surface-water resources to which groundwater inflows contribute. Given groundwater's crucial role in western water, potential impacts of warming on mountain recharge deserve more consideration and research than they have received to date.

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