ÓRBIGO RIVER

Title		**Órbigo River ecological status improvement (segment I)**	
Organization		Duero River Basin Authority (Ministry of Ecological Transition, Spain)	
Start	**End**	2011	2011
Length		23.5 km	
River typology		Braided/wandering large gravel river	
Q mean		25 m^3/s	
Contact		Ignacio Rodríguez Muñoz (Duero Basin Authority) irm@chduero.es	

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LOCATION

The project comprises the restoration of a 23.5-kilometre segment of the Órbigo River between Cimanes del Tejar and Santa Marina del Rey (Fig. 1), near the city of León.

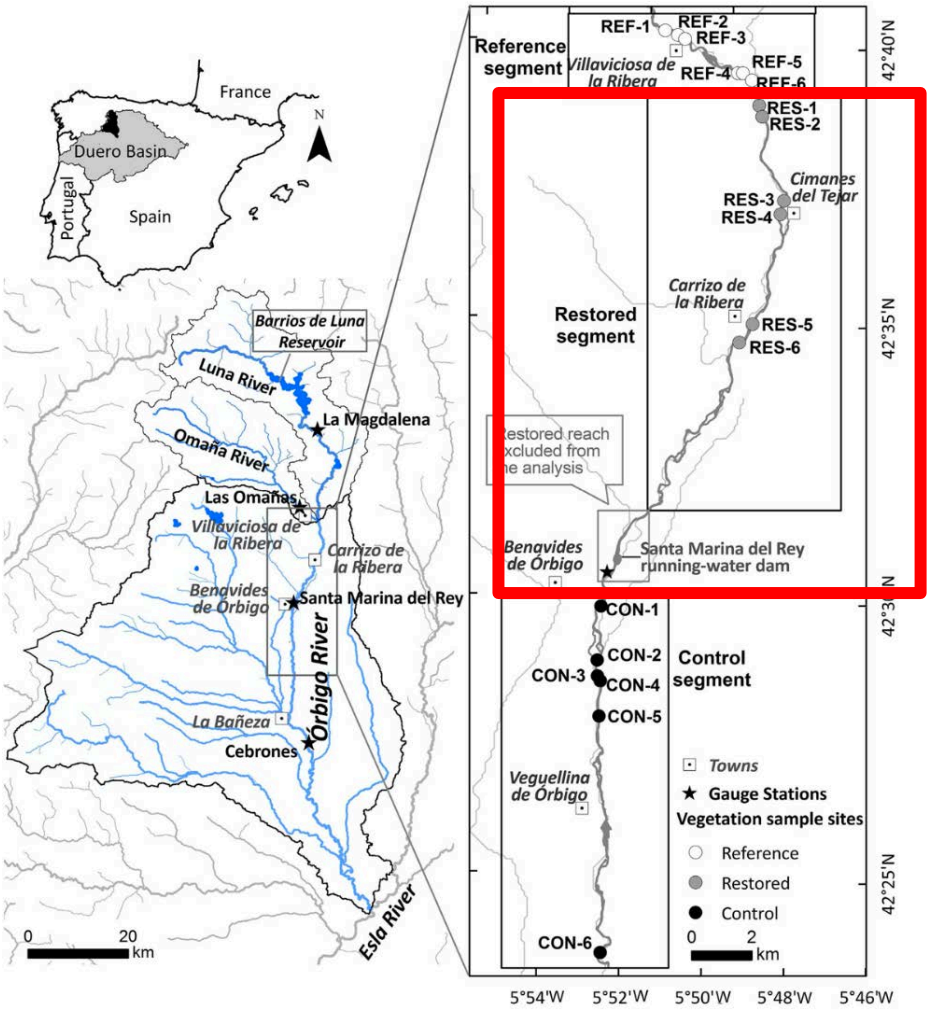

Figure 1. Location of the Órbigo River's restored reach (Martínez-Fernández et al., 2017)

CONTEXT

The Órbigo River is located in the northern part of the Duero/Douro Basin (NW Spain). Its length is 160 km and the total catchment area is 5,040 km^2 (fig. 2). The catchment area up to the restoration section is 1,600 km^2. The river is regulated at the head by the Barrios de Luna reservoir (in green in Fig. 2) since 1956.

