PROCEEDINGS OF THE FINAL SEMINAR OF THE LIFE + MINK TERRITORY PROJECT

LIFE09 NAT/ES/531

9-10-11 JUNE 2015
PAMPLONA/IRUÑEA

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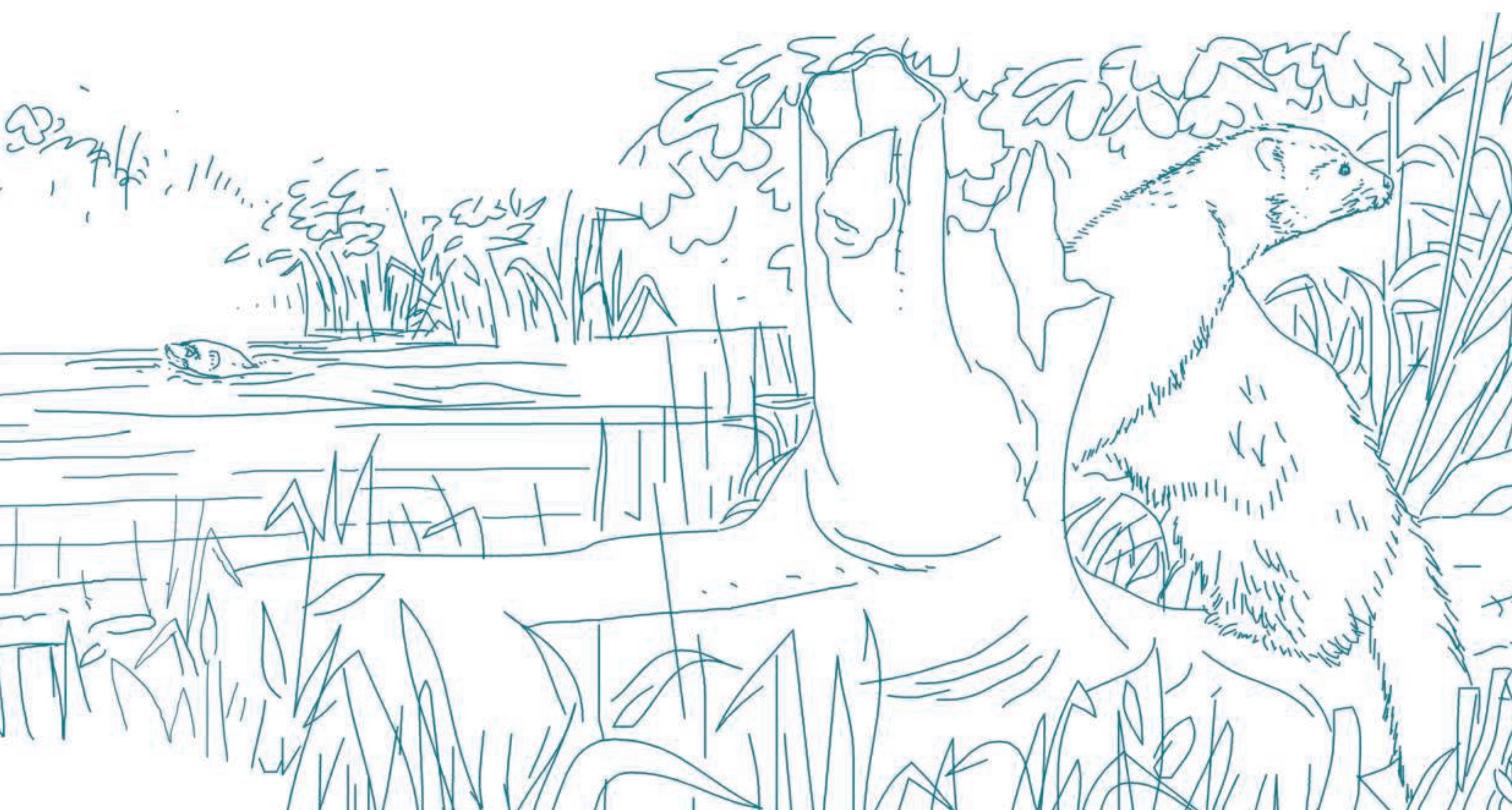

Contents

PREAMBLE

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The Seminar of the LIFE+ Mink Territory Project is one of the finishing touches to a huge amount of work carried out on the lower reaches of the Arga and Aragon Rivers in Navarre over the last few years. These Proceedings present a number of technical actions taken which may serve as benchmarks for similar work in the future both in Navarre and other places where comparable problems are faced.

The chief objective of this important project, which has accounted for an investment of just over six million euros, has been to ensure the conservation of the European mink, a highly endangered species and one for the conservation of which the responsibility of Navarre, as home to what is unquestionably the largest population in the European Union, is unique.

One of the distinctive features of the work performed has consisted of the dual approach adopted, which has involved both a conventional course of action based on direct work with the species itself, including trapping, censuses and the elimination of invasive species, and an ecosystem-based approach to return some of the river's previous freedom of movement in order that it might naturally create and shape feeding and breeding grounds in the regained river territory. It was probably this innovative approach which led to the work conducted on the Aragon River being chosen as one of the three finalists in the prestigious River Prize Awards.

In a document of this kind, it is hard to reflect the degree of engagement achieved. A project on this sort of scale calls for the joint efforts of different Government Services, Foundations and both public and private Enterprises. But on this occasion, the involvement of local entities and those actually living on the river banks has also been drawn in. Without the collaboration of the different Local Councils, the re-creation of the river environment, vital to the prevention of the damage caused by flooding, would not have been possible.

Notwithstanding the significant level of investment and all the hard work put in, this LIFE Project should only be considered an initial step towards the gradual recovery of the fluvial space, based on consensus with local entities and local civil society. The conservation of the European mink, fluvial biodiversity and the prevention of flood damage all depend on it.

INTRODUCTION

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These Proceedings of the LIFE+ Mink Territory Project Seminar aim to provide a synopsis of the project through papers summarising its key aspects.

First of all, there is a description of the area targeted by the Project, the SCI Lower reaches of the Aragon and Arga Rivers, a unique space which encompasses fifteen protected areas, a clear indication of its ecological quality. The site's importance lies not only in the values of the rivers themselves, but also in those of the territory they flow through, which consist of riverside scarps as a result of a peculiar geology of gypsum and folds.

Scientific information on the requirements of the European mink (Mustela lutreola), obtained through previous work and used to define more precisely what the species targeted for conservation needs and when and where it needs it, is also provided. This information proved vital when it came to designing actions which, while costly, would be useful to the species. Another article offers an in-depth analysis of the management of the species in Navarre.

A detailed explanation of the emblematic Sotocontiendas project on the Aragon River (Marcilla), chosen as a finalist in the 2016 River Prize Awards, is provided as an example of the work performed. The article outlines the complex problems of incision, narrowing and simplification affecting the Arga and Aragon Rivers which the project has addressed in a no less complex and original manner. One of the most noteworthy features of the work performed has consisted of returning sediments, most of which had been dredged, at no small cost, from the riverbed over decades, to the river.

There is also a complete account of the different solutions found to address the range of actions included in the project and the laborious technical, administrative and political processes preceding each action. Where possible, earth embankments have been set back, defences eliminated and water systems reconnected in order to return dynamism to the rivers. On other occasions, however, it has been necessary to create wetlands adjoining the river terraces, depending on the groundwater level and irrigation return flows.

Major projects of this kind involve considerable sums of money earmarked for conservation. Sometimes, however, mistakes, which, while appearing minor, can affect certain aspects of biodiversity very negatively, are made in such projects. Every precaution needs to be taken so that this does not occur in LIFE projects. Consequently, a strict protocol has been applied to monitor and continuously evaluate biodiversity in each constituent project. Original measures which had previously not been used very much in projects of this nature have also been tested out. The entire process is outlined in one of the articles.

The consequences of the processes involved in the simplification of the way in which large rivers work are sometimes extremely visible, as occurs when channels are corrected. Very often, however, the ways in which such complex systems are affected are subtler and take place over much longer time frames. Such is the case with the gradual depletion of peripheral wetlands. In the project area, the accelerated maturation of wetlands more distant from the rejuvenating influence of the dynamics of the rivers is further compounded by the fact that the rivers are constrained when it comes to forming new wetlands. One of the articles analyses these processes in the Arga-Aragon complex and sets a specific "expiration date" for one of the best conserved areas in the SCI.

Not only the American mink, but also many other exotic and, sometimes, invasive species have reached the Arga and Aragon Rivers. The work performed with the non-native turtles which have started to appear at different points in the SCI is described. There is still time to take preventive measures before these species become a real threat to one of the most important populations of European pond turtles in Navarre.

In short, the articles published in the Proceedings of the LIFE+ Mink Territory Project Seminar schematically outline the development of the project and the experience and the knowledge gained should prove useful to other similar projects.

1

LOWER REACHES OF THE RIVERS ARAGÓN AND ARGA, A FUNDAMENTAL NATURA 2000 NETWORK SITE FOR THE CONSERVATION OF THE EUROPEAN MINK

KARMELE ARETA CEBRIÁN / Government of Navarre's Biodiversity Conservation Service

karetace@navarra.es

Abstract:

Natura 2000 is an European network of natural areas aimed to ensure the survival of the species and their habitats. The Site of Community Importance "Lower reaches of Aragon and Arga", which is also a part of this network, hosts habitats and species of flora and fauna of great interest, among which highlights the European mink (*Mustela lutreola*). The Management Plan for the future Special Area of Conservation should consider this species as a key element and stablish the necessary measures to preserve it. LIFE project development allows the implementation of some of the actions contained in the management plans for Natura 2000.

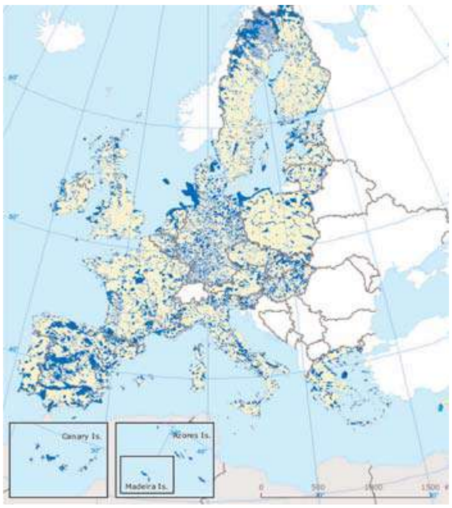
Keywords:

Natura 2000, management plan, European mink

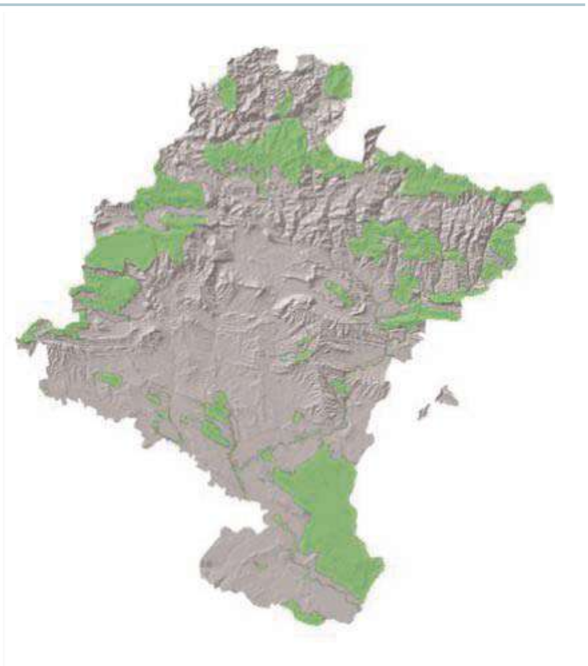
Natura 2000 is a European network of natural areas which aims to ensure the survival of different species and habitats. The network was created by Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive), and takes as a basis both this Directive and Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Birds Directive).

The network includes Sites of Community Importance (SCI), which are home to habitats and species listed in the annexes to the Habitats Directive, and Special Protection Areas (SPA), designated according to the provisions of the Birds Directive.

The Natura 2000 network consists of more than 26,000 sites of great ecological value located all around Europe and covers almost a million square kilometres.



Natura 2000 network areas in Europe (left) and the Spanish State (right).



Natura 2000 network areas in Navarre.

The Natura 2000 network occupies approximately 27% of Spanish territory.

In Navarre, the Administration of the Autonomous Community of Navarre provisionally approved a list of sites eligible for designation as Special Areas of Conservation (SAC) to be included in the European ecological network Natura 2000 by means of the Government Agreement of 15 May 2000. The Government Agreement of 4 March 2002 then also provisionally approved inclusion of the Artikutza site in the list of Navarre's Sites of Community Importance.

• Site of Community Importance

According to the Habitats Directive, once a Site of Community Importance has been approved, the Member State must designate it a Special Area of Conservation (SAC) and define the conservation measures needed in order to maintain the natural habitats and the populations of species which led to its being designated a Site of Community Importance in a favourable state of conservation or to return them to such a state. The European Commission approved the list of Sites of Community Importance for the Alpine biogeographical region through Decision 2004/69/EC of 22 December 2003, the list for the Atlantic biogeographical region through Decision 2004/813/CE of 7 December 2004 and the list for the

Mediterranean biogeographical region through Decision 2006/613/EC of 19 July 2006, meaning that these sites were to be declared Special Areas of Conservation for the purposes of application of the European Directive.

• Natura 2000 Network

The Natura 2000 Network occupies approximately 25% of Navarre's territory and consists of 42 SCIs. Navarre's SPAs either coincide with these SCIs or form part of them, with the exception of SPA B-150 "Peña de Etxauri".

There are currently 21 SACs in Navarre, each with its approved Management Plan.

The SCI "Lower reaches of the Aragon and Arga Rivers" (ES2200035), an area in the Mediterranean biogeographical region, is one of Navarre's Natura 2000 sites. The Technical Bases for its Management Plan are currently being drafted.

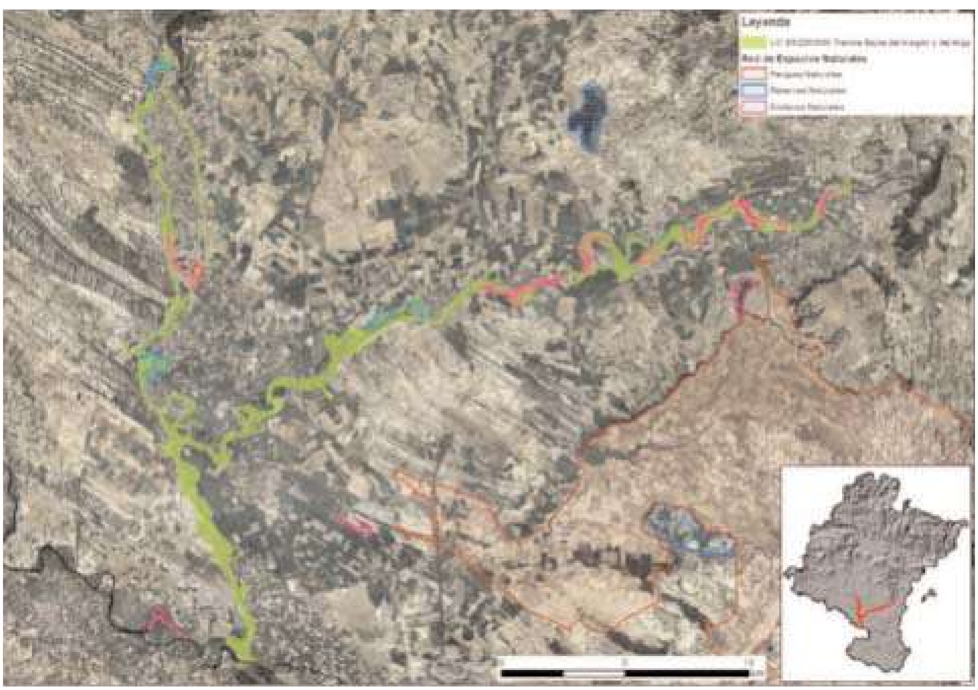
This SCI is in the south of the province and covers the final stretches of the Arga and Aragón Rivers. It spans an area of 2,447.85 hectares.

The section of the Arga River in the SCI is the stretch between the Nature Reserve "Sotos del Arquillo y Barbaraces" (RN-28) and the point where it flows into the River Aragón. It includes land located in the municipal districts of Falces, Peralta and Funes.

