

Rapid hydrological responses following process-based restoration in a degraded Sierra Nevada meadow

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April 26, 2024

Abstract

Mountain meadows are ecologically important, but often degraded, groundwater dependent ecosystems that retain and store water in upland forested landscapes. They tend to occur in low-gradient, broad valleys where water naturally slows and sediment accumulates, making them efficient locations for restoration. Over a century and a half of land use has degraded many meadows in the Sierra Nevada, reducing their hydrological and ecological functionality. Process-based restoration is a potentially economical and scalable restoration approach for numerous, small, remote, degraded mountain meadows. The approach uses onsite materials and leverages fluvial processes to achieve restoration objectives including increases in wetted area, groundwater elevations, sediment capture, and development of multithreaded channels. These changes in hydrological functionality can lead to improved ecological function over time. This study compares pre- and post-restoration surface and groundwater conditions in a degraded riparian meadow in the Sierra Nevada, California U.S.A. to understand changes in meadow hydrogeomorphic function following process-based restoration. Restoration included the installation of 35 postless beaver dam analog structures in ~1 km of incised meadow channel. Stage-discharge data at the inlet and outlet of the project area were paired with groundwater data collected from 15 wells distributed across the meadow in a power law model to estimate increased water storage of 3700 m³ (~3 acre-ft) due to restoration. After the wet winter of 2023, we estimated that pools behind structures filled to over half their volume with fine sediment. We also applied hydrodynamic modeling to evaluate fluvial changes at high flows and found that restoration increased flow complexity and wetted surface area. These short-term responses highlight the potential speed and effectiveness of low-tech, process-based restoration in achieving desired restoration outcomes.

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