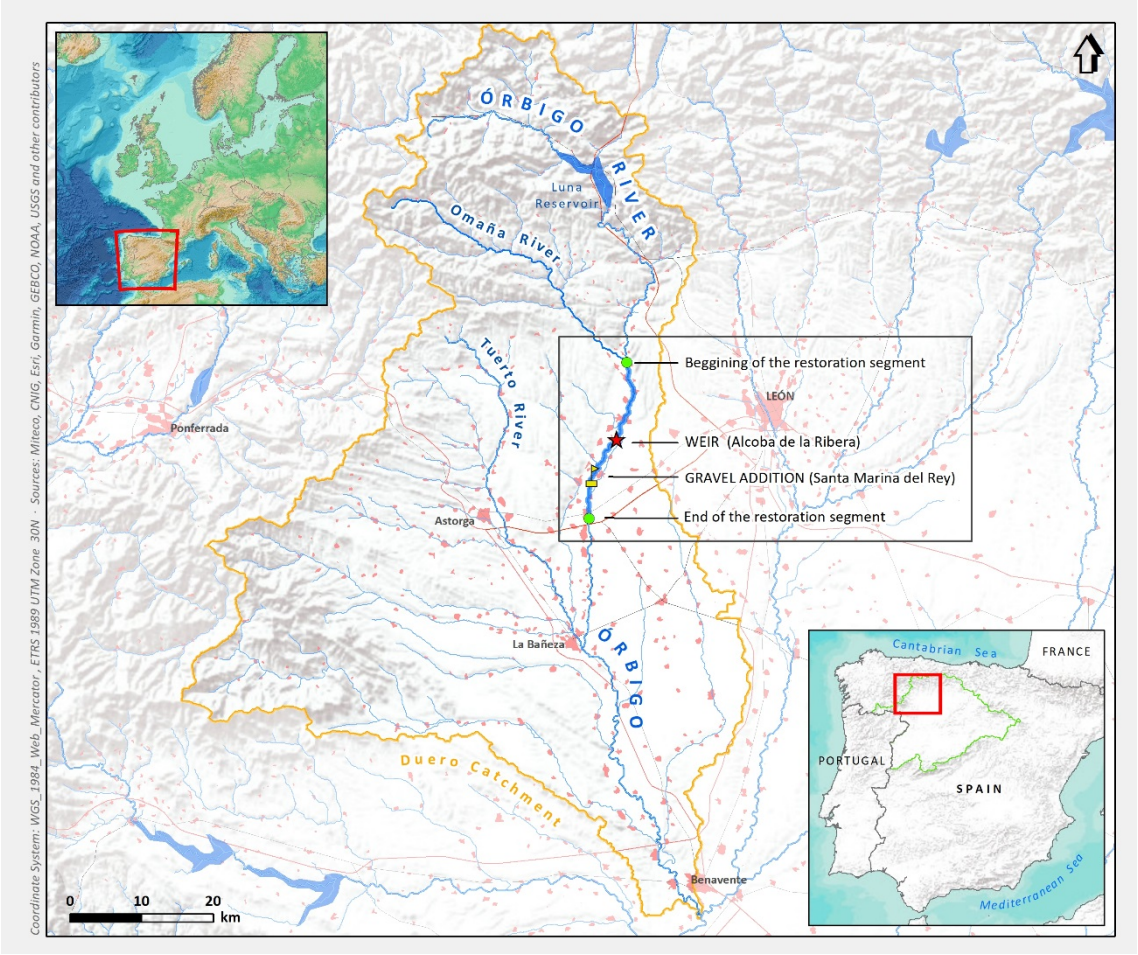

Figure 2. Órbigo River basin and restoration actions locations

Annual precipitation ranges from 530 mm close to the Esla River confluence to 1140 mm in the headwaters, being most abundant in winter and spring (Martínez-Fernández et al., 2017). The river has a pluvio-nival hydrological regime with a mean annual discharge of 25 $m^3.s^{-1}$ (Cebrones gauge station, 1972–2012). The Órbigo River generates significant and frequent flooding in its wide floodplain. The most relevant floods have been those of December 1909, December 1959, January-March 2001, March 2014 and more recently those of February 2021 and January 2023.