The section of the Aragón River begins at the bridge which joins Carcastillo and Murillo el Fruto, and ends at the point at which it joins the River Ebro. This section is located in the municipal districts of: Carcastillo, Murillo el Fruto, Mélida, Santacara, Murillo el Cuende (Traibuenas and Rada), Caparroso, Marcilla, Funes, Villafranca and Milagro.

3 Nature Reserves (RN) and 12 Natural Sites (EN) belonging to Navarre's Network of Protected Natural Areas (RENA) fall within the boundaries of the SCI. These areas are:

- RN-28 "Sotos del Arquillo y Barbaraces"
- RN-29 "Sotos de Lobera y Sotillos"
- RN-30 "Sotos Gil y Ramal Hondo"
- EN-6 "Soto López"
- EN-7 "Sotos de la Recueja"
- EN-14 "Soto de Campo Llano"
- EN-15 "Soto de la Biona"
- EN-16 "Soto de Escueral"
- EN-17 "Soto Sequero"
- EN-18 "Soto Artica"
- EN-19 "Soto Arenales"
- EN-20 "Soto Valporres-Soto Bajo"
- EN-21 "Sotos de Rada"
- EN-22 "Sotos de la Muga"
- EN-23 "Soto de Santa Eulalia"



Boundaries of the SCI ES2200035 "Lower reaches of the Rivers Aragon and Arga".

Activities in these RNs and ENs are regulated by Navarrese Act 9/1996 of 17 June on Navarre's Natural Areas, the RNs also being regulated by Navarrese Decree 230/1998 of 6 July, approving the Master plan for the Use and Management of Nature Reserves in Navarre.

The land included in the SCI forms a continuous, sufficiently wide riverside area which is home to the habitats and species of flora and fauna of interest which gave rise to its designation.

• Diversity of habitats

The lower stretches of the Arga and Aragón Rivers describe fairly regular meanders as a result of the intense fluvial dynamics characteristic of free meandering rivers. They are subject to constant variations in flow which continuously modify their courses, create abandoned meanders (oxbow lakes) and islands, erode their banks, etc. Riverside copses grow on the flood plain and represent a significant source of ecological and landscape diversity, and are particularly important in what is a highly modified, simplified environment moulded by irrigation farming and poplar groves.

In terms of habitats, the SCI "Lower reaches of the Aragon and Arga Rivers" stands out as home to a significant quantity of riparian woodland, willow shrubland and tamarisk cover. Most of these natural formations belong to the Habitat of Community Interest (HCI) 92A0, *Salix alba* and *Populus alba* galleries. There are also examples of HCI 3240 (Alpine rivers and their ligneous vegetation with *Salix elaeagnos*) in areas with water courses subject to frequent flooding and HCI 92D0 (Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)) in the final section of the Aragón, the riverside copses of the Arga and some ravines which reach the Site from the Bardenas area.

The Site is also home to a range of HCIs associated with river ecosystems, such as HCI "3150 Natural eutrophic lakes with *Magnopotamion*- or *Hydrocharition*-type vegetation", "3260 Water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation", "3250 Constantly flowing Mediterranean rivers with *Glaucium flavum*", "3270 Rivers with muddy banks with *Chenopodion rubri p.p.* and *Bidention p.p.* vegetation" and "3280 Constantly flowing Mediterranean rivers with *Paspalo-Agrostidion* species and hanging curtains of *Salix* and *Populus alba*". Areas of HCI "6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels", interspersed in among these habitats, have also been identified.

The SCI provides refuge for different communities of interest associated with water habitats, such as hydrophilous grasslands, rush beds, helophytic vegetation, etc. Some of these are relevant because they are Habitats of Community Interest (HCI 6420, HCI 7210*), while others are relevant habitats for certain species, such as the European mink.

The SCI is home to habitats of great interest within a relatively arid Mediterranean context. On the left, Mediterranean woodland with willows and poplars (HIC 92A0). On the right, wetlands associated with the main channel with areas of slow, shallow water used by the European mink (*Mustela lutreola*).

• Diversity of species

Such a diverse range of habitats also means a great diversity of bird species. The most notable breeding species are those associated with aquatic habitats, such as the purple heron (*Ardea purpurea*), grey heron (*A. cinerea*), black-crowned night heron (*Nycticorax nyctycorax*), white stork (*Ciconia ciconia*), little ringed plover (*Charadrius dubius*), common kingfisher (*Alcedo atthis*), great reed warbler (*Acrocephalus arundinaceus*) and European penduline tit (*Remiz pendulinus*). Western marsh harriers (*Circus *aeruginosus*) also nest and winter in certain wetland areas of the SCI.

Of the birds of prey which use the riverside copses and riparian trees, the most worthy of note are the black kite (*Milvus migrans*) and the booted eagle (*Hieraaetus pennatus*).

Several members of the Picidae family can be found in the woodland on the banks: European green woodpecker (*Picus viridis*), great spotted woodpecker (*Dendrocopos major*), lesser spotted woodpecker (*D. minor*) and Eurasian wryneck (*Jynx torquilla*).

• Bordering environments

The high, markedly folded gypsum scarps which run along the right-hand bank of the Arga throughout the SCI-designated area, the left-hand bank of the Aragón between Caparroso and Marcilla and its right-hand bank beyond the point at which the two rivers join form a unique geomorphological feature in the landscape of the SCI "Lower reaches of the Aragon and Arga Rivers".

These scarps provide very extreme, restricted environments which numerous cliff-nesting birds use to nest or rest in.

Several species of cliff-nesting birds make use of the scarps on the final stretches of the Arga and Aragón Rivers. The most noteworthy of these include several species listed in different protection catalogues: griffon vulture (*Gyps fulvus*), Egyptian vulture (*Neophron pernocterus*), peregrine falcon (*Falco peregrinus*), golden eagle (*Aquila chrisaetos*), European eagle-owl (*Bubo bubo*), red-billed chough (*Pyrrhocorax pyrrhocorax*), black wheatear (*Oenanthe leucura*) and blue rock thrush (*Monticola solitarius*).

The most striking reptile found in the area is the European pond turtle (*Emys orbicularis*), a species which is included in Annexes II and IV of the Habitats Directive, is listed as "Sensitive to changes in its habitat" in the Catalogue of Endangered Species of Navarre, enjoys "Special Protection" in Spain as a whole and is catalogued as "Vulnerable" by the IUCN. The lower reaches of the two rivers provide the European pond turtle with one of the finest environments available to it in Navarre.

The fish community living in the rivers principally consists of Cyprinidae. Four species endemic to the Iberian peninsula are worthy of note: (*Achondrostoma arcasii*, *Parachondrostoma miegii*), Ebro barbel (*Barbus graellsii*) and Cobitis calderoni. There are also several species of freshwater clam, such as *Unio mancus*, *Potomida littoralis* and *Anodonta spp*.

• Mammals

The aquatic habitats of the SCI provide breeding and feeding grounds, and places of refuge for two semi-aquatic mammals: the otter (*Lutra lutra*) and the European mink (*Mustela lutreola*).

The Site is home to the densest population of European mink (*Mustela lutreola*) found in Europe to date, hence its importance for the conservation of the species. The European mink features in Annexes II and IV of the Habitats Directives and is listed as "In danger of extinction" in Spain and "vulnerable" in Navarre.

Consequently, this species is one of the key elements to take into account in the Management Plan for the future SAC "Lower reaches of the Aragon and Arga Rivers". An area's key elements are taken as the foundations on which to base its ´active´ conservation. Rules, management guidelines

Two of the species targeted for conservation in the SCI. On the left, the European pond turtle (*Emys orbicularis*). On the right, the European mink (*Mustela lutreola*).

and actions through which to maintain and improve the natural values of the SAC as a whole are then proposed on the basis of objectives put forward for each of the key elements after analysing the factors which affect their current state of conservation.

The final objective to take into account in the Management Plan for the future SAC as far as the European mink is concerned has to be the maintenance of viable populations of the species at the Site. In order to achieve this, it is necessary to establish, among other goals, a short-term objective to conserve and improve the quality of the area's European mink habitats. The implementation of environmental restoration projects which specifically include the creation and improvement of this species' habitats should contribute towards the accomplishment of this objective.

• Funding

Funding for the measures included in the Management Plans is provided through the ordinary budgets of the Government of Navarre, according to the availability of budgetary resources, and extra-budgetary funds (European co-funding: LIFE, INTERREG; foundations, etc.).

The Government of Navarre has implemented a series of river restoration and environmental improvement projects through the public undertaking GAN in order to achieve a wide range of objectives over the last decade:

- Revegetation of river banks and riprap defences in order to provide riparian vegetation with continuity.
- Improvement of the quality of riverside woodland.
- Creation of wetlands annexed to the principal courses as specific European mink habitats.
- Reconnection of meanders.
- Setting back or removing levees to permit the natural development of riverside vegetation and abate flooding upstream of urban centres.

In general, these projects have been co-funded through different European programmes: LIFE GERVE, LIFE Mink Territory and Interreg III-A GIRE.

Implementation of the LIFE "Mink Territory" project makes it possible to carry out some of the actions required in order to conserve the species.

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EUROPEAN MINK HABITAT RESTORATION; A CASE STUDY OF DIRECT ECOLOGICAL APPLICATION IN ACTIVE CONSERVATION. LIFE + MINK TERRITORY PROJECT [09/NAT/ES/000531]

Fermín Urra Maya / GAN (Environmental Management of Navarre S.A.)

furramay@ganasa.es

Abstract:

European Mink is a species in danger of extinction; its population is estimated on 500 individuals in the Iberian Peninsula. Navarre hosts 75% of the Iberian population and restoration of European mink habitats has been one of the main working lines for the conservation of this carnivore in the region.

For a successful implementation of a mid and long term species conservation strategy based on the restoration of habitats, knowledge of the ecological requirements of the species is necessary.

Numerous studies provided knowledge about the distribution of the European Mink in Navarre, estimation of the population, densities related to river types, use of space and spatial organization, habitat selection, feeding, etc. Integrating this knowledge into the design and performance of the river restoration works, through specific practical measures, is what makes theses studies useful and effective to achieve the proposed objective: preservation of European Mink.

Keywords:

Restoration, habitat, European mink

1. Introduction and history

After the Iberian lynx, the European mink is the most threatened carnivore in the Palearctic and one of the animals facing the highest risk of extinction on the planet. This mustelid is classified as a Priority Species, is included in Appendices II and IV of the 92/43/EEC Directive, and it is classified in the Iberian Peninsula as In Danger of Extinction (Order MAM 12037, BON 165).

In terms of the distribution of the European mink, it has disappeared from most of Europe and in the Iberian Peninsula it can be found in Navarre, La Rioja, the Basque Country, Burgos, Soria and Aragon. Even so, Iberian population figures have been estimated at less than 500 specimens, of which between half and two thirds can be found in Navarre. This fact vests the Autonomous Community with the huge responsibility of conserving this species.

At this point it is important to remember that its classification entails the legal requirement to ensure its conservation. As stated in the Habitats Directive (92/43/EEC), the European mink is included in Appendix II, meaning it is a "species of Community Interest for whose conservation it is necessary to designate special conservation zones". Furthermore, it is included in Appendix IV, making it a species of Community Interest that requires strict protection. In addition, as a Priority Species, its conservation entails particular responsibility for the European Community, with conservation understood to mean: "the collection of measures necessary to maintain or re-establish populations to a favourable condition".

To comply with these requirements, the Government of Navarre Environmental Department has worked along different branches of action by:

- Protecting and preserving the current European mink populations and its habitats. Protection is undertaken both actively: Red Espacios Naturales (Network of Natural Spaces), Red Natura 2000, etc., and non-actively: environmental assessments, specific conditions, etc.
- Monitoring the European mink population (status, evolution, health conditions, genetic variability, etc.).
- Undertaking awareness campaigns and releasing information to the public.
- Also by recovering or restoring river territories, increasing the potential habitat of the European mink, with the aim of increasing its population and reducing the risk of extinction.

2. Approaching the issue

If we position the restoration of European mink habitats as one of the main lines of action towards its conservation, treating it as a species in danger of extinction and managing important resources (LIFE Mink Territory: €6,323,807), we must ensure that it is an effective measure.

Therefore, the fundamental issue is: how can we effectively restore habitats?

To do this, the first step is to understand the basic ecological requirements of the European mink. In short, what does it need to survive and where does it get it?

3. The ecological requirements of the European mink in Navarre

The European mink can be found in all river basins in Navarre, apart from the river Eska basin, though its occupation is not homogeneous in the basins or even along the same river.

In 2004, a systematic survey was undertaken in 6 river types in Navarre, which revealed that the population density of European mink differed significantly among the different types of river (Ceña *et al.*, 2005). Differences were revealed between the number of specimen found, as well as the sex ratio.

From all surveyed rivers, the lower stretches of the Arga and Aragon rivers showed the highest densities of European mink. In fact, the highest density of European mink in Europe was found in these stretches. From this moment, the monitoring of the European mink was regulated, and with the aim of improving our understanding of this species, particularly in this important area, a study based on the radio-monitoring of specimen samples was implemented (GIRE Project, Interreg III-A).

In 2007-2008, a total of 28 mink were captured and radio-marked (13 females and 15 males). Twenty-three of the mink were captured in the river Arga and the remaining from the river Aragon. This disproportion was telling, as it was not down to the trapping efforts invested in each river. The main results from this study are given below, undertaken by Palomares *et al.*, (2013).

Regarding the use of space of the radio-marked European mink, adult males had the widest seasonal territories (average of 77 Ha), followed by young males (59 Ha) and adult females (17 Ha), with the latter occupying a far smaller territory, just 13-22% of that of adult males.

The information obtained about the spatial organisation of the European mink is scarce, but information shows that males can include the territories of several females within their own, whilst there may be little spatial overlap between individuals of the same sex, a concept that had previously been described (*Palazon et al.*, 1998 and *Garin et al.*, 2002).

The European mink preferred to establish their territories in lagoon areas and to a lesser extent in rivers and streams, though there were significant differences between sex and age. The most frequently used macro-habitat for females was lagoons, whilst for adult males it was rivers, and for young males both lagoons and rivers.

In accordance with the number of locations in each macro-habitat type, the most frequented were also lagoons, with over 50% of locations, followed by streams and rivers. It is particularly interesting to note that adult males were located in river macro-habitats between 15 and 18 times more than adult females or young mink. Taking into account the availability of each type of macro-habitat, it can be considered that lagoons and streams were the preferred places.

The most used type of habitat by European mink were reed beds, with over half of locations, followed at a distance by thickets, with almost a fourth of locations. The remaining habitat types (banks, rocks, grasslands, open water, pond areas, crops and broom) were rarely used, representing at most 8%. No significant differences were found in the use of the habitat by active or inactive mink.

Figure 1. Aerial view of Soto Manolo, in Caparroso (Navarre). Example of European mink habitat restoration, LIFE + MINK TERRITORY Project (09/NAT/ES/000531)

Analysing the use of the habitat by sex and age or by season, the standard is the same as that previously observed, with reed beds constituting the most used habitat, followed far behind by thickets, though it has been observed that adult females seem to use reed beds less than adult and young males, preferring to use thickets. This may be linked to the fact that adult females use dense thickets to dig burrows, or spend more time there when they have offspring to reduce the risk of predators.

The lairs used by both sexes and all ages of European mink, were mainly located among brambles and reeds, with minor variations in the frequency of use between sexes and ages. Occasionally mink were spotted resting in lairs among the roots of trees or sticks.

Female European mink preferred to locate their burrows in areas with lagoons and small streams, and avoided digging them in rivers where the risk of flooding is much greater. 90% of the burrows were located in areas affected by flooding with a minimum frequency of over 25 years. Furthermore, the majority of burrows (80%) were found among brambles.

With regards to the alimentation of the European mink in Navarre, there does not appear to be a clearly basic or specific prey (Urra and Román, 2013). The red swamp crawfish is the most frequent prey, appearing in 33.33% of the tracts analysed, followed by small mammals, amphibians and fish. Furthermore, in the breeding grounds of the radio-marked females, remains of prey and waste from the excrement zones were collected. Among the remains of prey collected, the following were identified: 56 red swamp crawfish (*Procambarus clarkii*), 4 water snakes (*Natrix sp*), 4 southern water voles (*Arvicola sapidus*) and 4 common rats (*Rattus norvegicus*). Regarding the excrements from the designated zones, the red swamp crawfish appeared in 100% of the samples, fish (cyprinids) in 50% and small mammals in 40%, the same as birds.

