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Hydrological extremes shift controls on and pathways of carbon loss from mountainous watersheds

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Floodplain soils within mountainous watersheds are dynamic reservoirs of carbon (C), and experience seasonal flooding due to snowmelt and drainage. Climate change is shifting snowpack levels, making these ecosystems vulnerable to more frequent extreme flood and drought years. Here we show how extreme flooding or drought events, and associated redox dynamics, impact the dominant controls on microbial C cycling within and export from floodplain soils. Employing in-field monitoring with advanced analytical and molecular tools in the subalpine East River watershed (Gothic, Colorado) we compared seasonal flooding impacts in extremely low and high river discharge years (2018 and 2019, respectively), foreshadowing climate change projections. Our results show that reduced conditions during flooded periods caused reductive dissolution of Fe oxide, mobilizing previously mineral-bound organic C and enhancing export of dissolved organic carbon (DOC). At the same time, flooding decreased CO_2 production and selectively preserved chemically reduced DOC, likely due to metabolic constraints on microbial respiration. Upon drainage and re-oxygenation of floodplain soils, however, CO_2 production increased, but was limited by the concurrent entrapment of DOC by newly precipitated Fe oxides within the soils. Compared to the low discharge year, extreme flooding during high discharge years heightened microbial constraints and undermined mineral constraints, thereby suppressing CO_2 production and enhancing DOC export from floodplain soils. We conclude that seasonal flooding events shift the relative and interactive impacts of mineral and metabolic constraints on microbial C cycling in floodplains, altering the balance between CO_2 and DOC export. Our results suggest that extreme hydrological events expected with climate change will shift the control on and pathways of C loss from floodplains.