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An assessment of river habitat quality as an indicator of conservation status. A case study in the Northwest of Spain

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ABSTRACT

There are several methodologies for the characterization and evaluation of river habitats. The scientific community has made a great effort in designing the best indexes for this purpose, and they have also been tested in different countries and rivers. Nevertheless, there has not been a transfer of that knowledge to land managers of these spaces or, at least, to those who design improvement and restoration measures. The aim of our research was the assessment of the Riparian Forest Quality Index (QBR), the "Riparian Quality Index" (RQI) and the "Fluvial Habitat Index" (IHF) as indicators of the ecological status of fluvial habitats and their application in restoration projects. The main results of this study were that the IHF index could be used as a support resource and as a monitoring tool to assess the habitat heterogeneity before and after any action is taken. However, when we evaluated the QBR and RQI indexes, the best results were with the first one. The total QBR suggests the urgency level of restoration in the section that is evaluated, and each of its sub-indexes identifies which element of the river is affected. Therefore, it will be a useful tool in decision making for the conservation of these characteristic spaces, especially for engineers who, as a result of their experience in biological and ecological processes, are involved in the design and building of ecosystems, particularly in rivers and on their banks.

1. Introduction

River ecosystems are increasingly being affected by different factors caused by the development of human activity. In particular, these ecosystems have been altered by dams and reservoirs, the channelization of some stretches, the reduction of their flow (human consumption, agricultural irrigation, etc.), and land use change (Adeel et al., 2005; Jetz et al., 2007; Nilsson et al., 2005) such as the establishment of population nuclei and industries throughout their drainage basins (Petts, 1989). All this means alterations in water quality, in the type and quantity of energy and food sources (organic matter and nutrients) that reach the ecosystem, and alterations due to biological interactions with exotic species (Arizpe et al., 2008).

River management, from the environmental perspective, initially focused on water quality and species protection. Currently, there is a new objective for European water policy towards maintaining the ecosystem health (European Commission, 2008). Water Framework Directive (WFD) of the European Union (European Commission, 2000) represents an important advance in the sense that it recognizes the importance of achieving good ecological water quality, as well as conserving aquatic ecosystems, and not least, the riparian ones.

Galicia (NW Spain) has more than 10,000 rivers and streams with 11,400 ha (Membiela et al., 1991) that, along with floodplain and upland areas, comprise corridors of great economic, social, cultural, and environmental value (Bernard and Tuttle, 1998). These corridors are complex ecosystems that include fauna, flora, microclimate and special conditions, all interrelated with each other, and dependent upon each other. Therefore, any change in one of them represents an influence on the others.

Different methodologies and research have been developed over recent years for characterizing river habitats in order to know the status of these ecosystems, as well as complying with European guidelines. Many researchers have used biological indicators for this purpose (riparian quality indexes, rapid bioassessment protocols, macroinvertebrates, etc.). For example, some of them have focused their study on riparian quality assessment throughout recent years. Munné et al. (1998, 2003) and Suárez et al. (2002) began with the "Riparian Forest Quality Index" (QBR). Subsequently, this index has been used to establish a protocol for

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assessing the hydromorphological quality of rivers (Munné et al., 2006) and the habitat condition with the HCI index, for assessing stream habitats in northern Portugal at a variety of spatial scales and levels of perturbation. (Oliveira and Cortes, 2005). Other authors, with the same need for assessment of these ecosystems in the rivers of their countries, described the adaptation of the QBR index, as is the case of Acosta (2009) with the QBR-And index. This one differs from the original one in the cover quality aspect, which was adapted to neo-tropical high Andean vegetation. Further evidence of being of common interest to the scientific community is the research of Sirombra and Mesa (2012), who adapted the index (named QBRy) and applied it in three sub-basins of Northwestern Argentina. Also, In Portugal, RHS was adapted to Portuguese regional and river characteristics (Ferreira et al., 2011).

On the other hand, the "Riparian Quality Index" (RQI) has also be used to evaluate the riparian quality (González del Tánago et al., 2006; González del Tánago and García de Jalón, 2011) which was applied in various researches such as Blanco et al. (2007), Navarro-Llacer et al. (2010), Barquín et al. (2011) and Belmar et al. (2013). Finally, to assess the river habitat heterogeneity many researchers like Argyroudi et al. (2009), Mendoza-Lera et al. (2012) and Villamarín et al. (2013) have used the "Fluvial Habitat Index" (IHF) of Pardo et al. (2002).

Recognizing previous research, as well as the need to maintain fluvial ecosystems in a good ecological state, it is important to transfer the knowledge and advances in research to the managers of these spaces. All of this with the aim of these innovations are taken into account in the projects carried. For all these reasons, the main objective of this paper was to apply these three indexes (QBR, RQI and IHF) as indicators of the conservation status of rivers. Specifically, the authors pretended to select the best one as a practical tool in the restoration and conservation projects of river ecosystems.

The specific objectives were to compare two riparian quality indexes (QBR and RQI) and select the best of them, combining or adapting them to the needs of running a possible restoration project. In addition, an index of habitat heterogeneity (IHF) was evaluated as a possible complementary indicator.