4. Restoration of European mink habitats in Navarre

Once we have acquired a basic understanding of the species ecology, if we want to follow an efficient line of action regarding the conservation of the European mink based on the increase of reproductive females (which sustain population numbers in the mid to long-term) by expanding available habitats, we must:

- Select units of action of 15-20 Ha (average area occupied by a potentially reproductive adult female);
- Ensure they are located adjacent to the main river, if possible with flooding frequency over 25 years;
- Make sure they incorporate the restoration and/or creation of small streams and lagoons (the main macro-habitat of adult females and where they establish their burrows), with the correct vegetation for the species (reedbeds, brambles and thickets), with a permanent covering of water and a very slow current, even with artificial shelters (made from stumps, branches and brambles);
- Ensure that as well as shelter areas (for resting and breeding), there are feeding zones, i.e. that the wetlands have different depths so they can host different prey: fish, crabs, amphibians, etc. in their different environments: free waters, helophytes, wet grasslands, etc.;
- Attest that the streams of canals and lagoons or wetlands have very extensive slopes to create an optimum feeding habitat for the European mink, as well as ensuring that its banks are very winding to increase their length and therefore the available habitat, and finally that the wetlands include islands where artificial shelters can be placed (for resting or raising offspring) with lower risks from predators.

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3

BASIS AND PRELIMINARY RESULTS OF THE EXPERIMENTAL PROJECT OF RESTORATION AND HABITAT CREATION FOR THE EUROPEAN MINK IN THE RIVER ARAGON (NAVARRE)

César Pérez Martín / Water Services. Navarre Government

Margarita Manzano Serra, Oda Cadiach Ricomà, Roger Pascual Garsaball, Camino Jaso León, Guillermo García Pérez, / MN Conservation Science Consultants.

Juan Pedro Martín-Vide / Hydraulic, Maritime and Environmental Engineering Department, Polytechnic University of Catalonia (UPC).

ggarcia@mnconsultors.com

Abstract:

Fluvial incision processes favored by human activity at a territorial scale are a growing phenomenon in numerous hidrogeographic domains of Europe. When vertical degradation affects meandering streams systems and are accompanied by narrowing and implementation of stabilization measures, then lateral geomorphological adjustments by bank erosion, widening and migrations are strongly limited, leading to a simplification of channel forms towards quadrangular geometries. Morpho-functional restoration measures in reaches affected by incision have been assayed, assessing the relationship between geomorphological simplification by incision and the consequent impoverishment of the range of morphodynamic variability and, ultimately, pauperization of habitat heterogeneity and biological diversity of the system, including the disappearance of perifluvial wetlands. The theoretical design and conceptual keys of the hydrogeomorphological and ecological model chosen are presented, as well as hydraulic and morphodynamic validation of it, the experience gained in its engineering implementation, and a preview of some preliminary results.

Keywords:

Incised rivers, geomorphological simplification, biodiversity, sediment transport, fluvial restoration

1. Introduction

In Europe, climatic fluctuations initiated by the irruption of the Little Ice Age (Lamb 1995; Man 2002) were accompanied by a generalised destabilisation of watersheds, the result of disturbances in the ground layers deriving from an extensive yet intensive model of forestry and agro-pastoral exploitation (Thornes, J.B., 1999). All this marked a period, between the 16th century and the second half of the 19th century, in which there was a significant injection of sediment into the river systems, with the consequent accretion and reactivation of riverbed dynamism. This in turn affected the course of the mountains and foothills, and the subsequent stream systems, and even delta formation. This process was well documented both on a national scale (Goudie, A., 1986), and in the river systems draining through mountainous reliefs from the Alpine orogeny in the Mediterranean (e.g.: Bravard, 1989, in the Alps, and García-Ruiz and Valero-Garcés, 1998; García-Ruiz, 2010; García-Ruiz y López-Bermúdez, 2009, in the Iberian Pyrenees).

Since the beginning of the 20th century (Lapparent, 1907) a new period has been heavily documented, particularly active in present times, revealing the sudden reversal of these dynamics. It is characterised by the generalised incision and narrowing of the waterways, in which Liébault and Piégay (2002) differentiate two sub-cycles: the first stage responds to a simple attenuation in hydrodynamic intensity in relation to the reversal of climatic trends. The second river alteration also constitutes a reduction in hydraulic response and in the afferent solid load, but is induced by human activity via the contemporary abandoning of farming (García-Ruiz and Lasanta, 1990 on the Southern Pyrenean slope), and is greatly aggravated by direct physical interventions, such as hydrological and sedimentary regulation (reservoirs), channelling, and protection and contention structures, dredging, or channel straightening. From the 1960s, works emerged that carefully studied the precise relationship that each of these interventions has with processes of incision, narrowing and geomorphological simplification (e.g.: Williams and Wolman, 1984; Bravard *et al*., 1997; Kondolf *et al*., 2002; García-Ruiz, J.M.; Lana-Renault, N., 2011). This documentation has been collected in literature and syntheses works (Schumm, 1977; Kondolf and Piégay, 2003).

On the other hand, the conceptual and theoretical framework that relates structural heterogeneity with habitats and the promotion of species richness has been well demonstrated in empirical works undertaken in the field of classic ecology (McCoy and Bell, 1991), also gaining strength as a dominant paradigm in river ecology, where there has been a widely recognised link between morphodynamic diversity and geomorphology with biological wealth. Aligned with this, hydrodynamic and morphological simplifications lead to an impoverished space-time heterogeneity of habitats (HH), whether expressed as physical, structural, topographic or granulometric complexity or as biotopical diversity (Tokeshi and Arakaki, 2012). However, the underlying mechanisms and relationships are still relatively unknown (Ward and Tockner, 2001; Kovalenko *et al*. 2012) while some authors note that their application in the field of conservation and river restoration is not satisfactory and requires a critical review (Palmer *et al*. 2010).

• Sotocontiendas project

Over the past few decades the aforementioned issues of incision, narrowing and simplification, have affected the lower stretches of the River Aragon, where the experimental Sotocontiendas project is located (River Aragon, Ebro Basin, Navarre) (Fig. 1). This, along with the lower Arga, formed a complex river system influenced by unique geographic and geological factors. Karst dilution processes and syn-sedimentary subsistence affected the sub-desert Palaeogene Bardenas reliefs, which the river met on its path (Benito *et al*., 1998; 2000).

Because of this, whilst these reliefs were easily diluted and transformed into vast water meadows due to the river activity, the process was accompanied by constant topographic changes, making this system one of the most dynamic in Spain (Fig. 2a). Here began an extraordinary river ecosystem and a unique natural and cultural landscape, both symbolic and highly representative of Spanish geography: The Navarre Ribera. This landscape was dominated by free meanders, which generated a network of river lagoons as it wound across the land, highly unusual in this hydrogeographical context if it were not for this dynamic. These lagoons, interlaced with the main river, made up a system of continental wetlands with great ecological transcendence, today under serious threat (Berastegui *et al*. 2015). It comes as no surprise that this section is still home to Southern Europe's largest population of the European mink (*Mustela lutreola*), considered one of the most threatened mammals in the world (Schreiber, 1989).

Concerns for controlling this dynamism led to the construction of defences and channel narrowing and to the boom of intensive dredging (Ibisate *et al*., 2013; Martín-Vide, *et al*., 2012). All this, along with the regulation of the basin and causeways and shortening of its path in the tributary, the river Arga, sparked off an accelerated river incision process (Martín-Vide *et al.* 2010; 2012), inhibiting its mobility and its capacity to change its morphology and generate new wetlands. The pre-existing 'old mother rivers' (abandoned branches), today disconnected from the main river, continue their natural path into silting, and constitute a paradigmatic case that illustrates the silent disappearance of the river-sourced Iberian wetlands (Berastegui *et al.* 2015). The morphological and ecological structure of the rivers was simplified, and they too lost the capacity to generate wetlands in their main axis (small channels and lateral pools). The characteristic richness produced by the riparian areas has been weakened due to the isolation from hydraulic and sedimentological processes and the topographical disconnection of the alluvial as a result of the incision. This phenomenon also inhibits any possibility of regenerating new natural groves, whose representation has been relegated to the outstanding yet threatened pre-existing alluvial forests, which survive in areas where incision has been less drastic and the growth of their radicular systems has been simultaneously accompanied by the depression of the rivers.

The Sotocontiendas project was conceived as a pilot trial, which would lay the foundations for facing the difficult challenge of reverting the deterioration of this unique ecosystem and the disappearance of the associated landscape. Unfortunately, the alterations studied also affect large areas of Europe and North America (Kondolf *et al.*, 2002), meaning that the Sotocontiendas experiment, and in particular its long-term follow-up, will be considered an experimental benchmark and will contribute hugely valuable knowledge to the cause.

• Pioneering experience

This article outlines the conceptual and methodological focus and some preliminary results (mainly morphodynamic) of the project, which tries out techniques to fight against river incision and hydro-geomorphological and ecological simplification in meandering rivers. The activities presented also aim to create habitats for the European mink (wetland areas), and fall within the framework of the Life+ 'Mink Territory' project (LIFE09/NAT/ES/000531), developed within the heart of the Special Preservation Zone 'Lower stretches of the rivers Arga and Aragon' [ES00035] (hereafter referred to as SPZ) (Fig. 1a).

In all likelihood, Sotocontiendas is one of the few experiments in Mediterranean Europe which applies measures of massive

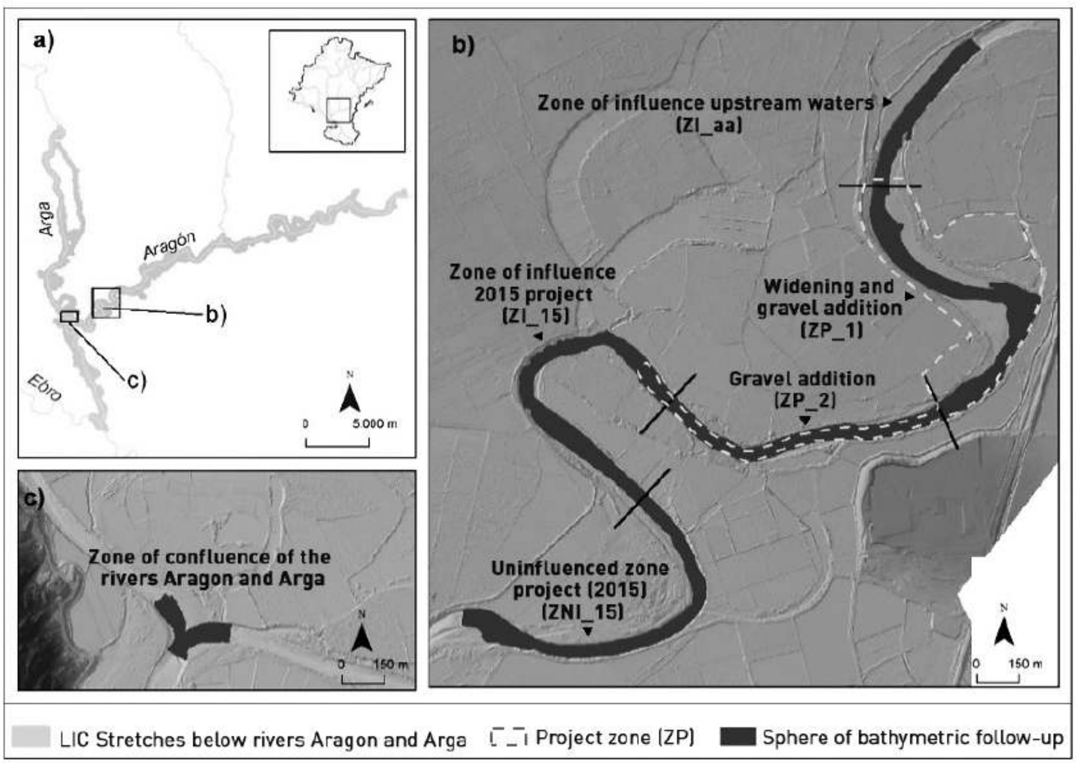


Figure 1. Geographical placement of the SPZ (a) and sectioning of the intervention area [ZP_1 y ZP_2] and the monitored stretch as a whole (b), including the confluence of the rivers Aragon and Arga waters below the project area (c).

restitution of sediments to the river – originating from former dredging – of geomorphological reconstruction (eliminating structures, widening and morphological naturalisation), and the functional recovery of the riparian territory under the principles of minimum intervention and passive restoration, in which the effects on the biological diversity of rivers and riverbanks is analysed (Steiger *et al.*, 2005). It also constitutes a cultural milestone: the drive of the project has been accompanied by a model process of social awareness and partnership in an area where the ever-present hydraulic risk had prompted political and popular standpoints, which demanded the provision of control structures and river dredging.

2. Methodology

Sotocontiendas was chosen as the experimental stretch, adhering to socially, legally and politically feasible criteria, in accordance with its characteristics and the alterations that affected it, which were representative of the problems occurring with the rest of the SPZ.

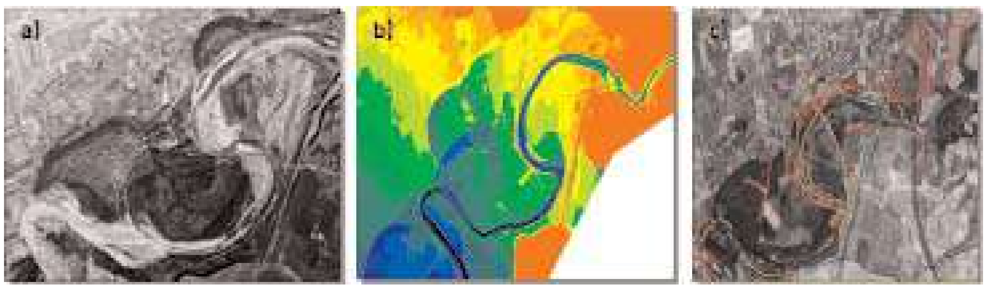


Figure 2. Dynamism of the Sotocontiendas meander system in 1966 (a) prior to which intense narrowing and solidifying measures were carried out, ending in morphological simplification ("culverting") and with the advancement of the incision, as can be deduced by the digital model of the territory of the stretch developed in 2009 (b). The final image (c) shows the narrowing of the stretch and its definitive fossilisation with dykes (in red), riprap (dotted orange) and other structures.

• 2.1 Pre-design studies

The design of the morpho-functional model was based on an analysis of alternatives, supported by geomorphological and ecological diagnostic studies of the stretch:

Geodynamic and geomorphological analysis: This was based around the study of the unique relationships between the external geodynamic that affect the section, the morphodynamic response of the river and the resulting geomorphological evolution. It was undertaken via field works and the analysis of different data (previous works, geological cartography, topographic and bathymetric elevations model, soil pits).

Evolutionary morpho-functional analysis of the stretch, both on site (photointerpretation of aerial and ortophotogrammetric images obtained between 1927 and the present day: 1927, 1944, 1958, 1966, 1992, 2010), as well as its longitudinal profile (geomorphological interpretation, stratigraphic study of ancient river beds, piezometric evolution of wells, topographic references obtained from the analysis of historical documentary collections of projects).

Fluvial morphometry. Study of current forms of the channel and riverbed (via high resolution topo-bathymetries of river beds and banks, field works and photointerpretation) and analyses using empirical methods of the relationship between channel width and riverbed forms with different degrees of alteration.

Sieve analysis. Obtaining granulometric samples of river material from the study area, thus adding to other known data (Ibisate *et al.*, 2012).

• 2.2. Hydraulic and morphodynamic validation

The project also has a demonstrative purpose on a social level. As such, the hydrodynamic and morphodynamic studies were particularly important: to validate the morphology of the proposed model, and also to socially endorse the innocuousness (in terms of hydraulic risk) of putting sediments back into river beds, reactivating the erosive processes and lateral overflow.

Hydraulic validation: A two-dimensional model has been created (SRH-2D programme, Sedimentation and River Hydraulics-Two dimensional river flow modelling) to study hydrodynamic behaviour. The topography has been obtained from flights Lidar 1x1 (Tracasa 2009); using hydrology adapted in previous studies (Sener, 2003) and the contour conditions proposed by Inclam, 2009 (GUAD 2D).

