

A Comparative Assessment of the Riparian Vegetation Status using Two Different Indices: Results from a Large-Scale Study in Greece

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Abstract: The riparian zone plays an important role in the ecological stability of rivers. In particular the quality of the riparian vegetation is a significant component of the hydromorphological status. In Europe, the QBR index (Qualitat del Bosc de Ribera) and the River Habitat Survey (RHS) are commonly used for the qualitative assessment of the riparian vegetation taking into account the riparian vegetation cover, the cover structure and the channel alterations. In this study, we estimated the QBR index and the Riparian Quality index, which is derived from the RHS method, for 131 river reaches of the National Monitoring Network of Greece. These reaches were surveyed during the summer periods of 2018, 2019 and 2020, through the implementation of the National Monitoring Program in compliance with the Water Framework Directive (WFD). The aim of this study is to assess the riparian vegetation status by comparing these two indices and to identify linkages with the dominant land uses within the catchment. The Riparian Quality Index and the Habitat Modification Score, also estimated from the RHS method, were positively correlated showing that the overall hydromorphological alteration is associated with the degradation of the riparian vegetation. In addition, the QBR index and the Riparian Quality Index correlated negatively with the agricultural land uses in the catchment area and positively with the natural ones (e.g. forests). Both indices seem to present similar quality assessments. These results constitute a first assessment of the status of the riparian zones in Greek rivers in accordance with the WFD and set the basis for further research for the development of new and effective tools for a rapid quality assessment of the riparian zones.

Keywords: QBR Index; Ecological Quality; Riparian Zone; Water Framework Directive; River Habitat Survey; Rivers

PACS: J0101

1. Introduction

Riparian vegetation is known to provide numerous functions to lotic ecosystems. For instance, plant assemblages within the channel and along the banks form buffer zones that mediate nutrient and sediment transport from the land into the watercourse [1,2]. In addition, riparian vegetation prevents erosion by stabilizing the channel bed and the banks [3]. At the same time, riparian plant communities provide many habitats for fish, amphibia, birds and invertebrates [3–5]. Plants on the banks also provide shade and influence the light availability in the water column and the thermal regime [6,7]. This function is of particular importance for the stream productivity and the overall ecosystem metabolism [8,9].

However, hydromorphological changes are considered responsible for the degradation of the riparian vegetation which in turn impacts the ecological integrity of these systems [10–12]. Hence, hydromorphological assessments incorporate the evaluation of the riparian vegetation status placing emphasis on various features such as the total cover, the cover structure and the continuity along the

riparian corridor. Thus, many assessments of riparian zone that are using various protocols and indices are in globally practice (Kumar et al., 2019).

With this study we evaluated the riparian vegetation status of 131 reaches in Greece by applying two discrete methodological approaches. The QBR index (“Qualitat del Bosc de Ribera” or riparian forest quality) is an easy-to-use field method for assessing the habitat quality of riparian forests. It was designed and developed for use in Mediterranean streams in Spain (Díaz-Pascacio et al., 2018). It is a score-based index divided into four main aspects of the riparian zone which are total riparian cover, cover structure, cover quality and channel alteration.

The Riparian Quality Index (RQI) represents the complexity, naturalness and continuity of the riparian zone. It features three sub-scores for complexity, naturalness and continuity that are calculated separately for each bank and added to yield a final site score between 0 and 120. The final RQI is classed into five quality categories to represent increasing riparian quality from ‘Very Low’ to ‘Very High’ quality class.

Our aim was to present a first assessment of the riparian vegetation status and to explore for significant relationships with the dominant land uses in the catchments. Thus, our results can set the basis for improving the current or developing new methods for the assessment of riparian vegetation status.

2. Methods

Our study was carried out through the implementation of the Greek National Monitoring Program in compliance with the Water Framework Directive (WFD). Distributed among 11 water districts and 42 river basin districts, 131 river reaches were visited in total during the summer periods of 2018, 2019 and 2020 (Figure 1). QBR and RHS methods were conducted, covering stretches of 100 m and 500 m respectively. Additionally, there was an aerial depiction of these sections by drone flights. For the evaluation of the riparian vegetation status, the QBR score, as well as the RQI sub-scores for complexity, naturalness and continuity, derived from RHS, were assessed initially. In addition, the shares of agricultural, artificial and natural land use within the catchment for each sampling site were calculated based on the available CORINE (Coordination of Information on the Environment) 2012 maps. Then the two indices were compared, in order to examine whether they present common assessment results, as well as to identify possible relationships with the dominant land uses in the catchment.

