FACTSHEET
Multi-scale concept for sediment-based river restoration

Next to the channelization of the Alpine rivers, it is the disconnection from their sediment sources due to interventions such as hydropower use, torrent control and dredging, and the resulting change of sediment regime, which strongly affect the hydromorphology. Accordingly, for successful restoration of a river's hydromorphology and the related ecosystem services, consideration of the catchment-scale and of the sediment regime is crucial. HyMoCARES presents a multi-scale concept for sediment-based river restoration, which allows a better understanding of the consequences of various measures for a river's hydromorphology. In addition, it recommends existing or provides new tools for hydromorphological assessment.

The multi-scale concept for sediment-based river restoration (Klösch et al., 2019) considers two major scales which are relevant for the hydromorphology of Alpine Rivers: the catchment and the reach scale. The sediment regime of a reach is considered by the sediment discharge supplied from the catchment into the reach ($Q_{s,in}$), and by the sediment discharge $Q_{s,out}$ transported out of the reach (Fig. 1).

The sediment discharge is known to determine the morphology of rivers (e.g., Schumm, 1985; Church, 2006; Mueller and Pitlick, 2014), such as the lateral dynamics and the resulting condition between a single-thread and braided morphology (Fig. 2). In addition, the sediment supply determines the channel slope of a river reach (Fig. 3): If the sediment supply is increased, the slope steepens until the channel is capable of transporting the supplied sediment throughout reach. If the supply is reduced, the slope flattens to adjust the sediment transport capacity. Slope steepening and flattening are achieved via aggradation and degradation. The self-initiated development of an armouring layer, often present in channelized rivers, may temporarily prevent reaches with a sediment deficit from degrading, but large amounts of riverbed sediment may be mobilised during floods, with highly increased lateral loads on bank protections or width adjustment.

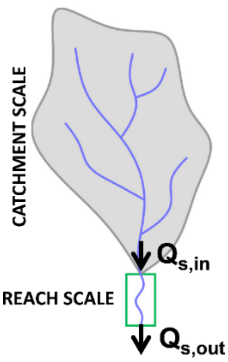

Fig. 1. Considered scales and sediment discharges.

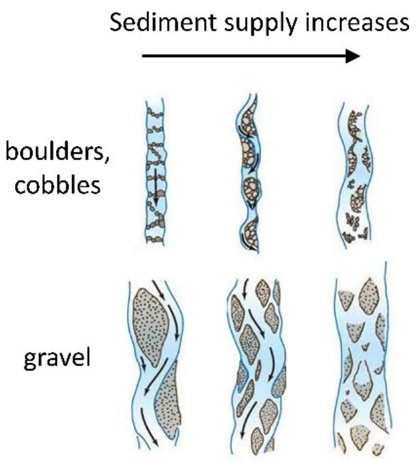

Fig. 2. The hydromorphology at varying sediment supply (based on Church, 2006).

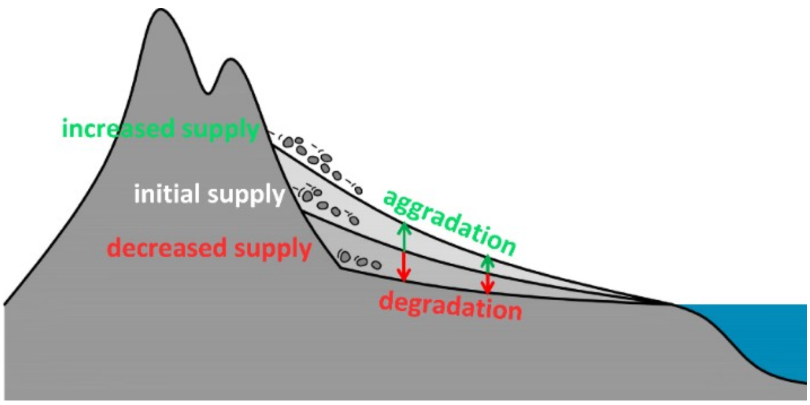

Fig. 3. Effect of changes in sediment supply on the channel slope.

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Based on these the diagram in Fig. 4 could be created. The diagram can be used to draw the trajectories of the river reach. Starting from an initial hydromorphological condition in the centre, the kind of implemented measure determines a shift on the $Q_{s,in}$- or $Q_{s,out}$- axis. Impacts move the reach's hydromorphology into the diagram areas of aggradation or degradation, and are then followed or overlapped by trajectories of adjustment. After the adjustment results in the establishment of an equilibrium sediment budget, the river reach may be transferred to a different morphological type and/or obtain a different channel slope. The trajectories are exemplified for different measures in deliverable D.T2.2.1 (Klösch et al., 2019).

