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Hydrogeomorphological variability and ecological impacts in straight and restored river reach sections

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Healthy floodplain ecosystems are characterized by high habitat diversity which tends to be lost in straightened channelized rivers. River restoration projects aim to increase habitat heterogeneity by re-establishing natural flow conditions and/or re-activating geomorphic processes in straightened reaches. The success of such projects is usually measured by means of structural and functional hydrogeomorphic and ecological indicators. Important indicators include flow variables and morphological features such as flow depth, velocity, shore line length, exposed gravel area and wetted river width. Also important are the rates at which these variables and features change under varying streamflow.

A high spatial variability in the indicators is generally connected with high habitat diversity. The temporal availability and spatial distribution of both aquatic and riparian habitats control the composition and diversity of benthic organisms, fish, and riparian communities. Spatial heterogeneity provides refugia, i.e. areas from which recolonization after a disturbance event may occur. In addition, it facilitates the transfer of organisms and matter across the aquatic and terrestrial interface, thereby increasing the overall functional performance of coupled river-riparian ecosystems. However the habitat diversity can be maintained over time only if there are frequent disturbances such as periodic floods that reset the system and create new germination sites for pioneer vegetation and rework the channel bed to form new aquatic habitat. Therefore the flow and morphology indicators need to be investigated on spatial as well as on temporal scales. Traditionally, these indicators are measured in the field albeit most measurements can be carried out only at low flow conditions.

We propose that flow simulations with a 2d hydrodynamic model may be used for a fast and convenient assessment of indicators of flow variables and morphological features with relatively little calibration required and we illustrate an example thereof. The advantage of using computer simulations as compared to field observations is that a range of discharges can be investigated. Using a flood frequency analysis the return period of simulated flows can be estimated and translated into frequency-dependent habitat types.

In order to investigate how flow variables change, we conducted a series of 2d flow simulations at different flow rates along the prealpine Thur River (Switzerland) consisting of both restored and straight reaches. Restoration basically consisted of widening the river cross-section and allowing a natural morphology to form. The simulated flow variables (flow depth and velocity) were then analyzed separately for the two reaches. The distributions of the both variables for the restored reach were significantly different from the straight reach, most notably an increase in the variance was observed.

In order to analyze the temporal variability we investigated the development of the riverbed morphology over time using different digital elevation models combined with cross section data measured at annual intervals. Spatially explicit erosion and deposition patterns were derived from this analysis. The riverbed topography at different dates was then used to analyze the temporal evolution of the flow indicators for the different flow conditions. Comparisons between the restored and straight reaches allow us to assess the success of river restoration in terms of flow variability and morphological complexity.