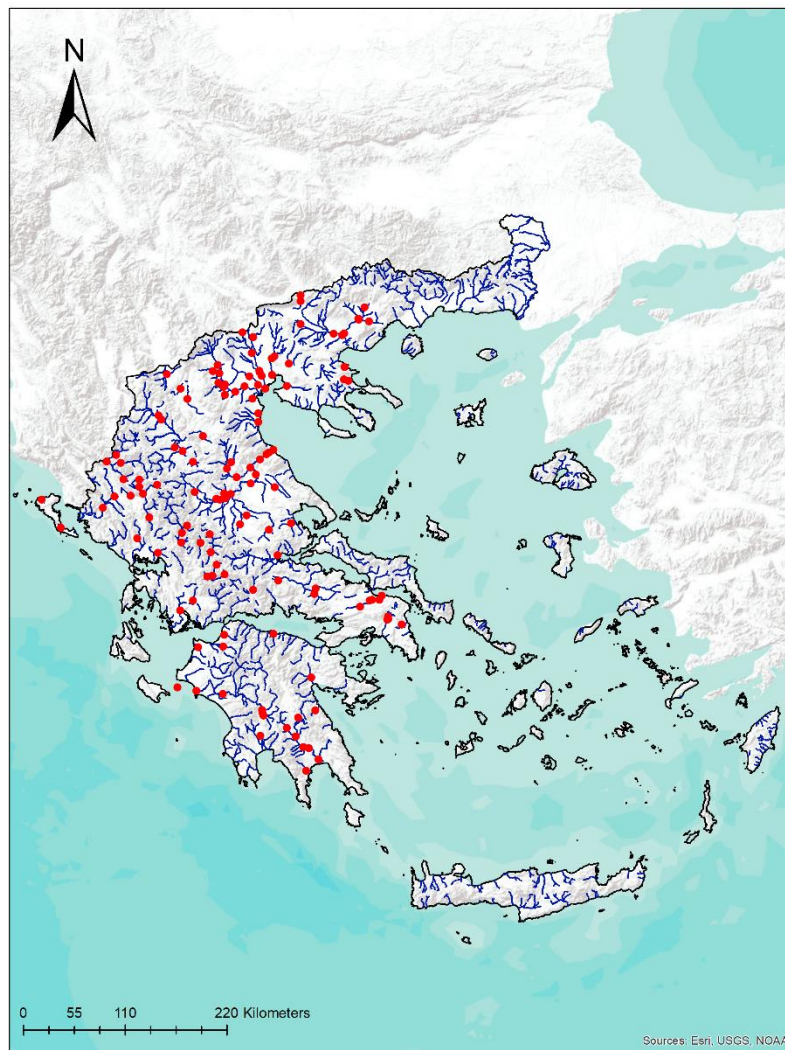


Figure 1. Map with the location of the samplings sites (n = 131).

We applied correlation analysis between the HMS, the scores of QBR and RQI, the altitude and the land uses by estimating the Spearman's coefficient. Our aim was to identify the significant relationships between the scores and the dominant land uses and to highlight issues for further exploration. The differentiations of the QBR and RQI among the six Mediterranean river types, as they result from the calibration of the typocharacteristic conditions of rivers [13,14], were visually assessed with boxplots.

Table 1. Quality classes according to the QBR index (Munne et al.,2003).

Riparian Habitat Quality Level	QBR
Riparian habitat in natural condition	≥ 95
Some disturbance, good quality	75–90
Disturbance important, fair quality	55–70
Strong alteration, bad quality	30–50
Extreme degradation, very bad quality	≤ 25

3. Results and Discussion

The distribution of the total number of sites among the riparian quality classes is presented in Figure 2. According to the implementation of the RQI, 50% of the sites belongs to good and high quality classes, while for the same classes QBR gives a smaller percentage. On the contrary, according to QBR 45% of the sites belong to poor and bad quality classes, while the corresponding site percentage estimated by RQI is 32%.