2. Materials and methods

2.1. Study area

The source of the Gallo river is situated 548 m above sea level (Latitude: 42°38′43″ N, Longitude: 8°30′36″ W: Fig. 1). Its basin has 44.3 km^2 and it is situated in the Southwest of Galicia (Northwest of Spain), within the domain of the Galicia-Costa District. The river runs 14.98 km to its mouth in the Umia river (Latitude: 42°36′52″ N, Longitude: 8°33′48″ W).

The main climate type in the basin is oceanic with an average annual temperature of 14.8 °C and average annual precipitation of 1500 mm (Carballeira et al., 1983; Martínez Cortizas and Perez Alberti, 1999).

With respect to its geology, the bedrock of the Gallo river basin is mainly granitic (Julivert et al., 1972). In terms of lithology, materials from plutonic rocks (Pluton of Caldas de Reis) are identified (Rodríguez Fernández et al., 1982).

The Gallo stream has been classified as salmonid waters (Ministerio de Medio Ambiente, 2004). According to Directive 2006/44/EC (European Commission, 2006), it supports or becomes capable of supporting fish belonging to species such as salmon (*Salmo salar*) and trout (*Salmo trutta*).

The Gallo river basin is characterized by a coline climate floor (Rivas Martínez, 1987). Natural vegetation on the riversides is Atlantic deciduous (*Quercus robur*, *Corylus avellana*, *Fraxinus* sp., *Sambucus nigra*). The riparian vegetation along the Galician rivers is dominated by groves or galleries of alder (*Alnus glutinosa*), and willow groves formed by *Salix atrocinerea*. The latter two are classified as priority habitat in Annex I of the Directive Habitats (European Commission, 1992). Where natural riparian forests have been modified by human activity, the vegetation is usually dominated by eucalyptus (*Eucalyptus globulus*), *Acacia melanoxylon* and *Acacia dealbata*. With pressure from pastures, the riparian forest is modified and in many cases it was eliminated.

Average population density is 147 inhabitants km^2, with a high rate of population dispersion. The main urban centre of the Gallo river has 10,045 inhabitants (IGE, 2010).

2.2. Field data collection

The data sets, comprising two riparian quality indexes (QBR and RQI) and an index of habitat heterogeneity (IHF), were measured and analyzed. We performed the fieldwork in 24 river stretches of 200 m in length along the Gallo river (Fig. 1), during the years 2010 and 2011 (both years the 24 river sections were completed).

2.2.1. Riparian Quality Indexes (QBR and RQI)

To characterize the quality of the riparian forest, the QBR index has been used (Munné et al., 2003) and without the possibility of taking reference points in the same river, we compared the results with the reference conditions in mountain rivers (the most restrictive values) according to Ministerio de Medio Ambiente, Medio Rural y Marino (2008). Specifically, four sub-indexes were evaluated: total riparian vegetation cover (QBR1); vegetation cover structure (QBR2); vegetation cover quality (QBR3) and river channel alterations (QBR4). Each part can score up to 25, thus the maximum value of the QBR index can be 100.

The RQI was also applied for assessing the structure and functioning of riparian zones based on hydrological and geomorphological conditions. For implementing of this index, we used the protocol described in González del Tánago et al. (2006). Specifically, seven different attributes of visual reconnaissance were considered: (1) longitudinal continuity of natural riparian woody vegetation; (2) lateral dimensions of riparian area; (3) species composition and structure of riparian vegetation; (4) woody species regeneration; (5) bank conditions and habitat quality; (6) lateral connectivity; and (7) vertical connectivity by means of permeability, substratum and topography of riparian soils (González del Tánago and García de Jalón, 2011).

2.2.2. Fluvial Habitat Index (IHF)

The IHF (Pardo et al., 2002) measures the ability of the physical habitat to host a particular wildlife. It has seven sections which assess the presence of different components in the stream channel independently. The IHF1 represents the percentage of embeddedness in riffles or sedimentation in pools. The IHF2 is the frequency of riffles in sampling reach (distance between riffles/stream width). The IHF3 measures the substrate composition (the percentage of boulders, stones, pebbles, gravel, sand and clay). The IHF4 shows the flow and depth regimes, specifically the number of classes present in sampling reach (slow-depth, slow-shallow, fast-depth and fast-shallow). The IHF5 represents the shading of stream bed. The IHF6 measures the elements of heterogeneity. Finally, the IHF7 stands for the aquatic vegetation cover. The final score of the index is the sum of the scores obtained in each of the sections and it ranges from 0 to 100 points. A habitat with an IHF below 40 is considered to be affecting the associated biological communities (Pardo et al., 2002). Based on this consideration, in this study the IHF was classified into five classes: (1) Very Good Quality (IHF > 90); (2) Good Quality (IHF 60–90); (3) Fair Quality (IHF 50–60); (4) Poor Quality (IHF 40–50) and (5) Bad Quality (IHF < 40), for a better comparison with the QBR and RQI.