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Centennial storage and release of hydraulic mining sediment determined by distributed sediment budgets; northern California

L Allan James
South Carolina, Geography, Columbia, United States (ajames@sc.edu)

Sediment budgets for a small mountainous watershed that received large volumes of mining sediment in the 19^{th} century reveal connectivity and dynamics over a 130-year period. Hydraulic mining was invented in California in the mid-twentieth century and produced 1.1×10^9 m^3 of distinctive hydraulic mining sediment (HMS) in the northern Sierra Nevada between 1853 and 1884. Mining ceased abruptly in response to a legal injunction, so the sudden start and end of this massive sediment production set up an unusually well-defined outdoor experiment in sediment production, storage, and delivery. Meso- to catchment-scale analysis includes the development of spatially distributed sediment budgets for two historical periods: 1853 to 1884 ending at the time of peak mine-sediment production and 1884 to 2014 ending at the time of airborne LiDAR data collection. Three common methods can be used to develop sediment budgets by creating DEMs of Difference (DODs) from digital elevation models (DEMs). (1) The morphometric method differences two DEMs constructed from sequential field surveys. (2) Historical cartometrics can be used to generate the early DEM for differencing. (3) This study modeled an early pre-mining surface by interpolation of contours manually generated from existing terrace remnants, hill crests, and valley sidewalls and differencing those DEMs with DEMs from 2014 airborne LiDAR data.

The resulting HMS storage volumes for pre-mining, penultimate mining, and post-mining periods indicate 23.5×10^6 m^3 HMS produced in the 54.6 km^2 mountainous study catchment, representing 43.0 cm of denudation over a period of 31 years or a mean denudation rate of 1.39 cm yr^{-1}. This shows two orders of magnitude increase in denudation rates following the sudden introduction of post-industrial human activities to the region. In ca. 1884, at the time of maximum channel aggradation, 7.15×10^6 m^3 of HMS or 30.4% of the production was stored, representing a sediment delivery ratio (SDR) of 69.6%. By 2014, only 3.75×10^6 m^3 or 16% of sediment production remained, indicating that the SDR had increased to 84.1%. Both SDRs are high compared to most North American rates reported in the scientific literature based on reservoir surveys. The dynamic nature of SDR implicated by increasing SDRs with time is intuitive, but rarely observed due to poor temporal resolution and control in most sediment production and storage data. SDRs provide a metric for sediment connectivity and can document changes in connectivity through time. During this extreme anthropogenic aggradation event, geomorphic changes to the fluvial system included major disruptions to longitudinal connectivity that greatly reduced initial flux rates but maintained elevated post-mining sediment yields at present as the stored HMS continues to be slowly released.