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Geomorphic evolution of a gravel-bed river under sediment-starved vs. sediment-rich conditions: river response to the world's largest dam removal

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The response of river channels to a major increase in sediment supply is a fundamental, long-standing problem in geomorphology, with important implications for flood-hazard assessments. However, this problem is rarely studied at field scale owing to the rarity and unanticipated nature of most large sediment pulses. We examine fluvial-channel response to a massive (~20 Mt) pulse of sediment that was released by the largest dam removal globally, on the Elwha River, Washington, USA. We conducted an 11-year before-after/control-impact study of channel topography, width, planform morphology, and bed-sediment grain size in the Elwha River. We use these data to quantify the geomorphic effects of a large sediment pulse in detail, and to test the hypothesis that for a given flow magnitude, greater geomorphic change occurs under sediment-rich conditions than under sediment-starved conditions. The results demonstrate that fluvial-channel processes and responses to flows of various magnitudes were distinctly different during the peak of the sediment pulse, which occurred 1–2 years after dam removal began, but that by 4–6 years after the onset of dam removal the geomorphic effects and process signal of excess sediment supply had largely faded. These findings indicate that given sufficient gradient, hydrology, valley morphology, and sediment grain size, rivers can recover rapidly from even a very large sediment pulse, and that (with spatially localized exceptions) even a large dam removal can have muted long-term effects relative to natural perturbations from floods.