HyMoCARES also provides tools to assess the actual state of a river's hydromorphology:

- HyMoCARES Chevo enables a standardised assessment of the hydromorphological evolution of a channel and provides information on the lateral and vertical changes based on cross section surveys, hence allowing to assess or verify the river's trajectories. All information is displayed at once in the Channel Evolution Diagram (Fig. 5).
- The River Freedom Index helps to assess the artificiality regarding channel constraints, which impede lateral or vertical self-adjustments and dynamics (Fig. 6).

Deliverable D.T2.2.1 also contains a recommendation of methods for assessing the sediment connectivity in catchments. Look up content of this HyMoCARES output on the HyMoCARES web page!

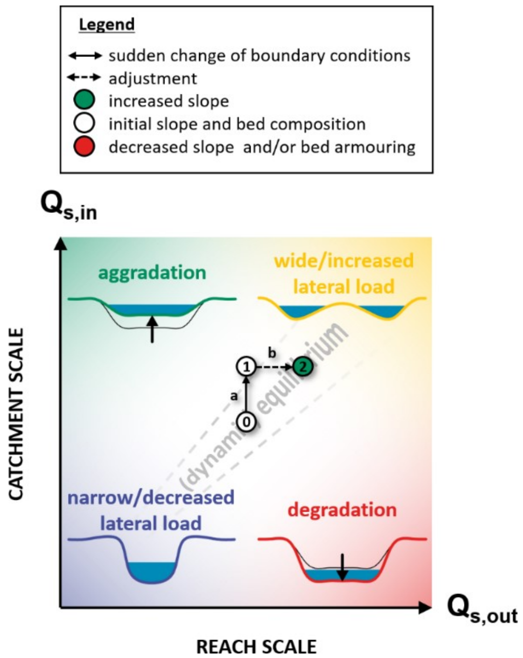

Fig. 4. The hydromorphological effect of a restoration of sediment connectivity displayed in the diagram of the multi-scale concept of sediment-based river restoration: Impact 'a' and trajectory of adjustment 'b' (see D.T2.2.1)

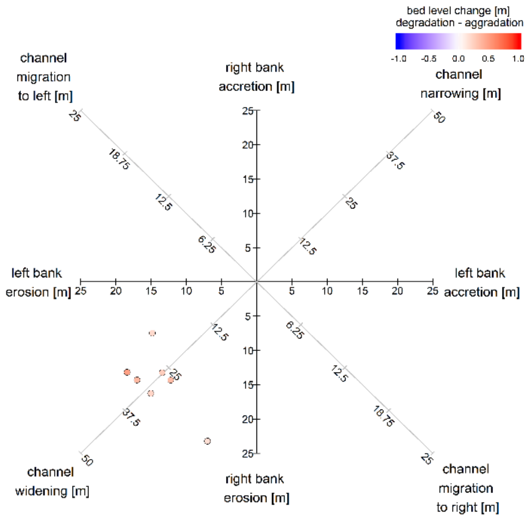

Fig. 5. Channel evolution diagram illustrating morphological changes based on cross section analyses with HyMoCARES Chevo (available for application online at https://hymo.azurewebsites.net)

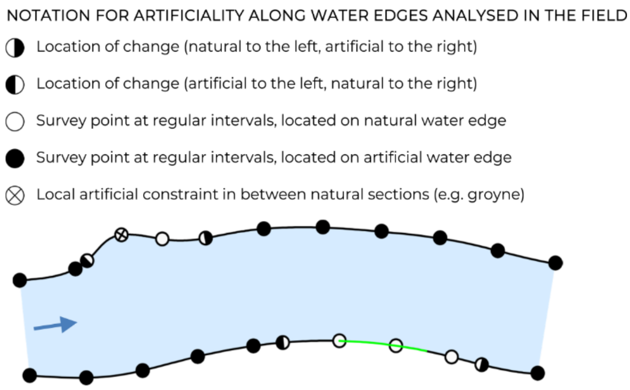

Fig. 6. Assessment of artificial channel constraints following the River Freedom Index (see deliverable D.T2.2.1): Lateral constraints are assessed along the water edges of different discharges. The definition of characteristic discharges simplifies the assessment in the field and/or office (low flow, vegetation line, bankfull, and flood). According to the River Freedom Index, a minimum length of unconstrained condition is needed before it is counted as available for lateral dynamics.

References
Church, M. (2006). Bed material transport and the morphology of alluvial river channels. Annu. Rev. Earth Planet. Sci., 34, pp. 325-354
Klösch M. et al. (2019). Techn. notes on a multi-scale framework for assessing the hydromorphological conditions of Alpine rivers. D.T2.2.1 HyMoCARES.
Mueller, E. R., and J. Pitlick (2014), Sediment supply and channel morphology in mountain river systems: 2. Single thread to braided transitions, J. Geophys. Res. Earth Surf., 119, 1516–1541, doi:10.1002/2013JF003045.
Schumm, S. A. (1985). Patterns of alluvial rivers. Annual Review of Earth and Planetary Sciences 13:1, 5-27