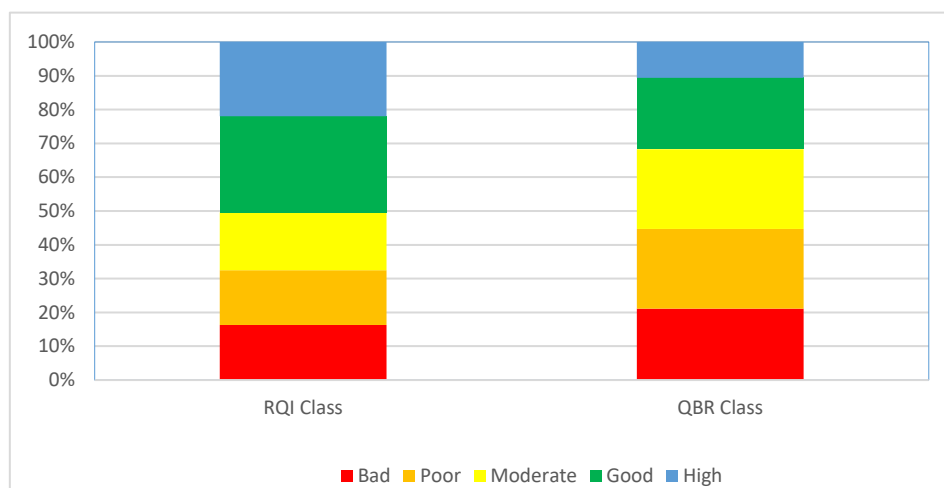


Figure 2. Distribution of the sites according to their riparian quality class as derived by the calculation of the RQI and QBR .

As shown in Table 2, both QBR and RQI are positively correlated with altitude, which implies that at low altitude sites, where an extended agricultural activity exists, the riparian zone and thus the riparian vegetation is impacted. This is also shown by the significant negative correlation between agricultural land use and altitude. In contrast, natural land use is positively correlated with both indices ($p \leq 0.01$ for QBR and $p \leq 0.05$ for RQI). Finally, QBR correlates positively with RQI ($p \leq 0.01$) which implies that both indices show similar results concerning the riparian quality status.

Table 2. Spearman’s correlations between HMS, scores of QBR, RQI, altitude and land uses according to the CORINE land cover inventory. * means that correlation is significant at the 0.05 level and ** means significance at the 0.01 level.

	HMS	Altitude	% Near Natural LUs	% Artificial LUs	% Agriculture LUs	RQI
Altitude	-0.071	1				
% Near Natural LUs	-0.053	0.434 **	1			
%Artificial LUs	0.091	-0.142	-0.427 **	1		
% Agriculture LUs	0.050	-0.438 **	-0.978 **	0.318 **	1	
RQI	-0.223 **	0.208 *	0.228 *	-0.196 *	-0.196 **	1
QBR	-0.445 **	0.441 **	0.294 **	-0.151	-0.312 **	0.319 **

Figures 3 and 4 show the variation of QBR and RQI among the 6 Mediterranean River Types. There is an obvious variation of QBR in relation to Mediterranean river types, as the index values increase in sites of higher altitude and extended vegetation (R-M4 type). Opposed to QBR, RQI shows no significant variation in relation to Mediterranean river typologies.

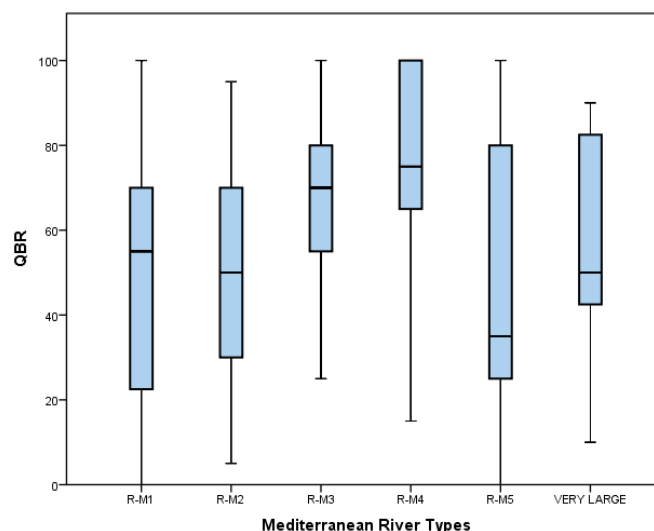


Figure 3. Variation of QBR score in relation to the Mediterranean River Types. According to [13,14], R-M1: Small -mid altitude mediterranean streams (<100km² catchment area) with strong seasonal flow, R-M2: Small-mid lowland mediterranean streams (100–1.000km² catchment area) with strong seasonal flow, R-M3: Large Mediterranean streams (1.000–10.000km² catchment area) with strong seasonal flow, R-M4: Small-mid mediterranean mountain streams with strong seasonal flow, R-M5: Small lowland temporary streams with temporary flow, Very Large Rivers: (>10.000km² catchment area).

