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Watershed resilience following large-scale megafire identified from multi-year stream water chemistry observations in a Mediterranean Climate (Northern California, USA)

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Wildfires are increasing in frequency, size, and severity globally, yet the long-term effects of wildfire on source watersheds are unknown. Forested regions in the Western U.S.A. that are crucial to the drinking water supply are particularly vulnerable to large-scale fire due to persistent drought and fire suppression. These factors preceded the 2021 Caldor Fire, which burned 221,835 acres of mixed conifer forest in the Cosumnes River Watershed. To investigate the hydro-biogeochemical response of a Mediterranean climate watershed to wildfire, we implemented a citizen scientist stream water sampling program following the 2021 Caldor Fire. Stream water samples were collected across a gradient of burn severities and over 2000 m in elevation at 21 sites and used in a battery of geochemical analyses. Historical streamflow records from National Water Quality Monitoring Council and hydrological data from USGS databases were used to compare pre-fire and three years of post-fire hydro-biogeochemical interactions. We observed the magnitude, duration, and drivers of change in dissolved organic carbon (DOC) and nitrate (NO3-) at the watershed outlet to determine disruptions to ecosystem nutrient cycling, exceedences in NO3- levels, and DOC levels that complicate downstream water treatment. The average DOC load from water years 2022 to 2024 increased by 265% when compared to water years 2001 to 2015, while the average nitrate load in water year 2023 was 344% that of water years 1961 to 2015. In kind, the average historical discharge increased from 4.74 m3/s to 19.20 m3/s in water years 2022 to 2024. DOC loads exceeded the historical baseline at mid to high-discharges, while nitrate loads were elevated to a lesser degree at low to mid-range discharges during water year 2022. High discharge events were primary drivers of post-fire nutrient delivery, while seasonal snow melt and burn severity were not. These events drive concentration spikes in each post-fire water year that diminish in magnitude with time. This analysis suggests watersheds can recover from large scale wildfire nutrient influx in the first three post fire years. Longer-term and high-frequency monitoring of stream water chemistry offers insight into the influence of mega-fires on the hydro-biogeochemical processes of source watersheds.