The area of action is located in the middle reach. In this segment, as in many other rivers, the Órbigo River was channelized between levees, with very little space for natural overflow and many problems with each flood. Longitudinal and transversal obstacles altered its dynamics and disconnected the active channel, banks and floodplain. The sediment yield was reduced with the recovery of hillslope vegetation along with the depopulation of the mountainous areas and the construction of the Barrios de Luna reservoir. This rural area was abandoned by the population when people migrated to urban areas in the 60-70's, and that supposed a natural recovery of the vegetation due

to a lower pressure, reduced crop areas, and in some places the plantation of vegetation with the objective of reducing erosion.

PRESSURES & IMPACTS
1) Lateral defences and embankments 2) Agricultural use (poplar plantations) 3) Weirs 4) Narrowing 5) Incision

The Órbigo River has been highly affected by pressure from two main human activities (Martínez-Fernández et al., 2017). The flow regime regulation of the Luna River keeps the summer base flow in the Órbigo River higher than normal to allow water extraction for irrigation purposes. The conversion of the natural floodplain to farmlands and poplar plantations (Rodríguez Borrego, 2015), which intensified during the second half of the 20th century with the construction of earth embankments, rip-raps, and levees. In turn, both of these activities have limited free streamflow, changed the channel from a braiding planform in 1956 to the current single wandering planform, and caused artificial cutting of meanders and, ultimately, narrowing of the natural riparian corridor (Fig. 3), and drastically reducing its sediment bars (colonized by riparian vegetation and stabilized). This evolution has also initiated incision processes (García et al., 2021), as well as subsequent damage of the lateral defences that required continuous funding for their repair (Barquero and Santillán, 2012). In spite of infrastructure constructed to reduce, theoretically, flood risk and control erosion, flooding persisted and even increased because of the false sense of security created by these structures.

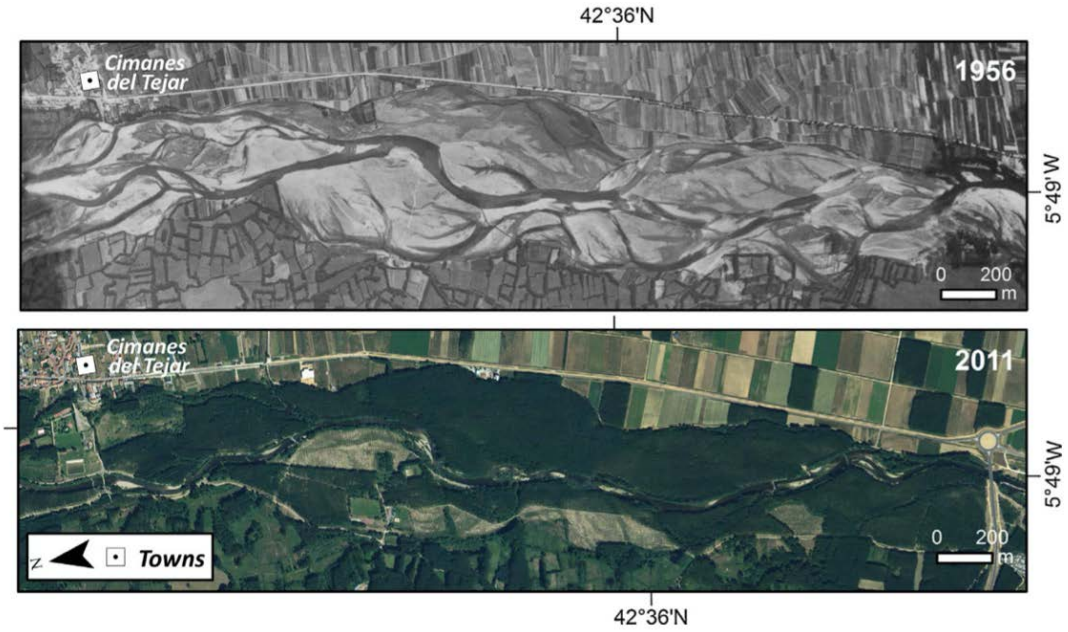

Figure 3. Disappearance of the braided channel of the Órbigo River, narrowing and occupation by poplar plantations (Martínez Fernández et al., 2017)

OBJECTIVES
The project has 2 main objectives: ➢ **Reduce flood risk** ➢ **Healthier and more diverse nature**

Target species/habitats	Hydromorphology, alluvial forest

The essence of the project consists of "flooding to avoid dangerous flooding", that is, to prevent urban areas from suffering flood damage, although the flooding of compatible areas must be allowed to occur. The main objective of the project was to recover the stream space and therefore the capacity to attenuate floods in the floodplain, which has been systematically encroached upon, resulting in much less frequent floods than before regulation.

