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A geomorphic framework for predicting downstream response of rivers to dams: examples and prospects

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Despite many decades of research on downstream effects of dams on rivers, we have few general models predicting how any particular river is likely to adjust following impoundment. In the absence of such a framework, most research on downstream effects is based on individual case studies. To integrate these studies, we develop a conceptual and analytical framework for predicting geomorphic response of rivers to dams. This conceptual model emphasizes the role of geologic setting and history as first-order controls on the trajectory of channel change. Basin geology influences watershed and channel processes through a hierarchical set of linkages, extending from the drainage basin to the valley and channel, which collectively determine the sediment transport and discharge regimes. Geology also directly shapes the suite of hillslope processes, landforms, and geomorphic disturbances that sculpt and define the channel and valley floor morphologies. These factors, in turn, affect the capacity for adjustment of the downstream channel. In particular, they determine the type, direction, and extent of channel adjustments, including incision, widening, and textural changes.

To incorporate hydrologic and sedimentalogic factors, we extend this framework to include two dimensionless variables that, taken together, predict geomorphic responses to dams depending on the ratio of sediment supply below to that above the dam (S*) and the fractional change in frequency of sediment-transporting flows (T*). Drawing on examples from dammed rivers in the US and China, we explore how trajectories of geomorphic change, as defined by these two variables, are influenced by the geological setting and history of the river. This approach holds promise for predicting the magnitude and trend of downstream response to other dammed rivers, and can identify river systems where geological controls are likely to dominate.