Ecological Engineering 108 (2017) 132–142

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Research paper

Dismantling artificial levees and channel revetments promotes channel widening and regeneration of riparian vegetation over long river segments

Vanesa Martínez-Fernández[a,*], Eduardo González[b], Juan Carlos López-Almansa[c], Sofía Maura González[c], Diego García de Jalón[a]

[a] Department of Natural Systems and Resources, E.T.S Ingeniería de Montes, Forestal y del Medio Natural, Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040, Madrid, Spain

[b] EcoLab (Laboratoire Ecologie Fonctionnelle et Environnement), Université de Toulouse, CNRS, INPT, UPS, 118 Route de Narbonne Bâtiment 4R1, 31062 Toulouse Cedex 9, France, France

[c] Departamento de Medio Ambiente y Desarrollo Sostenible, Universidad Católica de Ávila, c/ Canteros s/n, 05005 Ávila, Spain

ARTICLE INFO

Keywords:
Channel widening
Assessment
Dike removal
Floodplain
Gravel-bed river
Monitoring
River restoration

ABSTRACT

Longitudinal structures manipulation can re-activate channel migration and thus restore flood-dependent riparian plant communities in human-constrained floodplains. However, it has been rarely implemented over long restored river segments and has been infrequently assessed while taking into account river conditions prior to restoration. This study describes the morphological and vegetation response to this type of restoration in a project completed in 2012 along a 21.6 km river segment in the Órbigo River (NW Spain). Land cover changes and channel planform evolution in the restored segment were compared with a downstream non-restored (control) segment and to an upstream unregulated (reference) segment before (2011) and shortly after (2014) the restoration implementation. Riparian vegetation was surveyed in 18 gravel bars of the three river segments four years after restoration completion (2016). The restored segment presented the largest increase of active channel area. Rejuvenation of landforms predominated over transition toward mature stages (succession) in the restored and the reference segment, while succession predominated in the control segment. The sinuosity and braiding indexes in the restored segment increased much more than in the reference and, especially, than in the control segment. Riparian plant communities that colonized gravel bars in the restored segment resembled those found in the unregulated segment and slightly differed from that found in the non-restored segment. Within-segment variability was much higher, indicating the dependence of riparian plant communities on local processes. Although positive, our results showed that the high stability of floodplain areas in the human-constrained rivers of industrialized societies limits the short-term effectiveness of longitudinal structures manipulation as a restoration strategy. We also showed that assessments using relatively simple aerial photointerpretation and vegetation surveys in pioneer habitats can illustrate trajectories in river restoration projects shortly after their completion. Long-term monitoring of the geomorphic trajectory and associated plant communities, however, will help define the timing of future additional interventions to assure the natural resilience of riparian habitats.

1. Introduction

In degraded floodplains constrained by human activities, the regeneration of riparian vegetation is limited to narrow, unprotected areas running parallel to a main channel that no longer migrates (Cordes et al., 1997; Dixon et al., 2012; Martínez-Fernández et al., 2017). In these cases, the removal and setback of artificial levees and rip-rap channel revetments to re-activate channel migration, generally referred in this paper to as *longitudinal structures manipulation*, have been suggested as the most effective strategies for restoring endangered riparian plant communities (Biron et al., 2014; González et al., 2010; Göthe et al., 2016; Scott et al., 1996). Channel migration is necessary for the recurrent formation of open, moist surfaces that flood events left behind, such as bare gravel and sand bars, where pioneer, flood-dependent riparian plants can establish in the absence of competing vegetation (Mahoney and Rood, 1998; Scott et al., 1996).

The removal or setback of artificial levees and rip-rap channel revetments usually encounters strong social opposition: landowners are reluctant to yield their lands for restoration and neighboring communities fear higher flood risks following the dismantling of flood defenses

* Corresponding author.
E-mail addresses: vanesa.mfernandez@upm.es, vanesa.mfernandez@gmail.com (V. Martínez-Fernández).

http://dx.doi.org/10.1016/j.ecoleng.2017.08.005
Received 22 April 2017; Received in revised form 7 July 2017; Accepted 9 August 2017
0925-8574/