RESTORATION ACTION

The project received an investment of € 2.2 million and formed part of the Spanish National Strategy for River Restoration. Woks began in autumn 2011 and was completed in autumn 2012. The main actions consisted of eliminating earth embankments and rip-raps along a total of 13.4 longitudinal km and setting them back along another 5.2 km.

Figure 4. Before and after the river restoration (photo: J.I. Santillán)

Also, the Alcoba de la Ribera weir has also been made permeable by breaking it through the centre for a length of 16 m, adopting a removable system using profiles and planks, so that during the times of migration of salmonids the weir can be completely remountable (Fig. 5). With this action, 22 km of river have been reconnected.

Figure 5. The Alcoba de la Ribera weir (Google Earth, 2017)

Gravel addition has also been done in this restored reach. The material added came from two sources:

- Gravel from removed lateral dikes, material that had been previously excavated from the river. In 2015 9,500 m^3 from the removed dyke between Castrillo de San Pelayo and Villoria de Órbigo added in Veguellina de Órbigo and 14,000 m^3 from the removed dyke in the confluence of Órbigo and Tuerto Rivers. In 2022 2,300 m^3 of a removed dyke in the Tuerto River tributary.
- 23,680 m^3 of gravel extracted in 2021 and 2022 from the Santa Marina del Rey reservoir and deposited downstream the weir (Fig. 6).

Figure 6. Gravel deposited downstream and extracted from Santa Marina del Rey weir (Google Earth, 2017)

This sediment addition practices are part of a larger sediment management plan in Douro basin.

In some areas, bioengineering techniques (*Salix* live stakes and fascines) have been applied along 1.4 km. And there was a removal of 1,100 m^3 of waste.

The project was supported by local communities after an intense public participation process that began in 2009. Informative meetings were held with mayors and neighbourhood councils (preparatory phase), information was collected on the problems of each segment of the river (diagnosis phase) and discussions were held about intervention alternatives with simulations on orthophotos (public exposure phase).

MONITORING

The Duero River Basin Authority assumed monitoring works: 1) From 2012 onwards periodic monitoring of hydrodynamic processes such as erosion and sedimentation, reconnected side-arms, flood events and social perception (stakeholders) regarding implemented actions and their evolution. 2) From 2013 onwards: floods events (drone photography vs ortophotography). 3) From 2014 onwards: river dynamics (most active areas) topography for monitoring changes in channel patterns (Strosser et al., 2014). Regular inspection required channel, vegetation and fish ladders.

In a complementary way, the research of Martínez-Fernández et al. (2017) carried out morphological analysis and field surveys of vegetation in 2016, working in three segments of the river (Fig. 6).

Figure 6. Images of representative sample sites in the reference, restoration and control segments in monitoring research of Martínez-Fernández et al. (2017).

ACHIEVEMENTS

The project had a positive impact on land planning and flood-risk management (mitigation) and recovery of the river dynamics, morphology and hydraulic capacity of the channel (Fig. 7). The project has meant a paradigm shift on how to treat rivers and the problems that affect them (García et al., 2021).

