Different approaches for the use of bioengineering techniques in the rehabilitation of lotic and lentic systems: two case studies in North Portugal

R.M.V. Cortes, D.G. Oliveira, J.M. Lourenço & L.F.S. Fernandes
UTAD, Apart. 1013, 5001-911 Vila Real Codex, Portugal

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ABSTRACT: Two projects for rehabilitation took place in North Portugal in different conditions: a) in a fast flowing stream - River Estorãos - a tributary of River Lima and of crucial importance for the spawning of lamprey (*Petromyzon marinus*) and important for other native fish species, impacted by river bed dredging which led to bank collapsing; b) an artificial pond created for gravel extraction, on the banksides of River Tâmega, were this activity has recently ceased, and where we can observe the domination of exotic fish populations. However, in such a diverse situations, a similar analytical holistic approach was used to seek for long-term solutions for the aquatic systems functioning, preserving or implementing the natural linkages. Previous monitorization took place in order to assess upstream and downstream conditions, longitudinal and lateral connectivity, river corridor and fluvial habitats, which allowed to define the characteristics of the intervention.

1. INTRODUCTION

A restored ecosystem does not necessarily return to a pristine state but it is free to express a range of successional trajectories and states without being constrained by human pressure. This concept set the boundaries for restoration measures. These ones should not focus on recreating natural structures but on identifying and re-establishing the conditions under which natural states create themselves (Frissell & Ralph, 1998). River restoration will only be sustainable if structure, function and dynamics are included (Poudevigne, 2002). Treating large-scale disturbances like the ones acting at the catchment level (deforestation, hydrologic and sediment regimes) with small scale actions is ineffective and costly (Kondolf et al., 1996). However, most studies are faced with the difficulties concerning the right scale for restoration actions and with the inputs from a wide range of specialists. After all, localized interventions are an appropriate methodology when the principal cause of ecosystem damage is a local alteration involving the loss of aquatic habitat or the disruption of the riparian layer, where the most common consequence is the bank collapsing. We selected two clearly distinct situations where rehabilitation efforts took place: a) A physically disturbed segment of a low order stream (R. Estorãos) running trough a basin with a low human pressure and a rich native fish community; b) An entirely new aquatic system created on the flood plain of a relatively large river (R. Tâmega), intensively used for agriculture and where fish populations are dominated by exotic species. This work intends to show the different nature of the techniques used, according to the character of each ecosystem. Another objective is also to describe the nature of the physical and biological assessment which, in spite of the peculiar character of each situation, should determine the direction and the features of each project, where recreational and scenery values should as well be taken into consideration.

2. MATERIAL AND METHODS

2.1 Study area

R. Estorãos, a tributary of R. Lima (NW Portugal) is a 2^{nd} order stream draining an afforested catchment dominated by eucalyptus and pine stands. In 1995 a segment of nearly 8 km was dredged in order to avoid the flooding of the agricultural fields

