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Original Research Article

Identification of hydromorphological reference sites using the new REFCON method, with an application to rivers in the Czech Republic

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ABSTRACT

This paper presents a new approach to establishing reference sites and determining hydromorphological characteristics for establishing type-specific hydromorphological reference conditions for rivers in the Czech Republic – the REFCON method – as well as its application. This method is based on hydromorphological river types. Using available maps and field surveys, it determines potential reference sites for establishing reference conditions, and subsequently, on the basis of an assessment of anthropogenic impacts using set criteria, it identifies stream reference sites. Reference sites and river types are validated using field survey data. This method also identifies characteristics of channel pattern, flow, riverbed structures, sediment, and variability of cross-sectional profiles used for establishing type-specific hydromorphological reference conditions.

Reference conditions can be expressed using threshold values of individual characteristics (e.g., channel slope, entrenchment ratio, specific stream power); they can also be described qualitatively, that is, verbally (e.g., channel pattern, valley type). Nonetheless, reference conditions are always an expression of a set of characteristics or conditions that should be valid for a given river type.

One of the expected results of applying this method is the creation of a reference site database for assessing hydromorphological status of streams. This database will serve for proposing stream restoration measures and also as a database of stream sections in need of protection from potential human impact.

1. Introduction

Several studies conducted in the preceding decade deal with defining restoration target conditions (Jungwirth et al., 2002; Brierley and Fryirs, 2005; Palmer et al., 2005; Dufour and Piégay, 2009). Many methods and models, as PHABSIM (Milhous and Waddle, 2012), MesoHABSIM (Parasiewicz, 2007), RHS (Environment Agency, 2003), have also been developed for existing habitat assessment and prediction of changes in quality and quantity of river habitats. Since the introduction of the Water Framework Directive (WFD, European Commission, 2000) stream restoration target conditions in Europe have been established on the basis of set hydromorphological reference conditions and a set stream typology (Environment Agency, 2003; Pottgiesser and Sommerhäuser, 2008; Langhammer et al., 2012; Wimmer et al., 2012). Hydromorphological reference conditions are a benchmark for assessing the hydromorphological status of streams, and they also represent stream restoration target conditions.

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According to the WFD, the purpose of hydromorphological assessment is to determine if the status of hydromorphological conditions is sufficient for supporting biological elements. The status assessment and establishment of reference conditions are thus important framework of ecohydrology.

According to European standard EN 14614 (CEN, 2004), reference conditions should be determined for all river types so that they reflect undisturbed stream conditions – that is, natural cross-sectional profile and channel planform, free flow of water and sediment in channel, and natural vegetation in the riparian zone. Reference conditions may represent the present status of a stream or a past status, and therefore reference conditions do not need to be the equivalent of absolutely undisturbed original conditions (European Commission, 2003), as anthropogenic impacts that cause minimal disturbance are acceptable. Type-specific reference conditions may be spatially based (using data from monitoring sites), based on predictive modeling or hindcasting methods using historical data or paleoreconstruction, or derived from a combination of these methods. In cases where these methods cannot be applied, expert judgment may be used to establish such conditions (European Commission, 2000, 2003). Table 1 describes the advantages and disadvantages of these methods.

Most river systems in Europe, as well as on other continents, have been significantly influenced by human activities over the centuries. This fact has led many authors to the conclusion that defining reference conditions as pristine conditions is infeasible and doing so has little practical use (Leuven and Nienhuis, 2001; Dufour and Piégay, 2009; Wyżga et al., 2012; Rinaldi et al., 2013). Fluvial systems are the result of constant interaction between natural and anthropogenic factors; therefore, authors have abandoned use of historical reference conditions (Palmer et al., 2005; Dufour and Piégay, 2009; Wyżga et al., 2012), the naturalness of which can be doubted in many cases, and emphasize the importance of viewing fluvial systems as dynamic systems that develop over time under given environmental conditions (Palmer et al., 2005; Dufour and Piégay, 2009; Wyżga et al., 2012). Historical stream conditions may reflect conditions that diverge from present environmental conditions, and thus may not be of any practical use for stream management and restoration (Leuven and Nienhuis, 2001; Dufour and Piégay, 2009; Rinaldi et al., 2013). Therefore, present environmental conditions should be used for establishing reference conditions (Palmer et al., 2005; Brierley and Fryirs, 2005; Dufour and Piégay, 2009), particularly climatic conditions, vegetation cover, and anthropogenic impacts. Wyżga et al. (2012) state that defining hydromorphological reference conditions should be based on present or potential environmental conditions in connection with minimal anthropogenic impacts on the channel, riparian zone, and floodplain. Palmer et al. (2005) describe reference conditions using a "guiding image" of a dynamic, ecologically healthy river that could actually exist at the given location.

1.1. Establishing hydromorphological reference conditions in the countries neighboring the Czech Republic

Some neighboring countries use spatial methods for establishing reference conditions based on data from reference site (RS) monitoring. The German approach to establishing reference conditions is based on the following hydromorphological attributes: channel planform and sinuosity, valley type, riverbed substrate, cross-sectional profile, and floodplain characteristics. RSs are evaluated based on statistical analyses of similarities in sites that have very little anthropogenic impact. The advantage in establishing reference conditions in Germany was the availability of an ecomorphological stream survey results

Table 1
Approaches to establishing reference conditions according to Guidance Document No. 10 (European Commission, 2003), their advantages and disadvantages.

Approach to establishing reference conditions	Advantages	Disadvantages
Spatially based approach using survey data	Temporal and spatial variability can be taken into account; when data is available, it is a simple method	Undisturbed or minimally disturbed sites must be available; large data sets must also be available for all types
Predictive modeling	Data from similar regions or types can be borrowed; a lower number of sites/samples is necessary to establish reference conditions	Requires data, calibration, and validation; valid only for the ecoregion/type it has been created for
Temporally based approach using historical data, paleoreconstruction, or combination of both	Can be used in areas where human-induced stress is widespread and undisturbed reference sites are few or lacking entirely	Such approaches are usually site and organism-specific, and hence may be of limited value for establishing type-specific values; use of historical data may be limited by its availability and unknown quality
Expert judgment	Can be combined with other methods; can be used where reference sites are lacking or few	Substantial subjectivity and bias (particularly when this approach is the only source); the lack of clarity or low degree of transparency in assumptions used to establish reference conditions and the lack of quantitative measures for validation, often static values

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