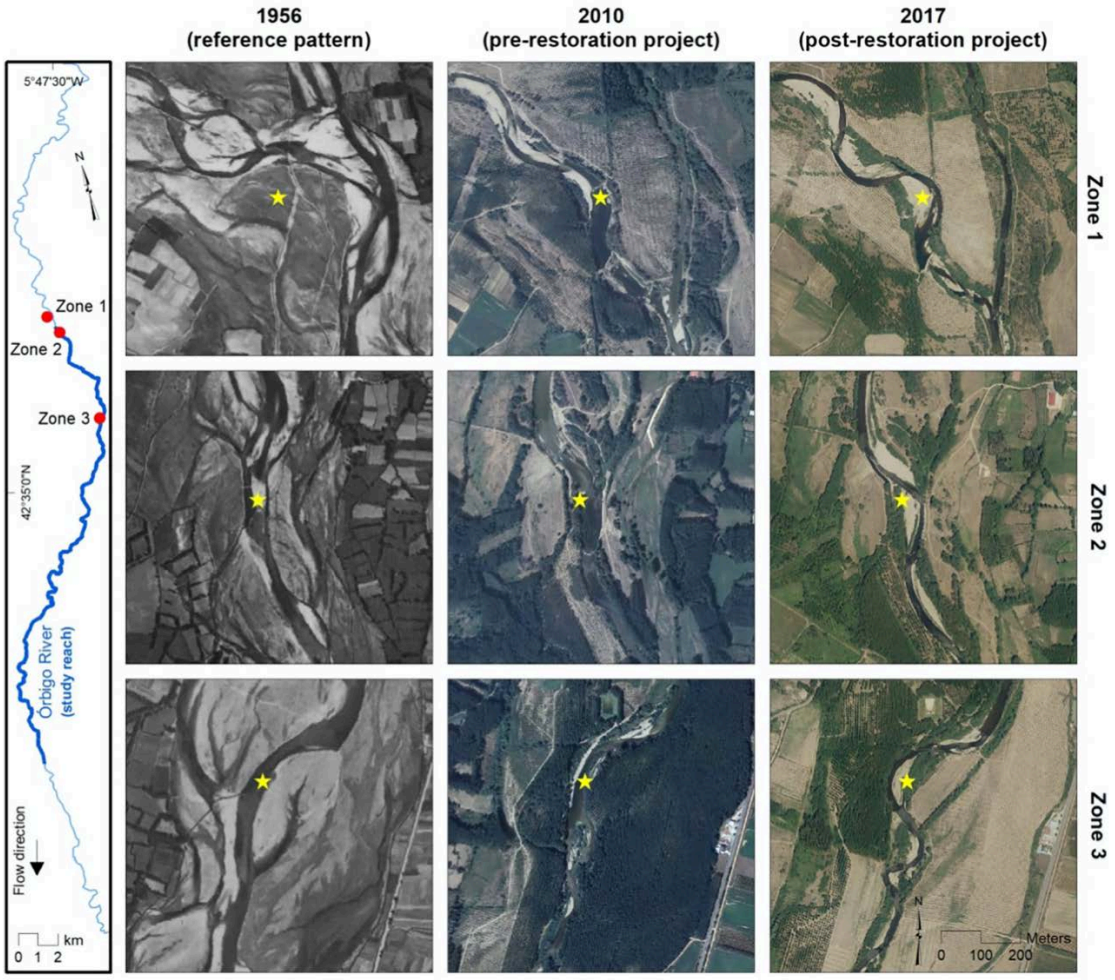

Figure 7. Morphological evolution of the channel and floodplain in the context of the Órbigo River restoration project. The yellow star points to the same site in each period (García et al., 2021)

1) ROOM FOR THE RIVER, FLOW AND FLOOD MITIGATION

The Órbigo River restoration action is an interesting case study to show the improvement experienced by giving more space to the river (Ollero and Ibisate, 2012). This reduces the danger of flooding and fluvial habitats are improved and regenerated, all under criteria of economic and environmental sustainability. The natural capacity of flood lamination has been recovered, gaining 480 ha of floodplain. In April 2013 and 2014 there have been important floods, and it has been possible to verify the effectiveness of the action: there was no damage to populations and infrastructures and the affected population showed their satisfaction. As an example, the 2013 flood had similar discharges as 1995 and 2001 during which floods caused serious damage. However, in 2013, peak flows were lowered so no damage was observed. The project approach resulted in a better cost-effective measure than structural defences (Rodríguez et al., 2012b), as well as a land planning measure that aligns with Habitats, Water and Flood EU Directives, in providing a sustainable green infrastructure, and a

successful lesson of how taking into account geomorphological functioning of rivers improves their management (Ollero and Ibisate, 2012).

2) CONNECTIVITY AND MORPHOLOGICAL REHABILITATION

Lateral and longitudinal connectivity are recovery: riprap, embankments and deflectors removed; 26 secondary arms (side-arms) recovery (10 km overall length); modification of transversal obstacles to allow fish and sediment transport (weirs of Alcoba de la Ribera and Santa María del Rey). The river has achieved to reactivate the channel (Fig. 8) and increase its sinuosity and braiding (table 1).