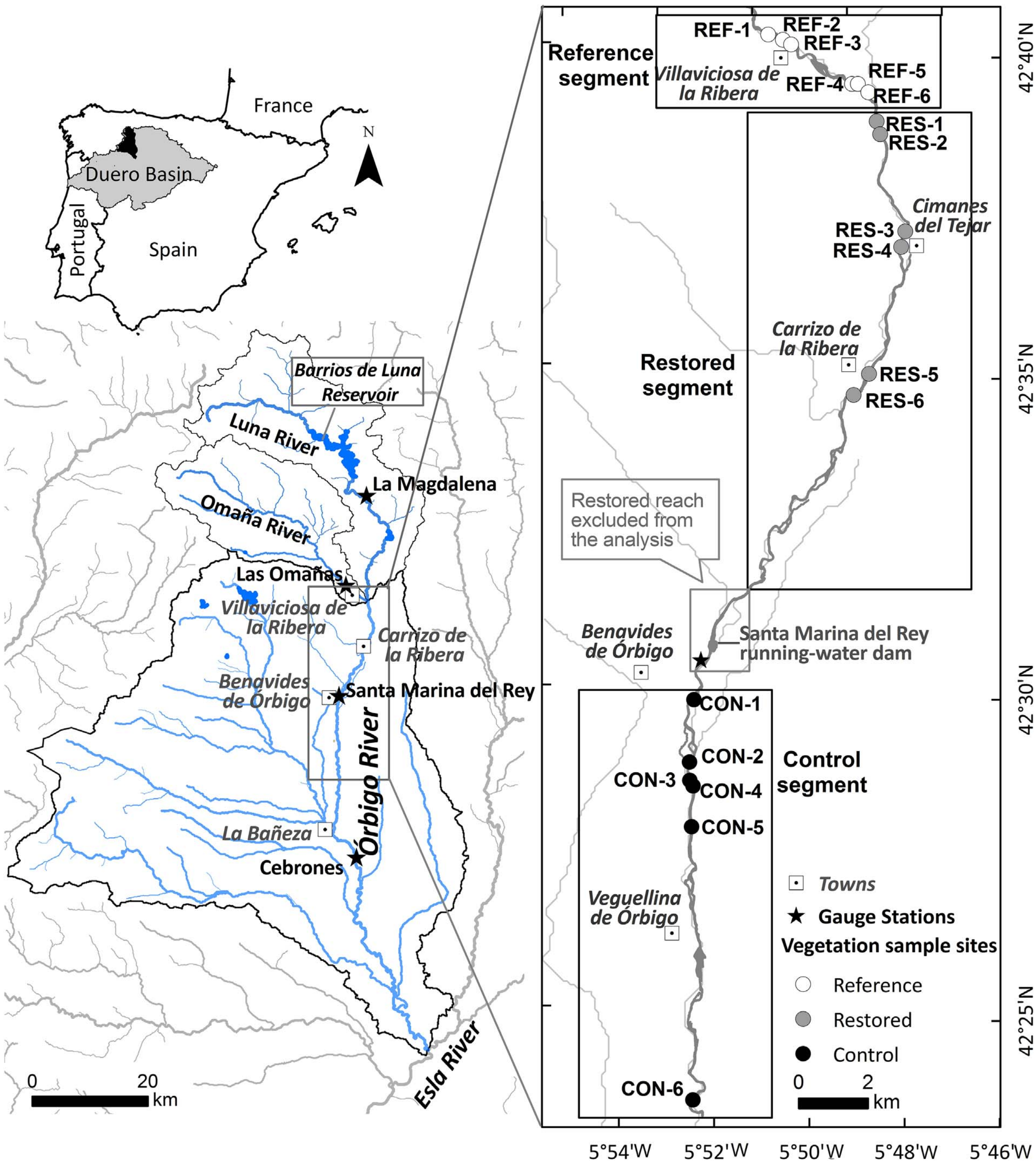

Fig. 1. Location of the Órbigo River ecological restoration project in the Duero River Basin (NW Spain), with a zoom view of the three study segments: reference (unregulated), restored, and control (non-restored), as well as the sampling sites for the vegetation survey: REF − reference, RES − restored, CON − control.

(Gumiero et al., 2013; Ollero, 2010). In this social context, this type of restoration actions has been employed much less often than needed, and its effectiveness in restoring riparian vegetation has not been frequently assessed (González et al., 2015). The few evaluations of this restoration method published to date have shown increases in riparian habitat heterogeneity and establishment of pioneer riparian plants when compared with unrestored control sites (e.g., Florsheim and Mount, 2002; González et al., 2017a; Göthe et al., 2016; Hering et al., 2015; Jähnig et al., 2009; Poppe et al., 2016; Rohde et al., 2005; note that in some of these papers the restoration actions are semantically confounded with the restoration goal as this restoration technique is generally referred as to "channel widening"). Surprisingly though, and despite recommendations (Bernhardt et al., 2007; González et al., 2015), we are unaware of any study taking into account river conditions *prior to restoration* (before-after-reference design).

Most of the abovementioned published evaluations of longitudinal structures manipulation have studied their implementation over short river sections, usually less than 2 km and even less than 300 m. Such a local-scale approach to river restoration might not be sufficient to maintain the key abiotic and biotic processes that sustain life in riparian areas, such as erosion, sedimentation, propagule dispersal, plant establishment, and organic matter decomposition, which are driven by factors, such as the flow regime or the flooding extent, that operate at multiple, higher and nested spatial levels, including segments of several kilometers in length, landscape units, and entire catchments (Gurnell et al., 2016). If this hierarchy of fluvial processes is not taken into