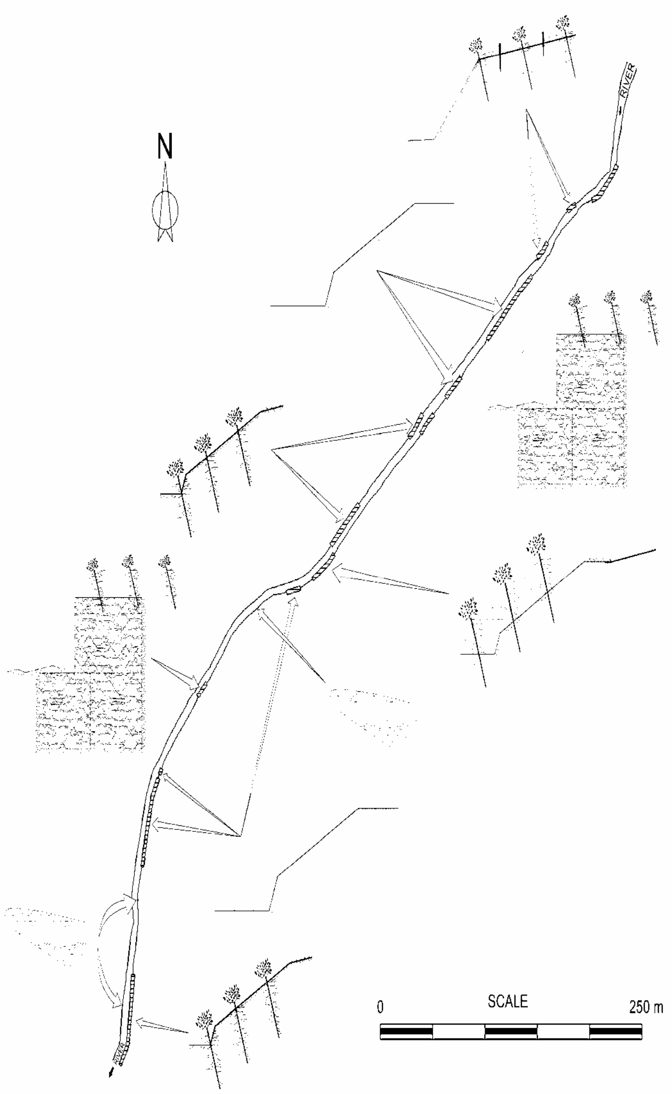

Figure. 1. Distribution of the selected techniques for stream bank stabilisation along the considered segment of River Estorães (about 1 km). We can observe the use of vegetated gabions, different forms of rip rap with joint planting, wing deflectors and bank shaping with vegetated geogrid.

in the river valley. This impairment lead to two effects: a) instability of the banks creating continuous collapsing of the alders bordering the stream, which was particularly dramatic since the soil is composed mainly by sand stone; b) water table lowering, causing similarly a decrease of the water level of the fens in the surrounding area. Because in the year 2000 a part of this segment and the connected fens were classified as a protected area, rehabilitation became a priority. The considered R. Tâmega segment is located in North Portugal near by the border with Spain and it is a 6th order stream running along a valley with intensive agriculture. Besides, the input of nutrients from this activity, there are also different point sources of contamination from urban areas and food industries. The area selected for rehabilitation is a large artificial pond (about 6 ha) created by gravel mining, immediately contiguous to the river, which renovates the water during the rainy season. The extractions took place during 3 decades and only about 3 years ago local authorities managed to put an end to the illegal continuous enlargement and destruction of the riverside. Since then there was a progressive colonisation of the banks by alders and willows, whereas aquatic birds exhibit already a notorious diversity. However, the deposition of waste materials in the banks and the water eutrophication contrasts with the demand of favouring new recreation areas for the local town (Chaves), together with the intention of creating the conditions to improve biodiversity in order to include this region under the status of a protected area.

2.2 Rehabilitation techniques

The improvement of fisheries was one of the targets considered by local authorities. In R. Estorãos there was a dominance of trouts and anadromous species (lamprey and salmon). To defend this important fisheries it was necessary to take into account their spawning requirements and the habitats for adults. Gravel composition influences the survival of the first stages, since incubation success decreases as the content of fines rises above 10-15 % (Cowx & Welcomme, 1998). Besides the trout adults are territorial and need refugees provided by the riparian vegetation. Consequently, the intervention in this river should create the consolidation of the banks in order to allow the establishment of vegetation and to avoid the deposition of fines in the river bed. In order to decrease the visual impact and to increase the physical heterogeneity it were combined different techniques according to the instability along the segment, namely gabions, different types of rip rap (variable height: from stone toe protection to a complete rip rap revetment), stone wing deflectors and organic fiber rolls, besides simple bank shaping followed by planting _Fig. 1. Besides, the visual mitigation of the artificial structures was achieved by using live stakes of native vegetation or joint planting in the rock rip raps and gabions.

On the contrary, in the artificial ponds of R. Tâmega the fish populations utilize a wide range of spawning substrata, where we may find phytolithophils, phytophils and lithophil species. So, all these conditions should be present, but since we want to favour the native populations that are mainly lithophil ones (eggs stick to stones and gravel), this habitat should be increase since is virtually absent. Since the local authorities want to favour recreational activities this aspect was also taken into consideration. The use of artificial structures was limited to the spots were it was necessary to stabilize the banks or to protect them from the pressure of the visitors. In the other areas it was preferred extensive habitat improvement by removing the remains of the previous human activities, cutting weeds and creating the conditions for a natural bank appearance. Fig. 2 illustrates the procedures used along the main area chosen for rehabilitation, since is less stable and offers an higher accessibility to the visitors.

3. DISCUSSION

Interventions at the habitat or reach scale are the most common procedures, either using instream structures for production and survival of target fish species or through bioengineering techniques to stabilize the banks and to increase the physical diversity. However, their effectiveness in re-establishing the natural equilibrium of the biotic community most of the times has remained uncertain (Reeves et al., 1997). Moreover, these actions have been criticized because of high failure rates and escalating costs of maintenance in watersheds where high erosion and sedimentation rates, high peak flows are pervasive (Frissell & Nawa, 1992). Therefore, the project needs previously a data collection relative to the inventory of the biological elements and the physical environment associated. This field work will allow to define the actual situation, this is the reference state in order to assess in the future the relative efficiency of the interventions thorough a monitoring program, but also it is fundamental to analyse the linkages between the selected area and the surrounding ecosystems. Therefore, such observations should encompass a larger area and not only the strict one where the instream techniques are going to be installed. Besides, such survey is of a great utility in order to set the goals of the project. For the cases presented here the assessment done showed the deviation between the impacted areas and the surrounding ones and allowed to define the objectives of the projects: where in the R. Estorãos it was necessary an active action in a relatively limited segment, in the R. Tâmega it was more advisable a passive and extensive rehabilitation program. Nevertheless, because of economical constrains it was not possible to work on the linkages with the adjacent ecosystems. The two distinct options presented here are related to the different nature of the disturbances. In the first case, active techniques are associated to the mitigation of erosion and the creation of habitats that are appropriate in "natural"