Morphodynamic validation: The morphodynamic model is a unique, one-dimensional model based on an equation of transport and continuity. It has been developed to determine the development of the river depth (longitudinal profile) upon receiving a 100,000m3 addition of gravel from work excavation. The model numerically solves the equation of the gradually varied permanent flow (backwater profile) and the

Exner equation (conservation of solid mass), with the average hydraulic variables in transverse sections and a uniform distribution in the sections displaying changes in height due to an imbalance of solid mass. It was applied to 9.7 km. No means of transport were used to establish the formula of solid transport that was best suited to the river (and thus the dominant flow). Granulometric samples were obtained from the riverbed (see 2.1.), to which the Meyer-Peter and Müller equation was applied, modified by Wong and Parker, 2006.

• 2.3. The conceptual model and its material implementation

The morphological and ecological model chosen proposes the naturalisation of the forms as a means of (I) recovering riverbed-forming processes, (II) restoring the lateral dynamics of overflow and the processes they depend upon, (III) reversing sedimentary levels by promoting depositional nature, (IV) increasing the availability of sediments and (V) increasing the heterogeneity of habitats and biological diversity, making it possible for lateral backwaters to form in the riverbed (wetlands). Eventually the provision of longitudinal profile control structures as a way of stabilising the incision was ruled out. The model was based on a project that was carried out between February and November 2014. River restoration activities took place on a total of 32 ha and along 2.5 km of river (currently the extension of the lower waters project is being planned – Sotocontiendas II – which would extend this intervention up to 5 km). Activities consisted in:

(I) Recovering the geo-morphodynamic process of lateral adjustment by suppressing 985 lineal meters of riprap and similar structures.

(II) Reactivating overflow processes following the elimination of containing structures, which involved the removal of 1,342 linear meters of dyke.

(III) Restoring the original reliefs and forms in accordance with the morphometric studies. 4.6 ha has been re-sectioned, generating a land excavation volume of 200,000 m^3, of which 101,115m^3 was gravel and 98,885m^3 silt.

(IV) Returning the excavated sediments (mainly dredged material that constituted the borders and constructed the dykes). 90,485 m3 of silt was reintroduced back into the river during episodes of swelling, and gravel was spread evenly along the 2.5 km, creating an average regrowth of 0.65m.

(V) The reconstruction of the former lagoon that had been filled in for forestry purposes. It constitutes a hugely important habitat for the European mink.

• 2.4 Hydro-geomorphological, ecological and biological monitoring

In order to henceforth assess the relationship between morphological and functional improvements introduced by the project and the effect on the HH and the landscape, as well as to be able to carry out follow-up of the degree of completion of the proposed objectives, characterisation works were undertaken regarding the structural diversity and ecosystem of the stretch, along with the behaviour of the riverbeds prior to its execution (Mar. 2013 - Feb. 2014):

Ecosystem heterogeneity and hydro-geomorphological changes: High-resolution cartography of the habitats CORINE (CEC, 1991; MN Consultores, 2010) and study of the riverbed forms and structures using high-density topographies and bathymetries.

Biological follow-up: study of biological group indicators of aquatic (macro-invertebrates) and riparian (birds and flora) habitats, with surveys and specific samples from the stretch undergoing intervention and control sections (baseline and impacted).

To date (following work execution), another bathymetry has already been carried out on the rising river via echo sounder, allowing us to obtain a digital model of elevations, both of the riverbed and its banks. Between the works end (Nov. 2014) and the new bathymetry survey (Mar. 2015), there have been episodes of growth that correspond with the maximum ordinary growth (Q2.33), aligned with the hydrological characterisation of the natural behaviour of the stretch (fig. 4a). When compared with the bathymetry survey taken prior to the works, it provides an initial approximation of the morpho-sedimentary behaviour of the stretch during this first completed period. The frequency with which the foreseen studies will be repeated in the future is yet to be established, as are the possibility of reproducing hydrodynamic and morphodynamic models from the finally executed geometry, the real characterisation of the added sediments, and the hydrological trends that have circulated since the works end.

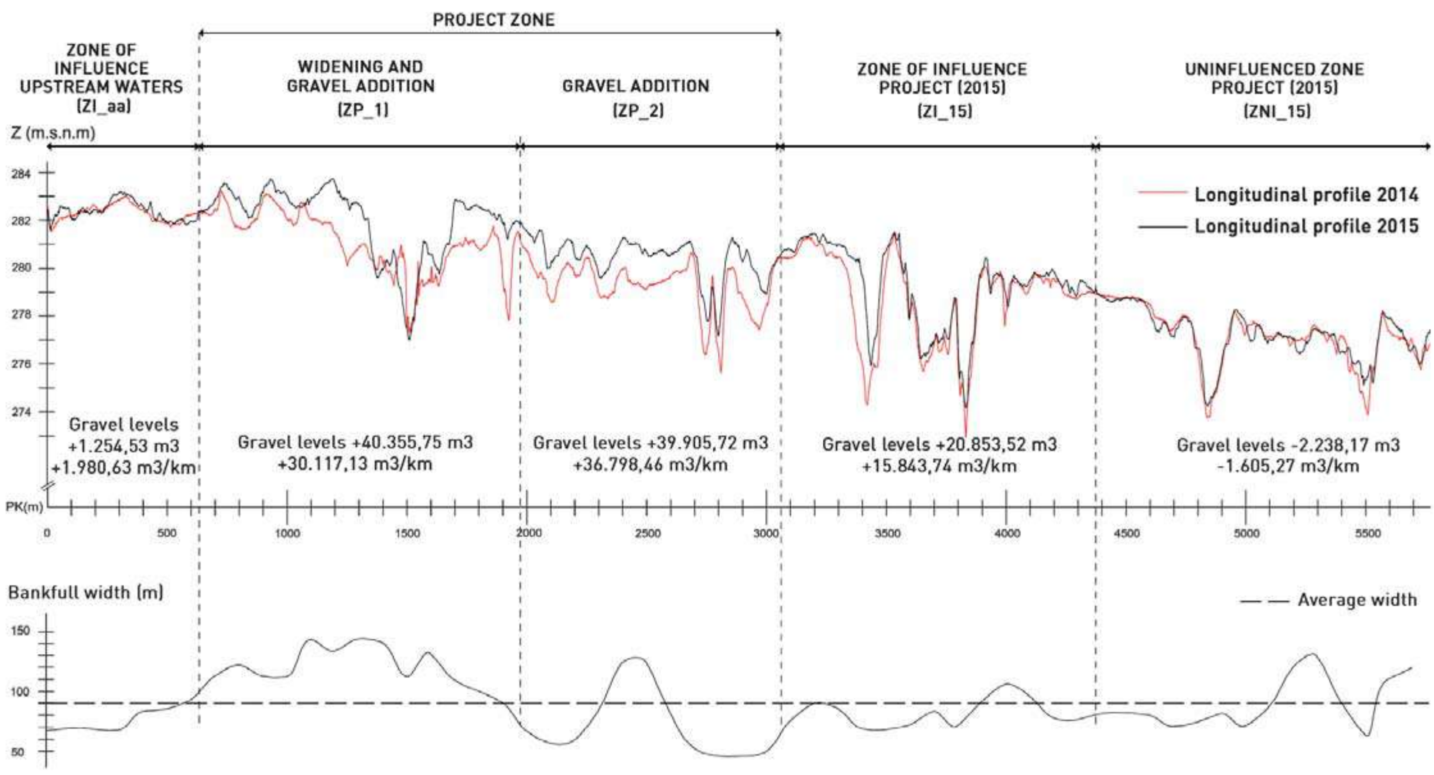
3. Preliminary results and discussion

The long-term follow-up of the stretch should provide information that allows us to assess the gap between real and predicted morpho-functional and ecological behaviour. However, to date, valuable experience has been gained in some aspects that are of particular interest to design and executive practices. Preliminary data has also been obtained regarding the new morphodynamic behaviour of the stretch.

In the design techniques chapter, it is worth noting that a considerable adaptation has been achieved in the excavation volumes and the granulometric characterisation (proportion of gravel and fines) predicted in the geomorphological and stratigraphic study, confirming the methodologies developed to resolve design uncertainties. Other uncertainties faced during the design phase, involved the capacity to spread the fines and the depositional behaviour of these waters below the adding points. Follow-up of the silting of riverbeds, islands and banks to ensure that benthic habitats have not been affected, has allowed us to check that the technique is valid, minimising the financial cost of moving ground (transport) and making up for the solid flow deficit in regulated rivers.

The preliminary data available (Fig. 3, Fig. 4b) indicates that the morpho-functional behaviour of the stretch is extremely similar to that envisaged. The results of the hydro and morphodynamic studies of model validation (prior to the works), concluded that the effect on the likelihood of flooding in the stretch were imperceptible, and that the filling would remain in the widened stretch, whilst in the rest of the stretch the material would not accumulate but circulated to lower waters. Following the envisaged addition, the bed of the river Aragon would balance out after around 100 days, understood as equivalent days of water flow (calculated at approximately 21% del $Q_{2.33}$). For its part, the river would maintain waters at the lower part of the widened stretch, and the initial slope.

Figure 3. First results from the sedimentary assessments of the monitored stretch. The red line corresponds to the riverbed levels recorded prior to the project (Feb. 2014), whilst the black line represents the profile of the stretch in March 2015, following the adding of materials and the growth episodes that occurred (Fig. 4a). At the bottom of the illustration there is a graph representing the channel width at its peak overflow level (*bankfull*), allowing us to fully appreciate the morpho-functional relationship.



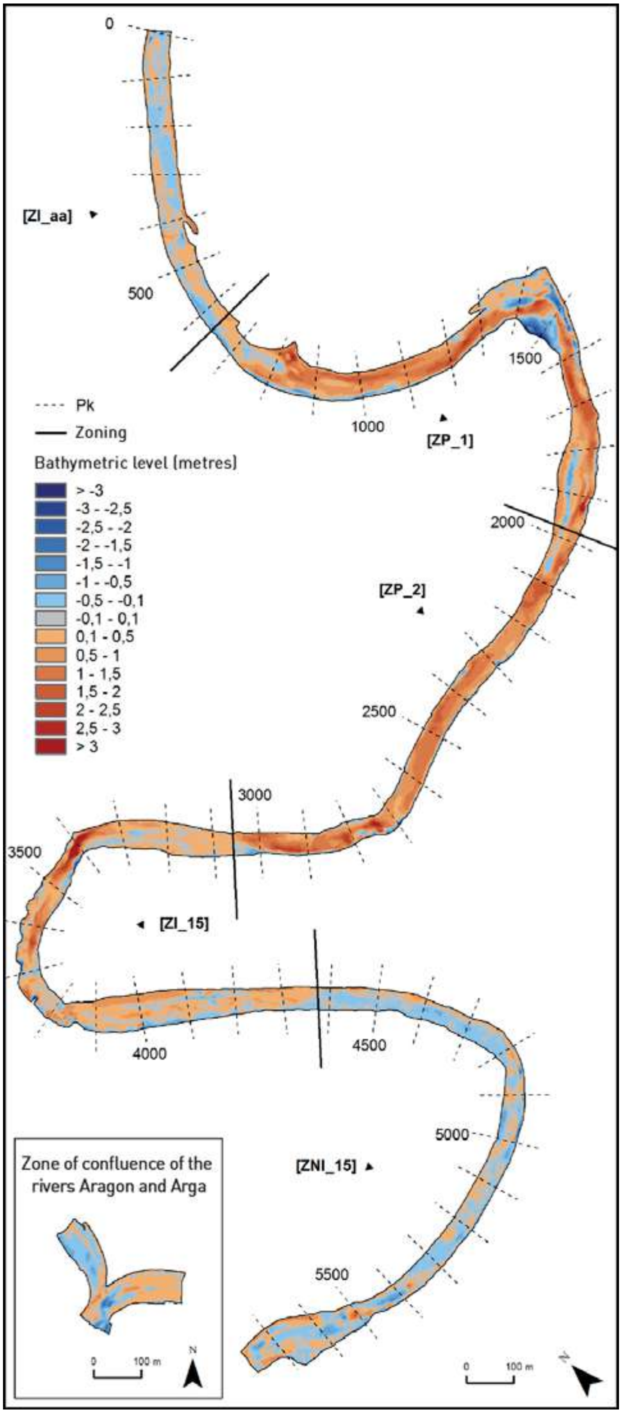
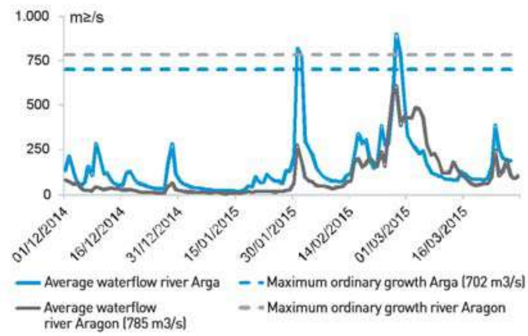


Figure 4. a) Hydrogram (daily averages) of rivers Aragon (EA005, Caparroso) and Arga (EA 004, Funes) between the work end (Nov. 2014) and the undertaking of the new bathymetry (Mar. 2014). b) Levels (blue = loss; red = gains) riverbed bathymetry between Feb. 2014 (works start) and Mar. 2015 (after works and the growth episode).



The growth periods that occurred (January-February 2015) after the addition of gravel and morphological corrections (Fig. 4a), contributed to revealing the real morphological behaviour of the stretch (Fig. 1 and Fig. 3). In accordance with the theoretical framework and the previous models, the first stretch can be observed [ZI_aa], waters above the works, in which an upstream accretion has occurred, seemingly attributable to the barrier effect of the addition (awaiting confirmation with additional future data). In any case, it indicates the positive effect that this type of measure has upon waters above the restored stretches. The sections that received gravel seem to more or less maintained the regrowth of riverbed in function with the width, just as was envisaged (ZP_1, ZP_2]. Waters below the addition clearly show the delimitation between the stretch that has already been colonised by mobilised gravel [ZI_15], and the stretch that has not [ZNI_15], providing valuable information regarding the river's capacity to transport.

ZNI_15 shows an interesting longitudinal alternation of areas with opposing sign levels (Fig. 4b), an aspect that denotes the transport of sediment with moving bars, characteristically influenced by helical flows belonging to river bends. Its level is negative and coherent with the known incision trend. Finally, the confluence level is practically nil overall (for both rivers), while there has been a slight accretion in the river Aragon, compatible with the greatest recorded magnitude in the growth of the river Arga (Fig. 4a), and its effect on the river Aragon (raising and deposition).

In conclusion, it can be said that the hydraulic and morphodynamic validation has emerged as an essential instrument in the design of incised river restoration projects and in social partnership processes.

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4

RIVER RESTORATION AND CONSERVATION PROJECTS AND ACTIONS IN THE LIFE+ MINK TERRITORY

MIKEL GOIKOETXEA BARRIOS / Project Coordinator LIFE+ MINK TERRITORY
Navarre Environmental Management

mgoicoeb@ganasa.es

Abstract:
THE MINK LIFE + TERRITORY PROJECT is being developed at Tramos Bajos del Aragón y del Arga SCI (Site of Community Importance), where some of the points are located with the greatest density in the West of the European mink (*Mustela lutreola*). This is one of the animal species at greatest risk of disappearing from the planet. The project's objective is to recover the habitat, by improving the river dynamic, as a method for improving the state of conservation of the mink and other species present, in harmony with the protection and interests of regional populations. To achieve these project targets, different projects are being executed with actions on these rivers to eliminate dams and reconnect meanders, as well as creating different types of wetlands, eliminating poplar groves and planting riverside forests, creating wet grasslands and recovering other habitats of interest, favouring other fauna species and eradicating exotic species.

Keywords:
Proyectos, Projects, river restoration actions, habitat recovery, *Mustela lutreola*.

• The LIFE+ MINK TERRITORY project

The "Mink Territory" project is co-financed by the European Union LIFE Programme, which aims to recover river habitats in the lower stretches of the rivers Aragon and Arga in Navarre, home to the largest population of European mink (*Mustela lutreola*) in Western Europe.

The Government of Navarre, the Spanish Ministry of the Environment and the Ebro River Water Board are working together on this project through their public companies: GAN (Navarre Environmental Management), TRAGSA, and the CRANA Foundation. Local authorities in the areas involved are also supporting the project.

The budget is €6,323,807, of which over 60% is financed by the European Union under the LIFE Programme, whilst the remaining amount is provided by the Government of Navarre and the Ministry for the Environment.

