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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

The Hydro-Morphological Index of Diversity: a Planning Tool for River Restoration Projects (2008-2012)

Walter Gostner

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Contemporary river engineering must guarantee effective long-term flood protection while also improving stream ecology. Nowadays, river engineering projects must aim at optimizing hydromorphological heterogeneity, as this is an acknowledged basic condition for maintaining stream biodiversity.

In the present project, a new Hydro-Morphological Index of Diversity (HMID) was developed. The purpose of the HMID is to deliver a tool for the practitioner engaged in planning of integrated river engineering projects where habitat enhancement constitutes one of the project targets. By calculating the HMID, a quantitative statement of habitat heterogeneity enhancement for different project alternatives is possible, and therefore recommendations of which alternatives to prioritize from an ecomorphological perspective can be given.

The HMID was developed within the framework of the "Integrated River Management" project, an interdisciplinary research program involving different University Institutes in Switzerland.

Figure 1. Left: natural, braided river (Site S1, river Sense). Right: artificial, channelized river (Site B2, river Bünz)

During extensive field campaigns, hydraulic and geomorphic data were recorded at morphologically contrasting sites at three streams (see examples in Fig. 1) in Switzerland (Bünz, AG; Venoge, VD; Sense, FR/BE). By means of correlation analysis, relationships between the measured variables (see example in Fig. 2) could be detected. Being significantly correlated to a number of hydraulic and geomorphic variables, the hydraulic variables flow velocity and water depth were found to accurately represent the hydromorphological template of a stream. A formula for the HMID could be proposed by comparing the variability of these two hydraulic variables between the study reaches. The developed formula used the coefficient of variation of flow velocity and water depth as a measure to describe hydromorphological variability.

A good correlation of HMID scores with rankings obtained by means of a multimetric visual habitat assessment method supported the capability of the HMID to represent the hydromorphological state of a stream. Correlation between HMID scores and macroinvertebrate-based biotic indices, on the other hand, did not meet expectations for all tested stream reaches.

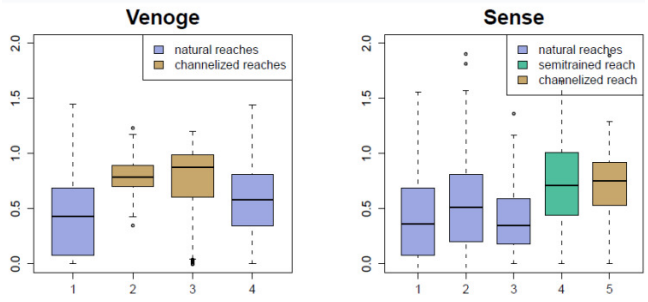

Figure 2. Boxplots of flow velocity (m/s) at rivers Venoge and Sense

Numerical modelling for the study reaches at the river Sense was conducted to examine the temporal variability of the hydraulic variables and the HMID. HMID scores were calculated for different discharges in river, and temporal variability was lower in natural than in channelized reaches. The increments of hydraulic variables for changing discharge are greater in channelized than in natural reaches. Thus, aquatic biota in channelized reaches must cope not only with a degraded habitat template but also with higher stress conditions (Fig. 3). However, physical habitats in natural reaches lose stability when discharges with major bed reshaping processes occur. These high discharges correspond to intermediate disturbance events, which are important towards maintaining ecological functions.

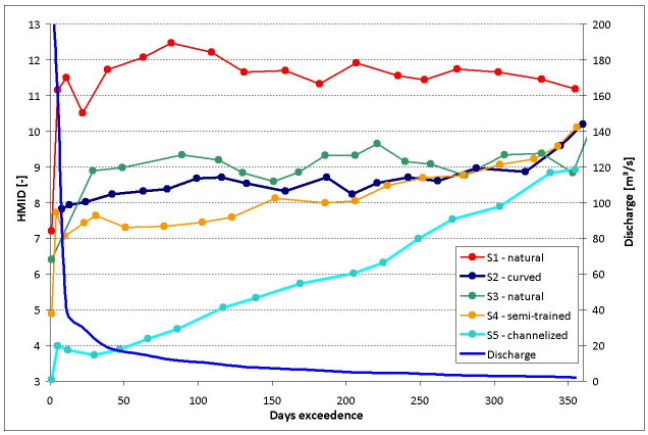

Figure 3. Temporal variation of HMID for the study reaches at Sense

In a case study, the suitability of the HMID for application was demonstrated. After completion of a restoration project, a stream reach should be characterized by a high HMID and a stable temporal variability (unless discharges above a disturbance threshold occur). In this way, the HMID provides the necessary hydromorphological template to achieve a high ecological potential for a restored stream reach.

However, it must be avoided that high hydromorphological heterogeneity does not become a primary aim in itself. For a sound restoration project, processes at the watershed scale also must be included. In particular, it is necessary to evaluate the sediment regime of the entire watershed (mainly of the upstream areas), to estimate the long-term geomorphic evolvement of the project reach and to verify whether a dynamic equilibrium for the reach can be obtained. Finally, the ecological success of habitat enhancement measures depends on the conditions of other potential stressors (e.g. sediment or excessive nutrients, chemical pollution, habitat fragmentation, strongly modified flow regime). An integrated vision of these factors is a primordial rule for ecologically successful river restoration projects.