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Gully evolution and geomorphic adjustments of badlands to recent afforestation

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Badlands and gullied areas are among the geomorphic environments with the highest erosion rates worldwide, however records on their evolution are very scarce and often limited to presumed initial conditions and the known present state. In this communication, we present a unique and very dense and annual record and outstanding example of erosion processes in a Mediterranean environment in Central Spain, where badland and gullying processes on sandy slopes of a set of mesas have been presumably triggered by quarrying activities since Medieval times. The gully channel evolution here analyzed provides an exceptional example of a larger setting of geomorphic.

Besides the analysis of geomorphic adjustments to historical land-use changes induced by historical quarrying and gullying dynamics, we also quantified the impact of current geomorphic adjustments to 20th century afforestation by combining multiproxy such as aerial photography, historical archives, and large dataset of exposed roots to date, quantify, and reconstruct the morphology of a rapidly evolving channel in a gullied catchment. In this analysis, more than 150 exposed roots were analyzed to quantify and report channel incision; widening and gully retreatment rates during the last decades, as well as to quantify sheet erosion on different soil units.

Our results suggest that, rather than stabilizing gully evolution, the afforestation carried out during 1960s has played an important role in water-sediment balance and connectivity and would have triggered the initiation of channel incision processes in the 1980s. Therefore, we observe that the channel incision match with a significant increase of the vegetation cover, which leads a significant decrease in sheet erosion rates. Based on our long-term annual gully reconstruction, we observed that sediment delivery does not correlate with the estimated intensity of precipitation (Fourier index). Instead, we observe abrupt morphological changes in the gully are presumably related with changes in connectivity after a specific intense event. Consequently, we hypothesize that the gullying process-vegetation interactions are subsidiary of the geomorphic adjustments and connectivity states of the system; and speculate that this understanding is essential for suitable restoration and management plans.