• The LIFE+ MINK TERRITORY project goals

The ultimate goal of the LIFE+ MINK TERRITORY (LIFE+ MT) project is to improve the conservation status of the actual European mink population (*Mustela lutreola*) on the lower reaches of the Aragon and Arga rivers in Navarre, home to the largest population of European mink in Western Europe. This Priority Species is included in Appendices II and IV of the Habitats Directive and is classified as "in danger of extinction" and "vulnerable" in National and Regional Catalogues respectively.

The project aims to restore the habitats used by the European mink during some stages of its life cycle as a way of improving the conservation status of the species. To achieve this goal, the proposal is to apply the *River Territory* concept as a way of safeguarding biodiversity and of achieving a good ecological status, whilst also ensuring that all actions adopted are compatible with the enhancement of local community interests, using the recovery of the river territory as a sustainable management model.

• Conservation problems in the SCI Lower Stretches of the Arga and Aragon Rivers

As is the case of most European rivers, conservation problems are related to a lack of space for the river. Most of the flood plains have been occupied by agricultural land. In the past, river ripraps and defences were constructed in order to protect the agricultural land and tree plantations and, in the case of the river Arga, the bed was channelled in order to protect downstream settlements against flooding.

These defence infrastructures considerably reduced the dynamics of these two rivers, leading to a reduction in the natural habitats available, in turn limiting the biological diversity of the area.

The European mink (*Mustela lutreola*) is particularly affected by the degradation of the riverine ecosystem, being a species that uses the natural woodlands and wetlands alongside the river during the different stages of its life cycle. As previously mentioned, this area is home to 20% of the population of this species in Navarre and 2/3 of the Iberian population, giving an idea of the importance of restoring the riverine ecosystems in the lower basin of these two rivers as part of the overall strategy for the conservation of species.

•Conservation actions

As mentioned, the project aims to restore the habitats used by the European mink during some stages of its life cycle in the lower reaches of the Aragon and Arga rivers, thus improving the conservation status of the species. Recovering habitat as a means of improving the conservation status of a species is a recurring idea in all technical biodiversity conservation forums. Likewise, numerous experts have earmarked recovering river territory as a model of sustainable river ecosystem management as an example to follow. Despite this, to date there are very few examples of this in Europe and even less in Mediterranean environments.

To achieve these project goals, LIFE+ MT proposes five branches of action:

- The setting back or removal of earth embankments to increase the River Territory
- The reconnection and ecological improvement of oxbow lakes
- Recovery of habitats specific to the European mink
- The restoration of river habitats of interest to conservation
- The eradication of non-native and invasive species

The TRAGSA company is responsible for the administration of the work under the direction and environmental supervision of GAN. The Government of Navarre Environmental Department and the Ebro Water Board shall undertake the Project Management.

To undertake the LIFE+ MT project initiatives, the leasing of usage rights for communal land must be considered, constituting land that has already been identified as potentially suitable for habitat restoration. Compensation for this loss of earnings as a consequence of restoration activities on farming land with the potential to be reconverted into copses is also a consideration.

•Drawing up of projects

The drawing up of a construction project is the necessary step between determining the need for a restoration scheme and obtaining the required authorisation. The projects have been grouped into action areas or municipalities as opposed to action types, as was initially envisaged, leading to a more integral restoration of action areas, which generally include various conservation actions proposed in the LIFE+ MT.

From a technical, administrative and social perspective, the drawing up of projects is complex, especially those that entail a greater likelihood of flooding, thus involving a lengthy and complex process of pre-assessment, decision-making, agreements between involved parties and the obtaining of authorisation.

Given that they are actions carried out in river ecosystems, and that they occasionally alter defence systems and existing river structures, the projects affect different fields and disciplines, thereby rendering it essential to integrate aspects such as hydraulics, geomorphics, biodiversity conservation, fauna, flora, engineering, civil security and protection, land ownership and leasing, productive uses, conditions, etc. As such, the project calls for the creation and coordination of a multi-disciplinary team. On occasions, LIFE+ MT projects have been undertaken with unique means and for certain pre-studies, or it has been necessary to call upon specialised technical assistance for projects.

On the other hand, despite participation from MAGRAMA, the CHE and the Government of Navarre Department of the Environment in the LIFE+ MT, and support from managing bodies for coordination, it has been difficult to obtain the corresponding authorisations quickly, involving various administrative processes to gain the different authorisations for each project.

The required authorisations for undertaking each project are as follows:

- Environmental approval from the Government of Navarre Department of the Environment
- Approval from the Ebro Water Board.
- Authorisation from the town council (approved in Plenary session)
- Disaffection of communal lands for the release of said lands, approved in Plenary session by the corresponding council and authorised by Government agreement of the Government of Navarre
- Permission to fell poplars from the Government of Navarre Forestry Management department
- Other permits and environmental authorisations (Environmental Quality Service)

Within the LIFE+ MT project a process has been developed for drawing up projects that allow us meet restoration targets and integrate the requirements from all the organisms and administrations involved. The steps followed are described below:

1. Firstly an action area needs to be located, which occasionally is already predefined in accordance with the project and the different existing proposals and studies. Consensus with the Water Service (SAG), the Biodiversity Conservation Service (SCB), and the Government of Navarre (GN) is required.
2. Later it is necessary to define and agree upon a project idea with the GN, ensuring that it fulfils the LIFE MT objectives.
3. In parallel to this, land authorisation and release must be obtained from both the council and the landowners. Sometimes this release and authorisation from the council cannot be obtained until the next phase has been undertaken – the assessment of alternatives – given that the council needs to know the possible impact of certain aspects, or has to establish conditions for inclusion within the initial idea.
4. Once the idea is approved, in many cases an analysis of alternatives is required, which occasionally involves hydrological (or other) studies, to evaluate the impact this may have in terms of flood risks, and to be able to assess and present the adequacy of the proposals to the councils.
5. Once one alternative has been approved and environmentally validated by the Water Service and the Biodiversity Conservation Service, and accepted by the council, project drafting can begin.
6. Prior to its final approval, it is transferred to the Ebro Water Board to obtain permission from the Water Board Confederation.
7. Once the project idea has been established, the participation process begins, involving the different local players.
8. Considering the different contributions, the definitive project is drawn up.

• The setting back or removal of earth embankments to increase the River Territory

This action requires direct work on the channel and the removal or setting back of defences in order to improve river system dynamics as a key to recovering floodplains, whilst favouring the restoration of natural ecosystems for conservation purposes.

These are complex activities. On the one hand it implies a change in the river management systems used until now, in accordance with the Water Framework Directive (2000/60) and the Flood Prevention Directive (2007/60). On the other hand, it requires a change in the social perspective of the local population; people that are concerned that these actions may affect their safety and that of their farming lands. This is why actions have to focus on removing the first lines of defence in the least productive areas whilst rebuilding a second line of defence to maintain the degree of protection over productive areas. This requires hydrological studies that can guarantee effectiveness of these actions and can determine the best course of deployment. It is also key to boosting the credibility and acceptance of new river management models. Likewise, this involves important participation processes, but thanks to them, local population and councils become familiar with these changes in river management models, gaining awareness and understanding their vital nature, thus becoming compatible with production, protection and conservation objectives. **With this strategy, we have been able to significantly increase the amount of earth embankment elimination work originally envisaged.**

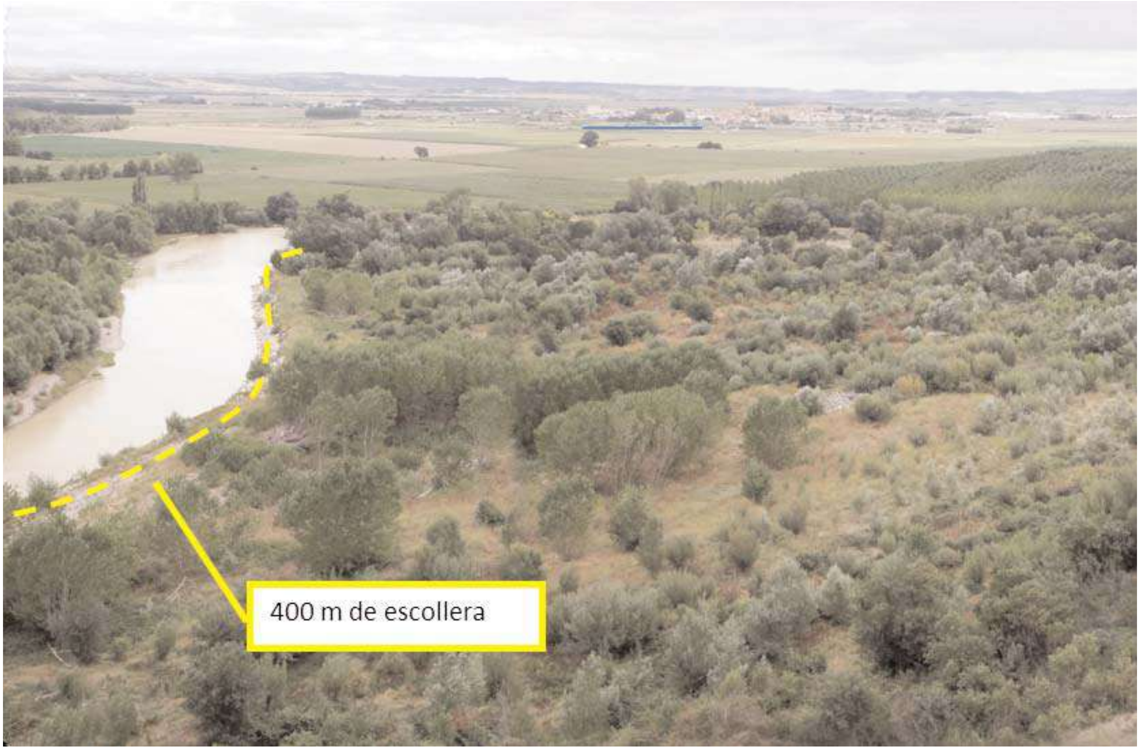


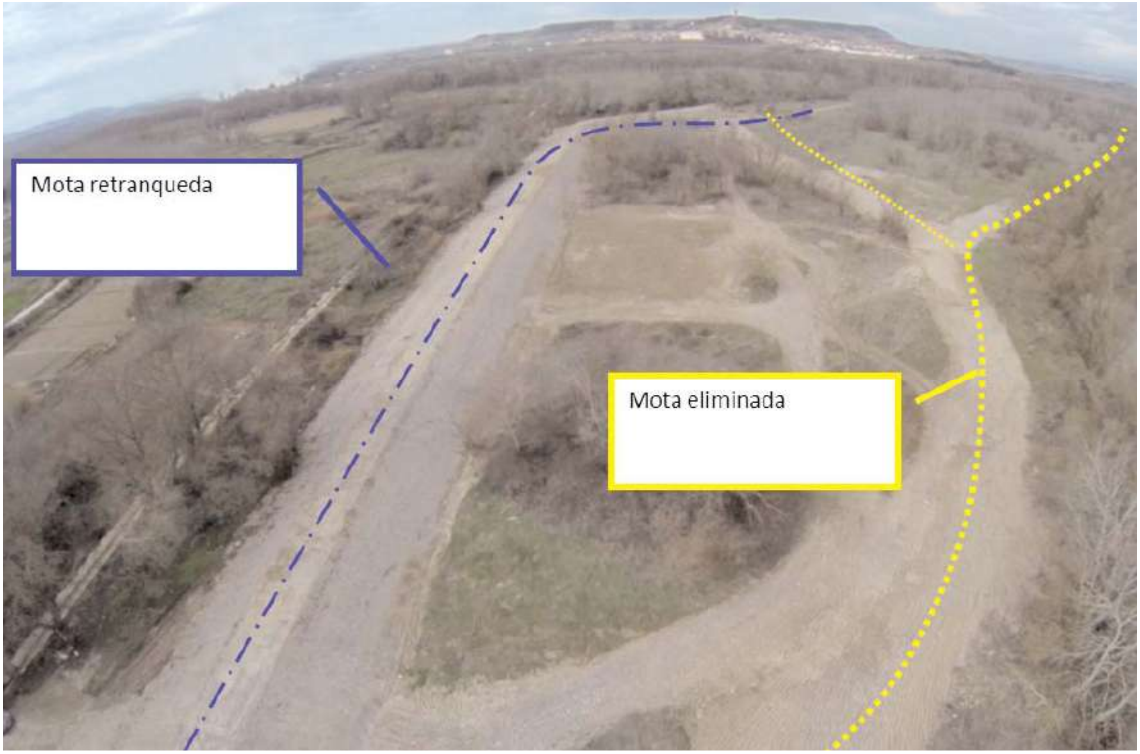
Figure 1. Example of an action proposed within the framework of the LIFE European Mink Project (LIFE09 NAT/ES/531): the elimination of 400 metres of earth embankment at Soto Montecillo (municipal areas of Funes and Villafranca on the Aragon River). After purchasing the land, the aim is to facilitate lateral movement of the river in order to permit the re-creation of habitats of interest (wetlands adjoining the main channel, erosive earth banks, etc.).

The activities undertaken are varied in both type and scale. One of the most important is the noteworthy Sotocontiendas project in Marcilla. This novel and pioneering river management project is a benchmark in the field of returning sediment to the river, as a way of minimising incision process that have proven to affect the river Aragon and which in the mid-term this could bring about a decrease in the groundwater level of water meadows, transforming into a serious agronomical and environmental issue. As part of this project, earth embankments (1,342 m) and ripraps (943 m) have been eliminated, the channel has been widened to recover the sedimentary nature of the stretches, and previously dredged river sediment (105,000 m3 of gravel and silt) has been returned to the river. Measures are based on geomorphological and ecological analyses, and the development of morphodynamic (sediment transportation) and hydrodynamic (analysis of the likelihood of flooding) models, to validate the ecological and hydraulic suitability of the proposed actions, as well as to ensure safety. This project undoubtedly constitutes a key initiative and drives towards one of the main challenges in eco-hydrological planning of major rivers: river incision on a national level.

Figure 2. Two views of the Sotocontiendas project (Marcilla). The first picture shows the two kilometres of platforms made using gravel removed from the banks and arranged in order to be returned to the Aragon River when the water level rises. The second picture shows the area recovered for the river once earth embankments had been set back and the banks reshaped.

In the Mélida (582 m) and Sotocontiendas projects in Villafranca (1425 m), earth embankments have been eliminated from the front line of the river and a second line has been refilled by reconstructing or rebuilding existing structures, guaranteeing with the corresponding models that the same level of protection is retained, not increased or diminished.

Figure 3. Earth embankment set back in Soto Sequero (Mélida), gaining 11.62 hectares for the Aragon River and, consequently, returning a certain degree of river activity to riparian woodland which was lacking in this regard.



Other simple actions have also been undertaken, without the need for hydrogeological studies, given that once land has been acquired for restoration purposes, there is no longer a need to protect it. As such, the release or purchase of land for conservation and restoration of habitats encourages the creation of floodplains and contributes to improvements in flood risks in other, lower stretches of the river. This action has been undertaken in projects such as Caparroso (800 m of earth embankments eliminated), Carcastillo (1450 m of earth embankments eliminates) and Soto Montecillo (400 m of riprap eliminated).

Finally, old and redundant earth embankments located in areas outside the current protections were eliminated, such as that in Falces, where 300 m of transversal earth embankment located in the former channel were removed, along with other earth embankments with crops that currently form part of the channel.

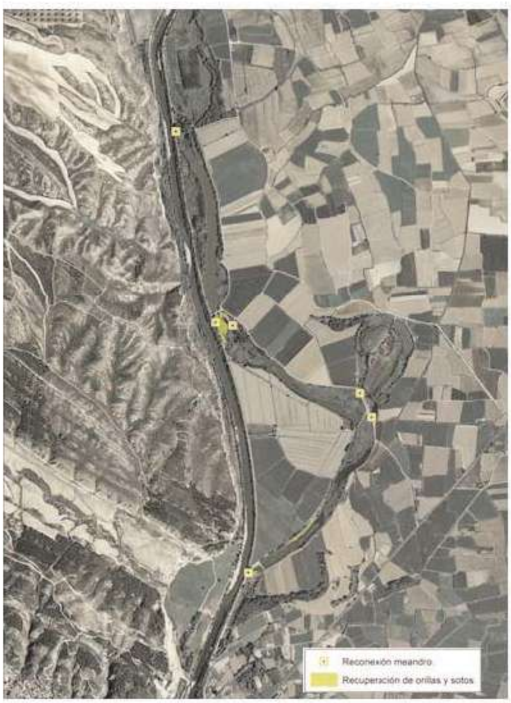
The reconstruction of earth embankments has been encouraged due to the need to manage the earth generated from excavations in the creation of wetlands to improve the mink habitat. This has led to the reconstruction of higher quality and larger earth embankments than previous ones, contributing to greater acceptance from local entity representatives and the local population living in the project area. Despite the current status of the project not being finalised, and the possible application of alterations, the current forecast is that a total of 7250 m.l. of earth embankments and riprap will be eliminated, with the resulting increase of river territory at over 80 ha.

