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Linking hydrology, morphodynamics and ecology to assess the restoration potential of the heavily regulated Sarca River, NE Italy

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We develop an integrated eco-hydro-morphological quantitative investigation of the upper course of the Alpine Sarca River (NE Italy), for the purpose of assessing its potential in terms of environmental restoration. The Sarca River has been subject to heavy exploitation for hydropower production since the 1950s through a complex infrastructural system. As for many regulated Alpine rivers, increasing local interest has recently been developing to design and implement river restoration measures to improve the environmental conditions and ecosystem services that the river can provide.

The aim of the work is to develop and apply a quantitative approach for a preliminary assessment of the successful potential of different river restoration options in the light of the recent eco-hydro-morphological dynamics of the Sarca river system at the catchment scale. The proposed analysis consists of three main steps: (1) detection of the main drivers of flow and sediment supply regimes alteration and characterization of such alteration; (2) a quantification of the effects of those alterations on geomorphic processes and fish habitat conditions; (3) the analysis of the restoration potential in the light of the results of the previous assessment. The analysis is tailored to the existing data availability, which is relatively high as for most river systems of comparable size in Europe, but not as much as in the case of a targeted research project, thus providing a representative case for many other regulated river catchments.

Hydrological alteration is quantified by comparing recent (20 years) streamflow time series with a reconstructed series of analogous length, using a hydrological model that has been run excluding any man-made water abstraction, release and artificial reservoirs. upstream and downstream a large dam in the middle course of the river. By choosing the adult marble trout as target (endemic) fish species, effects of the alterations on the temporal and spatial habitat suitability have been assessed by applying a hydraulic-habitat method combined with the streamflow time series. Geomorphological trajectories of the last decades have been reconstructed through the analysis of aerial photos, and the geomorphic effects of flow regime alteration have been assessed in terms of the changes in frequency and duration of gravel-transporting flood events.

Results indicate hydropower as one of the drivers of hydro-morphological alteration, with widespread torrent control works in the catchment playing a relevant role in reducing sediment supply. Recent changes in flow management related to the imposition of a Minimum Environmental Flow correspond to significant increase in the continuous duration of suitable habitat events, despite representing only a first step towards a dynamic ecological flow regime. While floods able to drive morphological changes still occurred after regulation, their frequency and duration have dramatically decreased, contributing to channel narrowing and morphological simplification. Overall, the analysis suggests that: (i) morphological river restoration aimed at restoring self-formed morphodynamics can only be effective if designed together with a dynamic geomorphic flow regime, and (ii) dynamic ecological flows should designed with a twofold objective of improving habitat and spawning sites conditions together with recreational uses of the river.