Developing a Sediment Budget for the Upper Elk River Watershed, Northwestern California: Do Natural or Anthropogenic Sources Dominate?

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Abstract. The 140 km^2 Elk River watershed in northwestern California is impaired for sediment under the Clean Water Act. The sources and magnitudes of natural and anthropogenic sediment from the steep upper watershed are controversial given the more than 100 years of timber harvest activities. The objectives of this study are to: 1) develop a sediment budget for the upper Elk River watershed; 2) identify the greatest sources of uncertainty and how these might be resolved; and 3) discuss the implications of the sediment budget for downstream water quality, nuisance flooding, and future watershed recovery.

Sediment inputs can be divided into natural sources, legacy sources from past timber management (1870s to 1990s), and sediment from current forest management under improved practices (1999-present). We posit relatively high natural sediment inputs from hillslopes to streams due to the uplift rate of 0.5 mm/yr, weak bedrock, prevalence of deep-seated landslides, high annual precipitation, and data from other North Coast watersheds. Improved road and forest management have reduced sediment inputs from forest management activities by at least a factor of five relative to 1988-1997. Legacy sediment sources are the most difficult to quantify, but may be substantially larger than current management inputs. The mean suspended sediment output from the upper watershed from 2003-2016 is 250 ± 260 Mg km^{-2} yr^{-1}, with nearly 80% of the variability explained by the instantaneous annual maximum peak flow. There are no bedload data, and values from other watersheds suggest that bedload could range up to 50% of the suspended load. Colluvial and fluvial sediment storage are another major source of uncertainty given the difficulty of direct measurements and calculating storage as a residual given the uncertain sediment inputs. Suspended sediment loads, cross-section data, and a possible bed coarsening are beginning to suggest some recovery from the large pulse of management-induced sediment from the 1980s and 1990s. The amount of natural, legacy, and stored sediment sources must be more rigorously evaluated, as the relative magnitude of these different sources has important implications for further regulations on forest management, the feasibility of attaining water quality standards, causes of downstream flooding and sedimentation, and identifying restoration or recovery options.