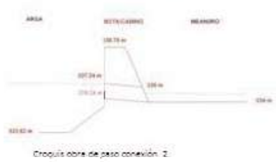
•The reconnection and ecological improvement of oxbow lakes

The construction of the river Arga canal in the eighties artificially cut off the meanders subject to this present reconnection and ecological improvement project. Since then, these meanders have undergone a slow process of deterioration. The lack of water has led to the desiccation of the associated riverbank woodlands and the infill of the former riverbed with fine sediments.

Oxbow lakes are unique places that play a hugely important role in the conservation of the European mink (*Mustela lutreola*). Otters (*Lutra lutra*), European pond turtles (*Emys orbicularis*), purple herons (*Ardea purpurea*) and black-crowned night herons (*Nycticorax nycticorax*) also regularly use these habitats, and would benefit from the land restoration of these rare environments.

Figure 4. Development of the course of the Arga River. The picture taken in 1957 shows how the Santa Eulalia meander was naturally separated from the channel. The picture from 2012 shows the "cut-off", which consisted of the creation in the 1980s of an artificial channel. The stretch of the Arga River shown in the pictures went from a meandering form measuring 5 kilometres in 1957 to a straight course measuring 3.6 kilometres.





CAUDALES

PR (años)	Conexión 1	Conexión 2
2.33	9,6 m³/s	7,0 m³/s
5	21,5 m³/s	18,8 m³/s
10	28,1 m³/s	22,2 m³/s
25	27,6 m³/s	21,2 m³/s

Figure 5. Actions to reconnect oxbow lakes, Soto de la Muga and Soto Santa Eulalia in Peralta, currently disconnected from the channel of the Arga River to facilitate the entry of the river when its waters swell to a moderate degree and permit the circulation of water through the meanders in order to make the habitat more favourable for the European mink. The objective is to include this area within the dynamics of the river and prevent accelerated clogging and the disappearance of free water.

Work is to be carried out on the remnant meanders of Soto la Muga and Soto Santa Eulalia (Peralta). Other possible work on the stretch has been rejected for technical, political and/or financial reasons (in addition to those presented in Funes).

Due to the incision processes, there is a significant difference between the height of the current channel and oxbow lakes. Therefore, recovering the flow will only be possible during ordinary flooding (2-3 times a year). Reconnecting oxbow lakes during flooding means the fines in the former channel can be cleaned at the same time that the target habitats are flooded, ensuring their conservation and natural regeneration.

The project has been undertaken on the basis of a study of alternatives, taking into account a series of physical conditions, infrastructures (such as the Falces water mains, concentration pathways and irrigation channels), protection and public use, which have all been incorporated into the project following a participatory process with the Peralta council, considering at all time that these actions should not alter the current flooding conditions of areas outside the field of action.

Some specifically sized opening have been designed based on this study, meaning that the oxbow reconnection will take place with pass works through the earth embankment, with the following dimensions: 5x2.2m entrance and a 2x10 m exit.

Reconnecting the Santa Eulalia oxbow is to be undertaken from the Soto de la Muga meander, using pass works of 2.5x2m and the lowering of an existing earth embankment-pathway.

• The recovery of habitats specific to the European mink (*Mustela lutreola*)

The standardisation of river ecosystems carried out over recent decades, has led to the disappearance of a number of habitats that are of vital importance to the survival of the European mink (*Mustela lutreola*), such as secondary branches and wetlands attached to the main channel. The invasion of floodplains for agricultural and forestry use, and the construction of earth embankments and ripraps to defend them, have resulted in the elimination of these wetlands from the river landscape, which constitute popular breeding grounds for the European mink (*Mustela lutreola*), and a place where they can peacefully hunt and raise their offspring. The same has occurred with the small gullies at the mouth of the Arga and Aragon rivers. The project proposes the recovery of these key habitats, vital to the reproduction of the European mink.

Figure 6. Creation of a new wetland adjoining the Aragon River at Soto Manolo (Caparroso). This project involved the elimination of a commercial poplar plantation and the creation of an irregular shaped basin receiving excess water from irrigation. Extremely diverse shallow and semi-flooded aquatic habitats highly suitable for the European mink have resulted.

Figure 7. Different views of and stages in the construction of new wetlands for irrigation return flows. These wetlands were created according to the "Directives and Technical Recommendations for the Conservation of the European mink and its Habitats".

The construction of wetlands has been proposed, with features aligned with the "*Directives and Technical Recommendations for the Conservation of the European mink and its Habitats*": this will be carried out via the irregular excavation of the land, seeking to create diverse and natural environments as far as is possible. Shallow areas will be created, making it easy for helophytes to colonise, and deeper areas, of up to 2 m, ensuring that the wetlands remain as a sheet of free water, thereby promoting the flourishing of other species such as the European pond turtle (*Emys orbicularis*) and the otter (*Lutra lutra*). The bank edges are lobed and irregular, in an effort to create the maximum riverbank possible, with gentle slopes, allowing for the regrowth of riverbank vegetation using naturalistic engineering (or bioengineering). In the central zone an island will be left for use as a refuge for the target fauna. To reduce the permeability of the gravel in the floodplains, where ponds will be excavated, silt and clay will be added to the bed, to reduce water infiltration.

In accordance with these directives, different types of wetlands are being created in 14 areas, over an envisaged total area of 13,61 ha. In some cases the wetlands are created based on traditional irrigation return flows, making use of a valuable resource that would otherwise be poured directly into rivers, even though water management undertaken by irrigation unions and in accordance with the interest and needs of agricultural farmers does not allow for a control over levels and may occasionally cause problems in guaranteeing a stable and constant sheet of water throughout the year. This type of wetland is being created in Caparroso, Milagro, Mélida, Marcilla and Murillo el Fruto. In other cases, wetlands are excavated to reach groundwater level. These have been created in Milagro, Mélida, Marcilla and Santa Eulalia.

In Villafranca Sotocontiendas the project proposes the excavation and direct recovery of a secondary branch of slow waters, directly associated with and connected to the main channel of the river Argon. Likewise, the Marcilla Sotocontiendas project has fostered the creation of slow, deep waters by widening the channel.

To enhance the mink habitat, surface drains are improved and thorny shrub corridors are created, a popular environment for the species.

Figure 8. Wetland adjoining the Aragon created at Soto Sequero (Mélida). This wetland was created at the site of an old poplar grove and is fed by groundwater and subjected to the flow of the river system after setting back an existing defensive earth embankment.

Refuges are also created for the mink, by constructing elevated earth platforms (to save them from frequent flooding), covered with trunks, loose soil and branches.

Finally, in the Soto de la Muga oxbow reconnection project, the creation of riverbanks is underway on the former channel, which has rugged riversides, with the aim of improving the mobility of this semiaquatic mammal.

• Restoration of other river habitats of conservational interest

The objective of this scheme is to restore the river habitats present in the Habitats Directive and therefore of interest to conservation (HIC), which are currently occupied for other uses such as poplars.

The habits of interest subject to the restoration project are mainly the 92A0 (*Populus nigra* and *Populus alba* gallery woodlands), 92D0 (*Tamarix gallica* woodlands), 3270 (nitrophilous plants colonising gravel banks) and the 3280 (annual and perennial nitrophilous grasslands).

The restoration of these habitats is undertaken in a number of ways, using active or passive restoration techniques. Passive restoration is associated with activities that increase river territory and consist in eliminating limiting factors, bringing about the spontaneous restoration of flora. Examples include eliminating earth embankments, re-profiling grazing land and competing vegetation such as poplar clones. It is envisaged that the increase in the frequency and intensity of flooding caused by these actions will lead to

Figure 9. The Milagro project, where a small lobed water course was created at the site of an old poplar grove.

Figure 10. Shelters for European mink, consisting of piles of trunks and branches at relatively high points, under construction.

greater ground humidity (at least seasonally), more heterogeneity of ecological niches for species (areas with an accumulation of different materials which causes different degrees of waterlogging, changes in micro-topography, etc.) and also a higher rate of species collection whose seeds or propagules are transported by the river. This action has been carried out in different projects including those in Carcastillo, Santacara, Caparroso, Marcilla and Falces, where poplar tree felling and stump extraction work was undertaken to eliminate the competition.

Work to eliminate poplars is underway on 116 ha, the result of an agreement with the councils that own the land, and following payment of loss of earnings. This area is considerably smaller than the previously envisaged 206 ha.
Regarding stump extraction work, as well as traditional mechanical methods, throughout the project other experimental methods have been tried out in Milagro (5500 Units) and in Marcilla (1450 Units), using biological stump extraction by inoculating the stumps with mycelium from saprophyte and edible mushrooms (*Pleurotus ostreatus* or oyster mushroom). This experimental method may be better for the environment than other mechanical or chemical methods. Initial results have proven encouraging, despite one part of the area where it was carried out being affected by flooding in June 2013.

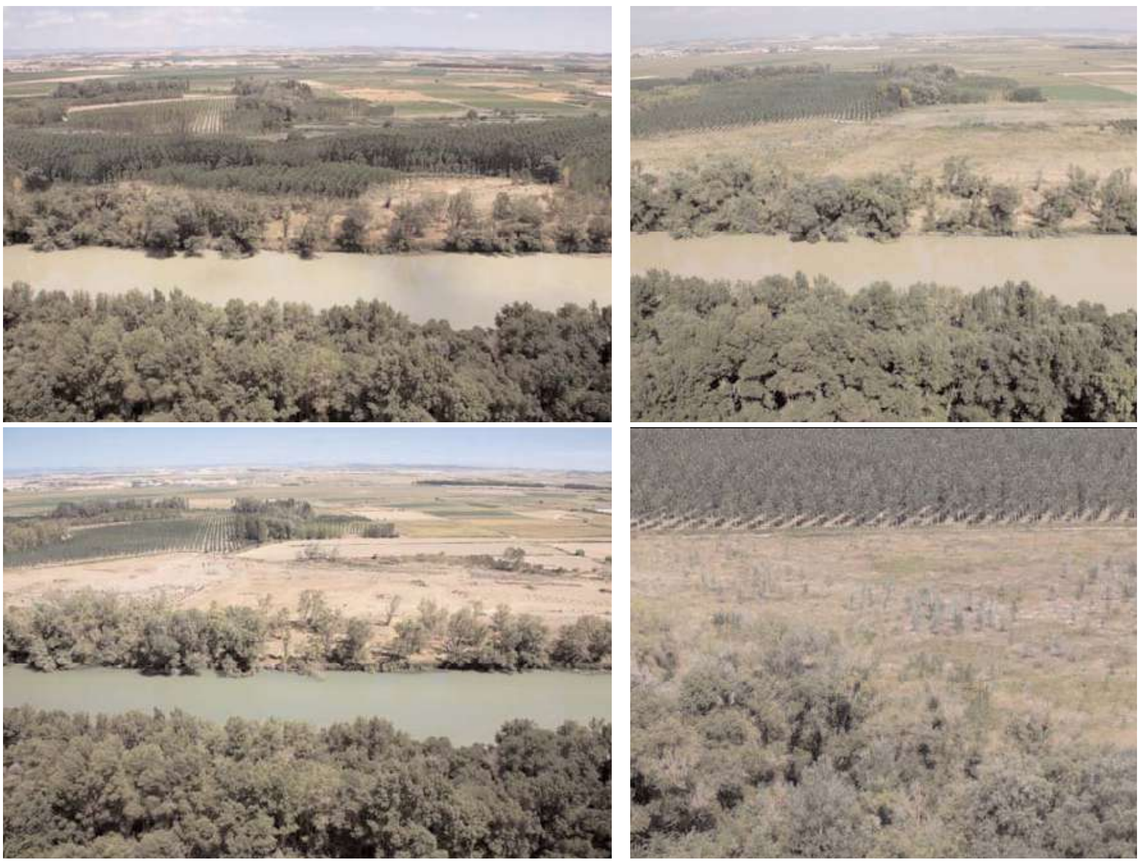


Figure 11. From left to right, top to bottom: development of the landscape and recovery of a habitat of community interest at Soto de la Higuerilla (Milagro) by removing poplars and plantation areas from more than 2 hectares and creating a strip of riparian woodland up to 100 metres wide.

The recovery of river habitats is encouraged and speeded up by directly planting native species from the riverbank woodlands and Mediterranean rivers into the habitats of communal interest 92A0 and 92D0: *Fraxinus angustifolia*, *Populus alba*, *P. nigra* and *Tamarix gallica*. Planting shrub species has mainly been carried out with deep roots, to reduce maintenance requirements. Furthermore, thicket and thorny shrub planting has been carried out, encouraging the growth of thorny corridors and water edges with shrub species such as *Cornus sanguínea*, *Crataegus monogyna*, *Ligustrum vulgare*, *Rubus ulmifolius*, *Prunus spinosa*, *Rosa sempervirens*.
In some surface drains and waterhole edges, bioengineering works have been carried out such as covering with willow branches (*Salix neotricha*, *S. eleagnos* and *S. purpurea*), and willow bud sticks and cuttings have been used to encourage vegetation growth and embankment stability. Lastly, coir logs and blankets with helophytic species have been placed in the waterholes.

Figure 12. Poplar stump removal using mushrooms (*Pleurotus ostreatus*). The process consisted of infecting the stumps with the mycelium of the mushroom and then covering them over in order to create optimum conditions for the growth of the mushroom, which could even be collected afterwards for consumption.

One of the LIFE+ MT project aims is to ensure that the flora used in the restoration activities are native species and varieties from local sources, given the vital importance of this action in improving biodiversity. To do this, seeds and progagules have been collected from the project areas, which have been nurtured in the Navarre Environmental Management (GAN) greenhouses.

Other complementary actions to restore riverside woodland and habitats of interest, are the restructuring of riverbanks, the elimination of ridges and topographical corrections of the land, as well as eliminating disused irrigation infrastructures and pathways, etc.

Finally, complementary measures have been taken to improve the habitat and to foster the appearance of other fauna species, binding the base of poplar trees or burying totem poles or "snags" to encourage the flourishing of woodpeckers, as well as fitting bat boxes.

Due to the lower availability of land obtained in negotiations with councils, the area to be restored will be considerably less than that envisaged (perhaps an excessively ambitious objective is to blame), but nevertheless, the number of zones to be worked upon has not been reduced. Despite the projects not yet being finalised, and alterations still being possible, the area for the recovery of other habitats of interest covers 128 ha in 25 zones.

• The eradication of non-native and invasive species

The proliferation of exotic and invasive species is a growing environmental issue in river ecosystems. The impact caused by non-native plant species in the river system, is mainly due to competition for resources (light, water, nutrients), space (even altering the habitat), and hybridisation with native species, as can be seen with the black poplar (*Populus nigra*). Regarding animal species, non-native species also

Figure 13. Different planting techniques used in the Mink Territory project. Bare-root planting, *Salix* cuttings on banks and coir logs with helophytic species on banks.

have an impact through depredation, as is the case with the Florida slider turtle, (*Trachemys scripta*), and its impact on European turtle populations or the introduction of diseases that may lead to the disappearance of native species.

Eradicating these species from the sites included in the Red Natura 2000 and preventing their reintroduction, are two priority issue when it comes to correctly managing biodiversity conservation, due to the fact that they affect habitats and species present in the Habitats Directive, such as 92A0 (*Populus nigra* and *Populus alba* gallery forests) or 92D0 (*Tamarix gallica* forests) or the European pond turtle (*Emys orbicularis*).

Figure 14. Production of helophytic species at the project's own nursery (Marcilla) from plant material collected in the area, guaranteeing the genetic adaptation of the plants used and minimising costs.

Figure 15. Complementary actions performed as part of the projects. From left to right, mink shelters, girdling of poplars to kill them gradually and the installation of bat boxes to palliate the lack of mature trees and cavities.