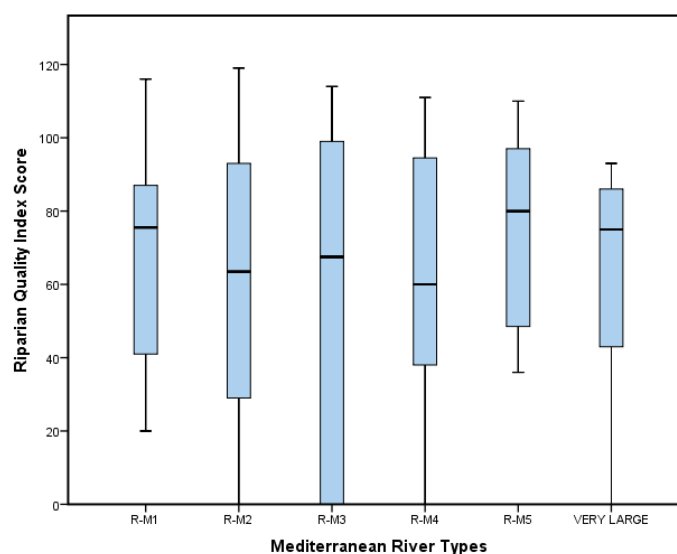


Figure 4. Variation of RQI in relation to the Mediterranean River Types. According to [13,14], R-M1: Small -mid altitude mediterranean streams (<100km² catchment area) with strong seasonal flow, R-M2: Small-mid lowland mediterranean streams (100–1.000km² catchment area) with strong seasonal flow, R-M3: type Large Mediterranean streams (1.000–10.000km² catchment area) with strong seasonal flow, R-M4: Small-mid mediterranean mountain streams with strong seasonal flow, R-M5: Small lowland temporary streams with temporary flow, Very Large Rivers: (>10.000km² catchment area).

4. Conclusions

This study presents the first results derived from the application of QBR index in Greek rivers. According to our findings, in particular the HMS results, the construction of dams and various small or larger permanent structures is responsible for the decrease of the riparian vegetation, due to the

alterations of the hydrological pressure, at upland reaches. Another pressure that contributes to the gradual reduction of riparian vegetation, especially at lower altitude sites, is the large expansion of agricultural activity. These two, are the main factors which contribute mostly to the degradation of the riparian vegetation in the Mediterranean riparian ecosystems.

Agricultural activity in particular is considered a major driver of hydromorphological modifications in Mediterranean rivers [15–17]. For instance, bank and channel resectioning is used as a practice of flood defense management to protect neighboring agricultural land from flood events. In addition, bank reinforcement that uses hard materials (concrete, bricks, rip-rap, etc.) aims to mitigate bank erosion [17]. These changes inevitably are associated with significant alterations in the riparian zone affecting the structure and cover of the vegetation.

Concerning the use of the Riparian Quality Index, as derived from the application of the RHS protocol, the RQI score correlates significantly with the QBR but it appears that the latter is better suited for distinguishing variations in the riparian quality status among different river typologies. It is also more effective on distinguishing sites with moderate impacts from sites with good quality status.

As a concluding remark we propose the need for further study, particularly on the effects of dams and other stable structures located mainly in higher altitudes of river basins, as well as the hydrological disturbances they cause, which have negative effects on riparian vegetation status.

Author Contributions: Conceptualization, K.S, A.L., T.K., E.D.; methodology, K.S, A.L, T.K; data curation, A.L., T.K., K.S., E.D., K.G.; formal analysis, A.L., K.S., T.K.; visualization, K.S, A.L., T.K.; writing- original draft, A.L., T.K., K.S.; writing-review and editing, K.S, A.L., T.K., E.D., K.G. All authors have read and agreed to the published version of the manuscript

Conflicts of Interest: The authors declare no conflict of interest.

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