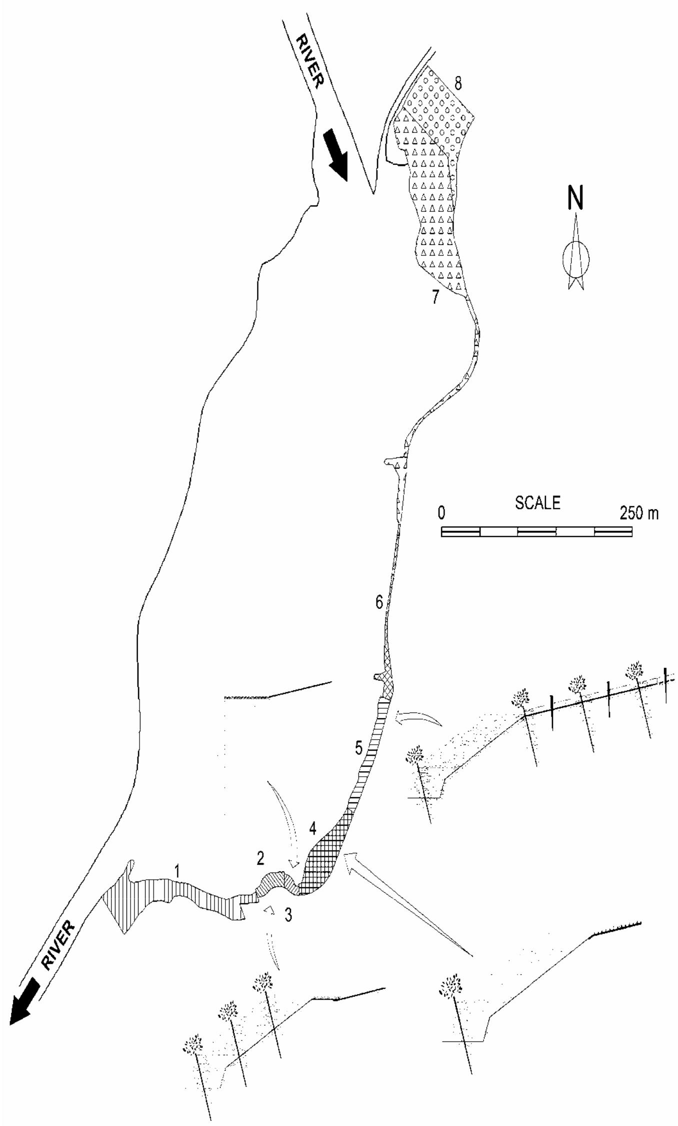

Figure. 2. It is exemplified along one of the banks of the widened channel of River Tâmega the mixed techniques used for rehabilitation. From downstream to upstream: 1-rip rap and establishment of sods and grasses; 2- rip rap and joint planting; 3-post wall: 4-toe rip rap and bank shaping covered with grass; 5- toe rip rap and branch mattress (with live stakes); 6 and 7-weed cutting and removal of soil heaps; 8-recreational area.

systems exhibiting a strong dynamism after a disturbance with the tendency towards an impoverishment of the biological conditions . Otherwise, in the case of an entirely new aquatic system (R. Tâmega) a passive intervention must be adopted, like the removal of stresses that cause degradation and the management of the riparian vegetation and human activities in the marginal layer in order that the vegetation achieve a self-sustainable successional stage. Here also there was an attempt to conciliate nature protection and biodiversity with tourism. In spite of the financial limitations that restricted the areas for restoration, these two examples show the need to adopt different techniques in the same system. These ones must be implemented in a short spatial scale, should respect the morphological characteristics of the river bank before disturbance and should allow to increase the habitat diversity as well as the rapid establishment of riparian vegetation.

Of course, these two study cases are not systemic approaches like the ones stated by Poudevigne *et al.* (2002) for restoration. But, following a quotation of McIver & Starr (2001), "the challenge for the restorationist is to find a way to restore more desirable conditions within the context of social and economic constraints that limit how processes are allowed to operate and how much effort will be invested in restoration".

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