Firstly the presence of non-native and invasive species to be later eliminated has been assessed within the scope of the project. Regarding flora, a cartographic inventory has been carried out of the areas hosting non-native and invasive species to be eliminated: reed cane (*Arundo donax*), black locusts (*Robinia pseudoacacia*), tree of heaven (*Ailanthus altissima*) and poplar clones (*Populus sp.*), as well as the chosen elimination method. In terms of fauna, a protocol has been drafted to deal with the elimination of Florida slider turtles (*Trachemys scripta*), to avoid their impact on European turtle populations. Later demonstrative eradication actions shall be undertaken in the field of project activity, using different methods to eliminate the species.

• Conclusion

To conclude, the LIFE MINK TERRITORY can be considered an ambitious project, undertaking important initiatives on the stretch, as well as measures to significantly improve the habitat of the European mink in the fight to conserve this valuable species, thus contributing to the recovery of the river territory with actions that act as a benchmark in the management of other Mediterranean rivers.

Furthermore, it is worth highlighting the significant support provided by the local governments involved in a project that implies making changes to philosophies regarding river management, aligned with new European Union directives and different to those applied in recent years that have proven largely ineffective in preventing flooding and the subsequent environmental consequences.

5

THE CONSERVATION AND IMPROVEMENT OF BIODIVERSITY IN RIVER RESTORATION PROJECTS

Garbiñe Telletxea Galdurotz, David Campión Ventura, Camino Jaso León, Guillermo García Pérez, Roger Pascual Garsaball, Oda Cadiach Ricomà, Jaume Solé Herce / Applied Ecology and Territory.

Fermín Urra Maya, Asun Berastegi Garziandia / Environmental Management of Navarre.

gtelletxea@mnconsultors.com

Abstract:

Lessons learned and derived from the work of the Technical assistance on biodiversity for achieving the objectives of improving biodiversity of the LIFE Project Mink Territory (09/NAT/ES/000531), for the conservation of the European mink (*Mustela lutreola*) in the Site of Community Importance (SCI) "Tramos bajos del Aragón y del Arga' [ES2200035] of Navarra.

The different phases of the work developed during the design, implementation and after completion of the restoration projects carried out under the LIFE project are described.

The two main followed strategies are presented (recreation of habitats versus ecosystem structural and functional restoration) and specific techniques tested on conservation of biodiversity to favour different species and biological groups are summarized.

Keywords:

Biodiversity, LIFE Mink Territory, European mink, River restoration.

1. Introduction

The main objective of the LIFE project 'Mink Territory' (LIFE09/NAT/ES/000531) is to recover the river ecosystem and the wetland system of fluvial origin at the Site of Community Interest 'Lower reaches of the Aragon and Arga Rivers' [ES2200035], a site in the Community of Navarre which is home to the area with the densest population of European mink (*Mustela lutreola*) in southern Europe.

The European mink is listed as a 'Priority Species' in Annexes II and IV of the Habitats Directive (92/43/EEC), categorised as "In danger of extinction" in the National Catalogue of Endangered Species (RD 139/2011) and labelled "Vulnerable" in the Navarrese Catalogue (DF 563/1995). The SCI "Lower reaches of the Aragon and Arga Rivers" is home to southern Europe's finest population of European mink, considered one of the most threatened mammals on earth (Schreiber, 1989). Although the project also aims to improve the conservation of other species (European pond turtle, Emys orbicularis), different groups of fauna (Chiroptera, Picidae and Bivalvia) and 'Habitats of Community Interest' (HCI codes: 92A0, 92D0 and 3240), the European mink is its target species.

A total of 14 river restoration projects for the creation of European mink habitat have been conceived and designed within the framework of the LIFE project. Some of these involve more than one site of action (Figure 1). Although the LIFE project spans a relatively long period of time (end of 2011-start of 2016), a lot of the restoration work projects are being executed simultaneously on stretches of river which, if not continuous, lie very close to one another and in areas of great value for the Navarrese population of the species. Some of the work consists of major restoration interventions and, as a whole, the project is of territorial significance, being one of the most important of its kind on the Iberian peninsula and the first on such a scale to be carried out in Navarre.

In order to guarantee the accomplishment of the LIFE objectives, a multidisciplinary team is providing continuous river diversity and ecology technical assistance. The function of this team is to offer support in those areas related to the interpretation and conception of the ecological restoration model, and in the development of a strategy for the conservation of the habitats, flora and fauna involved in each project in both the planning and performance stages.

The methodology to integrate environmental criteria used by the technical team for the diagnosis, conservation, improvement and monitoring of biodiversity during the conception and execution phases of the restoration projects is now to be described. Certain specific techniques tested on an experimental basis are also described.

2. Study area

The river ecosystem restoration measures all centre on the SCI 'Lower reaches of the Aragon and Arga Rivers' [ES2200035]. They are grouped into 14 sectors or projects in a range of municipal districts: Falces, Peralta and Funes on the River Arga, and Murillo El Fruto, Carcastillo, Santacara, Mélida, Caparroso, Marcilla, Villafranca and Milagro on the River Aragón. Some of these projects are carried out at more than one site, raising the number of sectors in which action is taken to 23 (Figure 1).

3. Methodology

• 3.1 Previous analysis to select sites

First of all, a diagnosis and 'feasibility analysis' process is undertaken in order to select those sites eligible for restoration which are home to Species and/or Habitats of Community Interest. This consists of a study of the spatial and ecological layout of the SCI in each of the potential areas of action (geographical, geomorphological, hydrological, hydraulic, biological and landscape characteristics) and of the determining factors identified (uses, exploitation, ownership, structures, etc.). Following this initial phase, some areas are selected and others are ruled out.

• 3.2 Establishing project objectives and actions

The ecological and biological values of each of the sectors selected are identified and the relevant environmental problems are diagnosed. Frequent problems revealed include a lack of habitat for the target species, the presence of exotic flora affecting the development of typical local vegetation and containment structures which restrict fluvial dynamics.

On the basis of the results obtained from the diagnosis, and bearing in mind the ultimate objective of the LIFE Project,

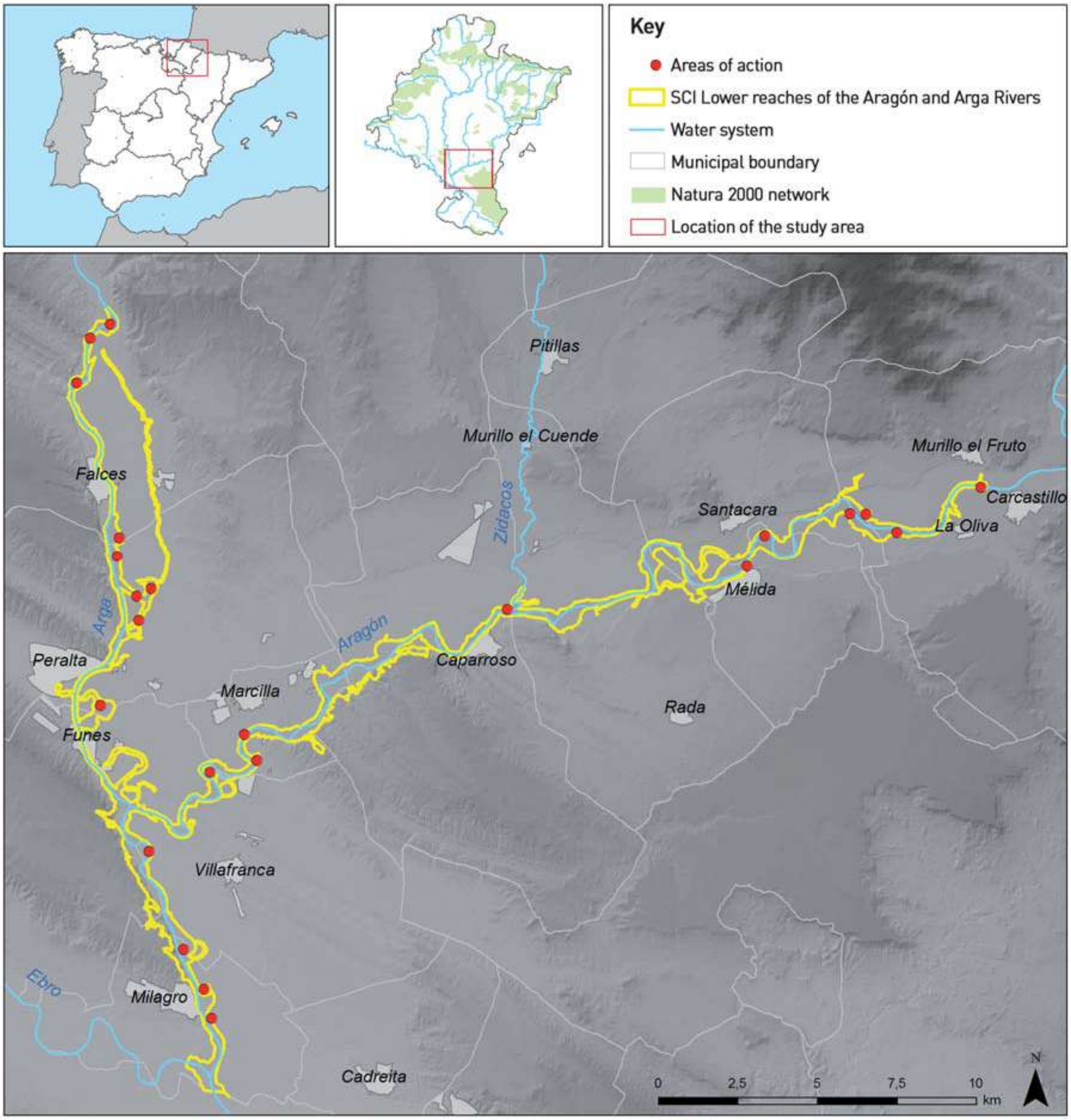


Figure 1. The restoration projects are all implemented within the geographical boundaries of the SCI "Lower reaches of the Aragon and Arga Rivers (Navarre)". The area is marked out (yellow) in the image at the bottom of the figure and the 23 sites at which river restoration actions are taken are indicated. These actions have been grouped into 14 executive projects.

the general and specific objectives it is considered necessary to pursue at executive project level are established. This stage also involves the analysis of alternatives and the conception and design of the measures to adopt for the restoration of the site and the improvement of its ecosystem. Having done all this, an initial report is produced and delivered to the planning teams so that the necessary aspects related to biodiversity conservation and improvement can be integrated into the executive project.

It is the support team's job both to ensure that these objectives are duly included in the final project and to take part in its production, providing the necessary technical information and solutions.

• 3.3 Work phase: Planning, setting out and monitoring

When the project has been written up, the work to be performed is planned with the project management, chiefly in accordance with the phenology of the species and, in the specific case of LIFE Mink Territory, with the foreseeable flood situation. Proper organisation of the stages of work not only ensures fulfilment of the environmental requirements defined in the relevant environmental permits, but also means that the species and habitats present in the areas of action are affected as little as possible.

The areas of action are marked out and revised with those in charge of performing the work as part of the setting-out process. Particular attention is paid at this stage to protection areas where action should not be taken, such as stands of vegetation of interest or the habitats of species to be preserved. All of these have been previously inventoried on identifying the site's biological and ecological values.

During execution of the work, the necessary visits needed for each type of action and execution stage are made in order to monitor progress. The visits are used to make sure that the contents of the project related to biodiversity conservation are taking shape properly in terms of time and methods used.

• 3.4 Final assessment of the work

Following execution, assessment is made of the state of the work as a whole, the suitability of the work performed with regard the project and the extent to which the environmental objectives have been achieved. The indicators associated with each of the actions performed are calculated.

The work described is reflected in a final report, which, together with the other setting-out and monitoring reports, and the summary files available on the project website, makes the relevant information generated over all the restoration project phases (conception, planning, setting out, performance and completion) available for consultation.

4. Chief action strategies

The improvement actions in the potential habitat for the European mink are framed within two complementary strategies:

• 4.1 Creation of artificial wetlands

The first consists of creating habitat which can be considered artificial, in that no recovery of formations and environments which have existed in the past is involved, although the areas are biotopes with physical and ecological characteristics highly adapted to the requirements of the European mink. This strategy involves digging wetlands into terraces alongside the rivers and providing them with characteristics which offer favourable conditions of habitability for the species. These wetlands aim to guarantee the short-term preservation of breeding populations.

Given the current situation and the degree of threat to the species, environments of this kind have proved key to the conservation of the Navarrese population of European mink. Continuous trapping surveys performed since 2004 on a standard sample unit and using a systematic methodology (Ceña *et al*., 2005) show that these formations are positively selected both in the breeding stage and out of it.

A priori actions of this type are less expensive, more direct and more controllable. On the other hand, they cannot be considered river ecosystem restoration as such.

• 4.2 Habitat creation through river restoration and renaturalisation actions

This strategy consists of designing and implementing measures through which to restore the river ecosystem or improve its ecological state from a structural and functional perspective by returning it to previous, more natural conditions. It usually involves: a) the removal of structures which contain the banks, b) increasing the section of the riverbed and renaturalising its morphology, c) recovering old channels leading off from the main riverbed and d) reconnecting meanders which have been artificially disconnected. Such measures involve work performed at everything from ecosystem-wide to microhabitat scale through more ambitious, more expensive projects. The results are neither as immediate or controllable, but they do favour the recovery of natural structures and dynamics, and, therefore, more natural, longer-lasting wetland areas.

5. 5 Original techniques tested

In both cases, a set of technical solutions are tested, either on a one-off basis or systematically, to restore habitats and recover specific biological groups or taxa.

• 5.1 European pond turtle (*Emys orbicularis*)

Structures, such as sizeable trunks or branches of dead wood which float and can be used by turtles to bask in the sun within the bodies of water of those wetlands suitable for the species are introduced.

These are located at points with good sunlight where the effectiveness of the measure being tested is not limited by the proliferation of the thick reed beds which usually occupy the fringes of these systems. These structures imitate the dead wood which can normally be observed floating in backwaters or old meanders, providing points from which the species can easily submerge on detecting danger of any kind.

This measure not only improves the habitat available, but also makes it easier to detect the species and, consequently, aids our knowledge of its distribution and that of invasive exotic species such as the pond slider (*Trachemys scripta*).

• 5.2 Sand martins (*Riparia riparia*) and other riparian species

Steep drops, narrow gorges and other river scarps constitute a key biotope for the conservation of riparian cliff-nesting bird communities, which in the section under study include the sand martin, the European bee-eater (*Merops apiaster*) and the kingfisher (*Alcedo atthis*). Small, steep river banks on relatively unconsolidated sedimentary materials (Heneberg, 2001; 2003), characteristic of rivers, streams and torrents, are a particularly valuable resource in alluvial valleys and floodplains where the vertical formations characteristic of the erosion fronts of positive relief (mountain systems) are scarce (Solé, J & García, G., 2013). Habitats of this type are rarely taken into consideration in territorial conservation strategies and little is known of their abundance, distribution and how they tend to develop (Solé, J. *et al.* 2013).

The sand martin population dropped throughout Europe in the 1960s and 1980s (Cramp, 1988). A certain increase in its distribution area on the Iberian peninsula has recently been detected, offset by a new drop in numbers of the species in certain parts (Seo/BirdLife, 2007). Within this context, some authors point to an increase in size of some colonies, normally smaller ones, on artificial banks, while larger colonies, characteristic of natural banks, are diminishing (Heneberg, 2007).

In the case of the Rivers Arga and Aragón, the scarce presence of the sand martin as a breeding species could be due to the lack of river banks suitable for colonies to settle on, a consequence of the habitual practice of defending river banks (eroding bends) with riprap, walls or other protective structures.

The creation of breeding habitat for the species, consisting of digging vertical sand-silt banks imitating those caused by river erosion, is tried out at suitable spots. The creation of artificial habitat for the species, the success of which will be monitored and assessed in the future, is an experimental measure; a similar experiment may have been performed in the past (Jiménez, J. 1992), but its results have not been reported.

• 5.3 *Picidae* and arboreal *Chiroptera*

The riparian arboreal vegetation present in these extremely humanised areas is often limited in terms of maturity and extension, and is in a very precarious state of conservation. In many cases, such vegetation has previously been replaced by hybrid poplar plantations which are now removed as part of the project's actions in order to favour the recovery of natural habitats. Consequently, the availability of suitable habitat for primary and secondary cavity dwellers (chiefly Picidae and arboreal Chiroptera) is diagnosed as a possible constraining factor. These species are associated with mature trees which can only be expected to develop in the area in the long term.