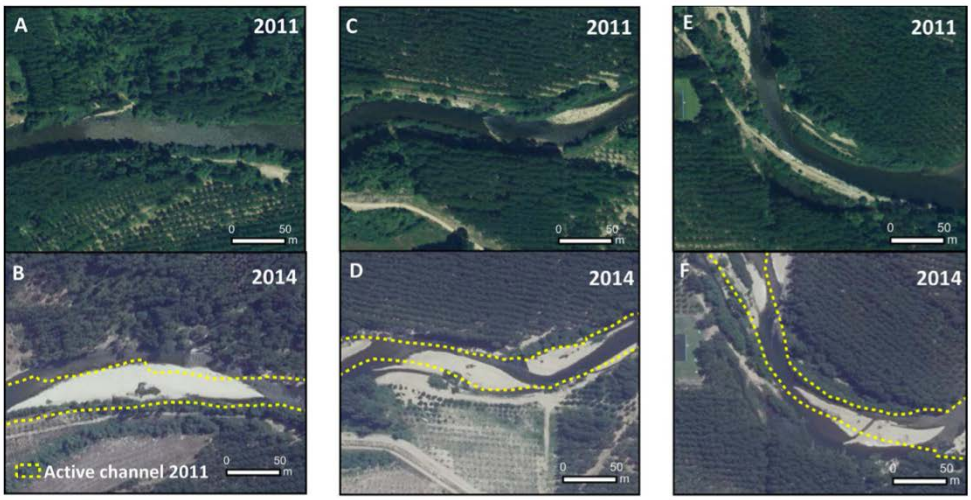

Figure 8. Reactivation of the channel between 2011 and 2014 (Martínez-Fernández et al., 2017)

	Sinuosity index		Braiding index		Proportion of multiple channels (%)	
Segment	2011 (prior to restoration)	2014 (before restoration)	2011 (prior to restoration)	2014 (before restoration)	2011 (prior to restoration)	2014 (before restoration)
Restored	1.17	1.28	1.15	1.24	7.9	11.5
Reference	1.17	1.20	1.33	1.40	17.5	17.8
Control	1.14	1.13	1.11	1.14	10.9	9.3

Table 1. Channel sinuosity, braiding index and the proportion of multiple channels before and after restoration (Martínez-Fernández et al., 2017)

3) REWILDING

Revegetation with riparian trees *(Salix alba, Populus nigra, Alnus glutinosa, Fraxinus angustifolia)*: 7.2 ha (recovery of riparian vegetation: 0.6%). This is an aspect to be expanded in subsequent phases of the project (not yet implemented). Riparian vegetation recovery has been analyzed in the monitoring research of Martínez-Fernández et al. (2017) (Fig. 9).

