How Does Riverbank Erosion Respond to Changes in Water Supply?

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As climate changes, melting glaciers, thawing permafrost, shifting storm patterns, and other factors are disrupting the amount of water supplied to rivers around the world. It is unclear how such changes affect the speed at which rivers erode their banks, with recent field studies and models showing contrasting cases of migration slowdown and speed-up. We tackled this question using a morphodynamically scaled laboratory stream-table experiment featuring systematic changes in water supply. During the first 100 hours, water and sediment supply were held constant and the river formed a 5-cm-wide, 0.8-cm-deep, ~3-m-long channel with turbulent, gravity driven flow similar to lowland rivers in nature (Re >> 1000, Fr < 1). Riverbank erosion rates were highly variable, with extreme values reaching 9 cm/hour, in a manner consistent with current theory. Water was then doubled for the next 100 hours of the experiment. After a brief (~2 hr) period of widespread overbank flooding, the river responded with a drastic slowdown in bank erosion rates (~ 80%) to a degree not explicitly predicted by current theory. Slowdown occurred because of other modes of river response: the channel widened by 100%, deepened by 70%, and incised to a gentler slope, which together effectively increased the bank sediment yield to the channel without increasing the capacity of the river to transport sediment. Our findings highlight the multi-modality of geomorphic response, and suggest that rivers downstream of melting glaciers and permafrost may reshape their channels in a way that naturally mitigates erosion hazards.