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Causal Influences and Implications for Drought Projection

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Increasing Hydrologic Drought Severity in Northwestern U.S. Mountain Rivers: Causal Influences and Implications for Drought Projection

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One of the expected consequences of a warming climate in the snow covered mountains of the western U.S. is an earlier snowmelt runoff pulse, leading to longer recession times through a dry summer and, consequently, lower summer low-flows. Given the historical decline in snowpacks and advancing timing of streamflows in the region, we tested for trends in low flows in free-flowing rivers in the region since the late 1940s, and further examined the degree to which the low flows have been affected by temperature-driven trends in snowmelt timing versus trends driven by precipitation changes that have also been observed in the region. We found statistically significant declines in monthly mean flows in late summer as well as in 7Q10, the annual weekly minimum flow with a 10-year return interval (after correcting for autocorrelation in time series and testing for field significance). We further examined the relative contribution of temperature driven timing changes versus precipitation trends affecting low flows. While temperature effects are observable, precipitation declines have outweighed the effects of earlier snowmelt on low flows on all rivers so far. The finding is given more weight by contrasting the geography of snowpack sensitivity with basins where drought has become more severe. Given that the region has experienced about 1°C in warming and a 20% decline in mountain precipitation over that period, it is not a surprising finding. An important implication is that water supply and water quality managers cannot interpret historical trends in low-flows as direct analogs for continuing low flow declines related to warming, rather there is a need to explicitly consider uncertainty in future precipitation and local snowpack sensitivity to warming. Related implications relative to drought impacts on forests are discussed.