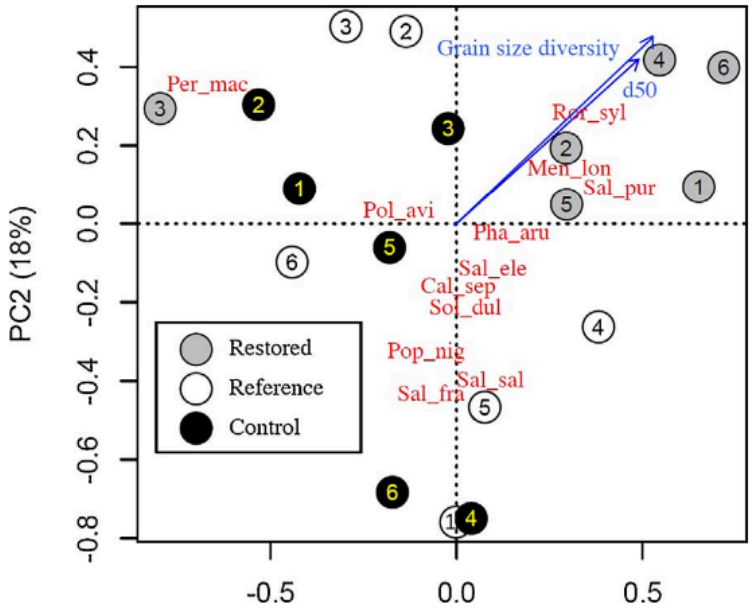

Figure 9. Monitoring of riparian vegetation recovery (in Martínez-Fernández et al., 2017): Plot of the two first axes of the Principal Component Analysis (PCA) processed from the community composition (Hellinger transformation, red acronyms) observed at the 18 study sites. Only the scores of the 10% species with the highest weight in the two first axes of the PCA are shown, multiplied by 1.2 to improve visual clarity. The positions of the three site types were compared on each axis using t-tests with site scores as the dependent variable. Letters indicating homogeneous t-test groups ($P < 0.05$). PC1: Reference = ab, Restored = a, Control = b; PC2: Reference = ab, Restored = a, Control = b. Species abbreviations are: Cal_sep = *Calystegia sepium*, Men_lon = *Mentha longifolia*, Per_mac = *Persicaria maculosa*, Pha_aru = *Phalaris arundinacea*, Pol_avi = *Polygonum aviculare*, Pop_nig = *Populus nigra*, Ror_syl = *Rorippa sylvestris*, Sal_ele = *Salix eleagnos*, Sal_fra = *Salix fragilis*, Sal_pur = *Salix purpurea*, Sal_sal = *Salix salviifolia* and Sol_dul = *Solanum dulcamara*. The blue arrow indicates the direction and strength of the correlation between PC1 and PC2 and the d50, i.e., 50th percentile of the grain size (PC1: P = 0.025, PC2: P = 0.086). The blue arrows indicate the direction and strength (see axes values) of the correlations between PC1 and PC2 and the d50, i.e., 50th percentile of the grain size (PC1: P = 0.025, PC2: P = 0.086) and the grain size diversity (PC1: P = 0.024, PC2: P = 0.049).

SOCIAL IMPACT

The social relevance of the project has been manifested in subsequent initiatives in other rivers near to the Órbigo R., in which farmers and managers have appreciated the actions and have also implemented them. For this process was notable the initiative "River school for mayors" (https://www.miteco.gob.es/es/agua/temas/delimitacion-y-restauracion-del-dominio-publico-hidraulico/Presentación%20Experiencias%20escuela%20de%20alcaldes_tcm30-214200.pdf) of the Duero Basin Authority.

The Órbigo River Restoration Project was a 2013 IRF European Riverprize finalist, due to the following values:

a) Good practice of integrated water management and land use policies

b) Implementation of innovative concepts (e.g. "room for the river", green infrastructure...)
c) Relevance of management and planning tasks
d) Example of integrated approach in WFD and FD implementation
e) Example of the relevance of public involvement during the whole process (public participation during the planning cycle and volunteering within the framework of environmental programme linked to the Project)
f) Impact on the media
g) Replicability potential

The Ministry for the Ecological Transition (MITECO) has chosen the restoration of the Órbigo River as one of the cases that exemplifies adaptation to climate change in the new portal of the AdapteCCa platform on Adaptation to Climate Change in Spain:

https://www.adaptecca.es/demolicion-de-barreras-en-el-rio-orbigo-para-recuperar-la-conectividad-ecologica

WEBSITES

https://www.youtube.com/watch?v=RLEGKJX3fGk

http://www.chduero.es/VerVideo-previo-orb1.aspx

http://nwrm.eu/case-study/órbigo-river-ecological-status-improvement-spain

Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I (León). Documento 1 Memoria (Clave 02.434-229/2111) (Órbigo River ecologic status improvement. Stretch I (Leí³n). Document 1 (Technical Report)

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Proyecto para la mejora del estado ecolí³gico del río Órbigo. Tramo I (Leí³n). Documento 4 (Presupuesto).

Estrategia Nacional de Restauración de Ríos (ENRR). Demarcación Hidrográfica del Duero

Proyecto para la mejora del estado ecológico del río Órbigo. Tramo I (León). Instrucción para la elaboración y tramitación de los informes de viabilidad previstos en el artículo 46.5 de la Ley de Aguas). [Clave: 02.434-229/2111]

El Proyecto de mejora ecológica del río Órbigo (tramo I)

Case Study: Improvement of the Ecological Status of the River Órbigo (Leon, Spain)

Ecological Improvement Project in the Órbigo River (Stretch I)

The Órbigo River Restoration Project and its implications in flood risk prevention

River Órbigo Restoration Project

Guía técnica para la caracterización de las actuaciones a considerar en planes hidrológicos y estudios de viabilidad

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