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Decadal sediment dynamics of a perturbed fluvial system: the case of the man-made Marecchia River canyon, Northern Apennines

Manel Llena, Tommaso Simonelli, and Francesco Brardinoni
University of Bologna, Department of Biological, Geological and Environmental Sciences, Italy (manel.llena@unibo.it)

River canyons are transient geomorphic systems shaped by river incision into bedrock and coupled by instability of the adjacent valley walls. Investigating the evolution of river canyons is typically challenging due to the geologic time scales involved. In this context, the Marecchia River, which hosts in its intermediate portion a 6-km canyon, developed since the early 1950's following intense gravel mining, may be instructive. Indeed, this setting offers the opportunity to: (i) document canyon development through highly erodible pelitic rocks; and (ii) evaluate relevant upstream and downstream effects on fluvial morphodynamics. To these ends, we subdivide the 50-km stretch of the Marecchia River main stem into 22 homogeneous reaches and evaluate decadal geomorphic changes through analysis of LiDAR-derived digital elevation models (i.e., 2009 and 2019) in conjunction with planimetric changes of active channel width delineated on orthophoto-mosaics (i.e., 2009, 2012, 2014, 2017, 2019). The estimation of patterns and rates of fluvial erosion into bedrock and its geomorphic effects are essential for understanding landscape evolution and for applying sustainable sediment management plans.

In terms of volumetric changes, the entire river stretch recorded a decadal degradation of 2,516,150 m^3 (57%) and 1,884,700 m^3 of aggradation (43%), with a corresponding net volume loss of -631,450 m^3. Highest specific volumes of aggradation were observed in a homogeneous reach located in the lower part of the study segment (0.5 m^3/m^2), while highest values of degradation were observed in the upper reach of the canyon (-2.3 m^3/m^2). During the 2009-2019 period, knickpoint headward migration within the canyon has progressed for approximately 500 m, producing an average bedrock incision of about 10 m. As documented by area and volume changes, both rates of fluvial incision and canyon widening, as modulated by landslide activity and valley wall collapses, are highest in proximity of the main knickpoint and tend to decrease progressively downstream. By March 2019, when the second LiDAR survey was conducted, the main knickpoint had reached the foundations of a major check dam, which eventually collapsed two months later. Upstream of the canyon, channel reaches displayed narrowing dynamics with an alternation of degradation and aggradation processes. In terms of total volumetric changes, these reaches presented an indirect correlation with confinement, with the most confined reaches acting as sediment transfer zones. In contrast, the segment downstream of the canyon displayed widening dynamics (+ 11 m on average) together with an increase of aggradation processes. Due to the pelitic nature of the hosting bedrock, despite the high geomorphic change observed, most of the material supplied by the canyon walls gets transported in suspension, contributing very

little to the estimated budget of the Marecchia River's distalmost reaches. In this way, we argue that most part of the aggradation observed in this segment was originated upstream, bypassing the canyon.