For this reason, 150 snags, dead trunks with their branches removed originating from the removal of poplar plantations, are installed. These consist of shafts measuring some 9 metres, driven two metres into the ground. This measure was tried out as a pilot experiment in a previous LIFE project and proved successful with Picidae (D. major and P. viridis), which use them for nesting and feeding. The durability of the measure has also been demonstrated, since most of the snags remain standing 8 years on from original installation, unlike girdled trees, which are very often blown down by the wind in the first two years. As far as we are aware, this is a measure which has not been tried at other locations. Plans exist to monitor its success.

An old, unused livestock shed is converted into a shelter for colonies of Chiroptera, thereby offering a quality refuge habitat for bat species, which will see the trophic supply increase in an area with very few natural refuges.

A lot of different types of top-quality bat boxes (>150) with service lives of >25 years are installed in accordance with the different target species in each work area. Recent stud-

Figure 2. LIFE Mink Territory, Project to improve and create habitat for the European mink (*Mustela lutreola*) and restore the River Aragón in Sotocontiendas (municipal district of Marcilla) – Navarre. Line of snags installed in among the natural vegetation on the edge of the excavated wetland.

ies in Navarre (Alcalde *et al.*, 2013) show how useful these boxes can be, registering signs of occupation in 60% of cases in a survey conducted with a sample of 405 boxes (with rates of use of 0-90% depending on the area). As with the snags, this measure represents an attempt to palliate the lack of tree cover until the trees planted are mature enough.

• 5.4 European mink

Taking as a basis the chief threats to the conservation of the European mink which can be addressed within the framework of LIFE Mink Territory, a set of habitat creation and improvement measures are applied, adapting the physical and ecological habitability of the wetland areas:

Creation of artificial litter and/or breeding shelters (>50) which imitate the large-scale build-up of plant debris deposited after floods. These shelters consist of placing several layers of different-sized tree stumps and branches on top of each other forming hollows suitable for the European mink to seek refuge in.

Surrounded by very thick plant cover in the form of shrubs and aquatic vegetation, these are located next to small brooks, secondary channels, islands, oxbow lakes and wetland areas on the banks of the river courses usually frequented by the species. Situated outside areas affected by flooding in the breeding season, these areas are selected by females of the species to give birth to and raise their young (Government of Navarre and GANASA, 2009).

Plantation of perimeter stands or rings of thorny species around the wetlands to provide greater coverage and protection from predators and also potential carriers of distemper (Government of Navarre and GANASA, 2014).

Creation or heightening of banks using bioengineering techniques to favour the existence of suitable corridors for movement and hunting areas along the banks of the existing wetlands. Priority is given to local living material, such as young transplanted trees, brushwood consisting of young willow branches (*Salix spp.*), silver poplar (*Populus alba*) root shoots and those of other Salicaceae. Non-living material from felling, lopping and stump extraction work performed on the existing vegetation (trunks, stumps and branches) is also used. This is all partially or totally submerged and inert filling material, left over from the digging work, is added.

Upgrading of 5 dry crossings at the points of intersection between the wetlands (or ditch network) and farm tracks to increase the longitudinal continuity of the habitat available and reduce the risk of non-natural death (from being run over).

• 5.5 Restoration of riparian vegetation

The principle of minimal intervention is applied to the restoration of the vegetation in the riparian woodland after assessing its ecological and economic advantages. This method permits greater phytosociological knowledge of the ecological and plant potential of the different sections in the LIFE project area.

To this end, a good number of sectors are left to develop naturally, allowing ecological resilience to mark the course of

Figure 3. LIFE Mink Territory, Project to improve and create habitat for the European mink (*Mustela lutreola*) and restore the River Aragón in Sotocontiendas (municipal district of Marcilla) – Navarre. Aerial view during the flooding which took place in the winter of 2015. The wetland created for European mink is in the middle of the picture, on the left-hand bank of the river. The heights of the islands on which shelters for European mink were constructed proved adequate since they were not waterlogged.

their development in a natural manner. Riverside areas are only fortified with plantations in those sectors where the topographical heights of the river terraces with regard the alluvial aquifer may prevent or hinder plant recolonisation. A set of test plots are selected.

• 5.6 Exotic species (flora)

Demarcation of specific sectors for the eradication of exotic species (mainly *Ailanthus altissima*, *Arundo donax* and *Robinia pseudoacacia*) at sites altered by man.
A combination of manual and mechanical physical methods (felling, lopping and repeated clearance work), and methods to encourage rapid colonisation by riparian species, on the basis of their capacity to reduce the expansion and productivity of invasive exotic species, is applied (covering with fertile branches, bales of straw or matting and then planting cuttings or transplanting straight from brambles and other groundcover species).
While also facilitating maintenance, action at specific points makes it much easier to demonstrate the effectiveness of the action taken to eradicate exotic species by comparing results with areas subjected to the techniques employed in the rest of the SCI.

6. Results

Most of the river restoration projects are currently in progress or work has been completed in recent months (second half of 2014). It is still not possible to assess the success of the strategies employed and techniques implemented because no representative results are available yet.

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6

LESSONS LEARNED IN RIVER RESTORATION PROJECTS: REFLECTIONS AND EXPERIENCES IN THE LIFE+ MINK TERRITORY PROJECT

Mikel Goikoetxea Barrios / Co-ordinator of the LIFE+ MINK TERRITORY Project
Gestión Ambiental de Navarra

mgoicoeb@ganasa.es

Abstract:

The MINK LIFE TERRITORY Project is ambitious, as it plans to execute river restoration actions with the final aim of improving the habitat of the European mink (*Mustela lutreola*).

Project processes and actions entail a series of experiences and lessons learned that may be of interest for implementing similar projects. Due to affecting rivers, the projects are complex from administrative, technical and social viewpoints. A process has been established to draft construction projects. The different administrations that have competences to manage conservation in river ecosystems are all participating in the project. The availability of lands is being obtained via agreements and is favoured by compensation for loss of profit. The entire process includes public participation. The debate has arisen of when and how to start these processes to combine the objectives of management and competent organisations with the local population's active participation. The LIFE+TV Project cannot provide an answer, but it can provide concrete experiences with both good and bad results that may contribute to reflecting and progressing in improving processes.

Keywords:

River restoration projects, experiences, lessons learned

1. Experiences and lessons learned

The LIFE+ MINK TERRITORY project (LIFE+MT) is an ambitious scheme to execute river restoration actions involving processes for drafting projects, works execution, public participation, management and coordination between administrations, land acquisition etc. This, together with the difficulties encountered during the project, represent a set of experiences, reflections and lessons learned that may be of interest for the execution of similar river restorationprojects.

2. The goals of the LIFE+ MINK TERRITORY project

The ultimate goal of the LIFE+ MT project is to improve the conservation status of the populations of European mink (*Mustela lutreola*) in the lower reaches of the Aragon and Arga rivers in Navarra, which has the highest density of European mink in western Europe. This Priority Species, listed in Annexes II and IV of the Habitats Directive, is classified as "endangered" and "vulnerable" in the National and Regional Catalogues, respectively.

Objetivos
LIFE+Territorio Visón

The project aims to restore the habitats used by the European mink at certain stages of its life cycle as a way to improve the conservation status of the species. In order to improve the specific habitats, the project proposed the integrated improvement of the river ecosystems, by applying the *river territory* concept as a way to safeguard biodiversity and to achieve a good environmental status, whilst also ensuring that all the work is compatible with improving the interests of local communities. Therefore, the aim is to restore the river territory as a sustainable management model.

3. 3. An ambitious, complex and pioneering project

Considering the objectives proposed and also the way adopted to achieve these goals, the LIFE+ MT project is ambitious and pioneering, given the fact that it seeks to restore the river territory for environmental purposes. Due to the fact that we are dealing with rivers, the projects are complex from an administrative, technical and social point of view.

It is ambitious due to the fact that it proposes the coordinated application of three mandatory European Directives: the Water Framework Directive (2000/60), the Habitat Directive (1992/43) and the Floods Directive (2007/60).

It is ambitious due to its scale, given the fact that actions are implemented along the river section and on two rivers that are regionally important, as are the Arga and Aragon rivers in Navarra.

It is ambitious, due to its budget: more than 6 million Euro.

It is ambitious at a community level. On the one hand, the aim is to use an important communication program to achieve social changes in order to develop attitudes, values and behaviours that guarantee the sustainable use of natural resources and the conservation of natural values, particularly with regard to the European mink, which is an unknown species for the majority of the population. The project also proposes a change in philosophy with regard to river management, in line with the new European Union directives. This is different from the philosophy applied over the last few years, which has often been shown to be ineffective in preventing flooding. On the other hand, the LIFE+ MT Project has developed and encouraged an important active public participation process, as established by the Water Framework Directive.

The project is also ambitious at an administrative level, given the fact that it involves the participation of all the administrations that have competence for the environmental management of river systems: the Ministry of Agriculture, Food and the Environment (MAGRAMA), the Ebro Water Board (CHE), the Department for Rural Development, the Environment and Local Administration of the Government of Navarra (DRMAyAL) and it also has the support of the local councils involved, all requiring considerable management and coordination. In this way, the project aims to resolve an important problem with regard to the management of the conservation of biodiversity in river ecosystems in Spain, namely the fragmentation of competences, given the fact that water management is the competence of the state, through the Water Boards, environmental management is the competence of the autonomous governments whilst land ownership (in the case of the south of Navarra), is primarily the responsibility of the councils.

4. 4. Experiences and difficulties

• Aims

As stated above, through its actions, the LIFE+ MT project combines and makes it possible to attain multiple objectives in different areas, ranging from the conservation of an endangered species up to the improvement of the management of river systems.

This fact is desirable with regard to the general approach, and is highly favourable for obtaining funding. Projects of this type are received with interest and are readily funded. However, once funding has been obtained, during the execution phase, considerable challenges and difficulties arise when defining the specific projects and actions. This is due to the fact that, in order to achieve different objectives, opposing actions may be required. Furthermore, due to this wide range of goals, the projects require multidisciplinary teams. Nevertheless, it is logical for participants to favour one particular goal over the rest, depending on their area of study.

For this reason, it is very important to be extremely aware of the main goal of the project. Although the LIFE+ MT project is also directed at river restoration, and projects to improve river management, the protection of the populations coming within the territory, etc, we should not forget that Europe has thousands of kilometres of rivers and that, in this case, we have received funding because we're practically the only place that is home to the European mink and that it is an endangered species. Therefore, in the final analysis, particular attention should be paid to this point. When implementing specific projects, it is not always easy to bear this in mind, and problems may arise from this lack of vision.

• Economic environment and scope of action

Moreover, it should also be pointed out that the LIFE+ MT project was submitted in 2009 (in a different economic environment) and was conceived as a contribution and combination for the implementation of other schemes included, for example, in the National River Restoration Strategy or in the DRMAyAL policy. In many cases, the financial situation of subsequent years, made it necessary to change and adapt the scope of action. This involved a readjustment of the participation processes and agreements with local entities. We initially considered a project scale which we were subsequently unable to assume, which has led to confusion and delays in some cases.

• Project procedure

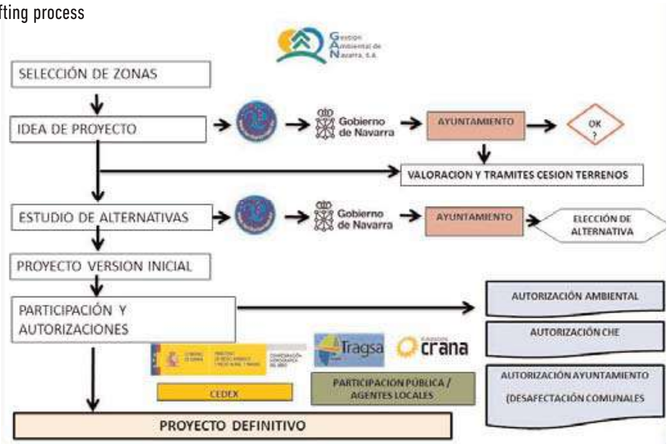
Technical projects are drafted for each action area. The preparation, drafting, approval and implementation of the action projects is a slow, complex procedure involving many technical and administrative formalities in order to comply with objectives and integrate the requirements of all the bodies and administrations involved.

1. Firstly, an area of action is defined. On occasions this is already predetermined, based on the project and the different proposals and studies available. This needs to be agreed with the Water Service (SAG) and the Biodiversity Conservation Service (SCB) of the Government of Navarra (GN).
2. The next requirement is to define and agree on a project idea with the GN and which meets the aims of LIFE+ MT.
3. In parallel, the authorisation and transfer of land by the council, as land owner, needs to be obtained. On occasions, cannot be obtained until after completion of the following stage in which alternatives are studied, due to the fact that the council needs to be aware of any impacts arising, or conditions are established that need to be included in the initial idea.
4. After the ideas has been agreed, a study of alternatives is often required, which sometimes involves hydrological studies (or other types of studies) in order to assess the impacts involved with regard to the risk of flooding, and to determine the suitability of the proposals and submit them to the councils.
5. Based on an alternative, agreed and environmentally validated by the SAG and SCB and accepted by the council, the drafting of the project commences.

6. Prior to its definitive approval, it is submitted to the CHE for authorisation.

7. Once the project idea has been defined, the participation process commences, involving local actors.

8. Based on the various contributions, the final project is drafted.



Project drafting process

The procedure was slow and it took a great deal of effort to prepare each of the action projects. It was sometimes necessary to redefine the projects, from highly advanced stages up to the initial idea, for reasons ranging from objections made by a council, the need to adapt actions to the data obtained in the studies or a difference of opinion on how to achieve the goals mentioned above. In September 2012, at the half-way stage in the project, before obtaining the extension, only 2 projects had been drafted and the implementation of the actions had not yet commenced.

• Land availability

Land availability is a limiting factor for the implementation of the projects, as discussed above. Moreover, it is a point that can be used by local bodies to put pressure on the project and to assert their demands and requirements. The project aims to carry out work on land that is the property of others and on something that the local population is highly sensitive about, namely the river, which can catastrophically cause very spectacular and visible damage to property.

The LIFE+ MT project did not resort to imposing the actions in the name of public interest, etc. Instead, it sought the agreement of the local entities at all times. Of the twelve councils coming within the "Mink Territory", only one mayor, and acting against the majority at the municipal plenary meeting, completely (and most actively and prominently) opposed the execution of the projects. This means that the approach based on coming to an understanding and agreement is feasible for river restoration projects.

For common land, the LIFE+ MT project contemplates the possibility of making compensatory payment for the cessation of forest or agricultural crop growing. There is no doubt whatsoever that money is an instrument that makes it much easier to reach agreements.

In accordance with the provisions of the LIFE program, payment is made by leasing the rights of use for a 20-year period. This begs the question, and one that was commonly made by all the councils, as to what happens next, once the 20 years are up, if a crop-growing area has been converted into a site of conservation interest? It must be clearly explained that, with current legislation, it is difficult to revert these areas back to crop-growing areas. This abandonment of crop-growing land is a handicap when incorporating agricultural land and the most productive poplar groves into the project, however it was not a limiting factor.

The LIFE+ MT project has solely acted on common land growing poplar trees, and has not acted on land with agricultural crops. The same amount was offered for the lease of the land, for all municipalities: 5,400 €/ha for 20 years. The price was set by calculating what a logging company would pay for the lease of land with good site quality (450 €/ha per year) for a 12 year period. The rest (8 years) was considered to be the contribution made by the council for the environmental improvement or conservation of its territory. However, when valuing the poplar groves, it is also necessary to value felling given the fact that, on occasions, there is a need to fell a poplar grove in production before the end period. In this case, a forestry appraisal needs to be made in order to compensate for the loss from the investments made and loss of income for felling the poplar grove before reaching optimum condition. This valuation was not initially contemplated and, on occasions, the resulting compensation could not be assumed with the initial budgetary provisions. The project contemplated an average of 7,125 €/ ha to compensate for loss of profit. However, there have been valuations made in good quality poplar groves where the compensation amounted to figures of up to 20,000 €/ha.

Taking all this into consideration, the project endeavoured to locate, throughout the territory, those zones with less productive poplar groves or ones in which the trees had already been felled, in order to facilitate agreements and adapt to the budget available. In some cases it was necessary to adapt the projects to the land available.

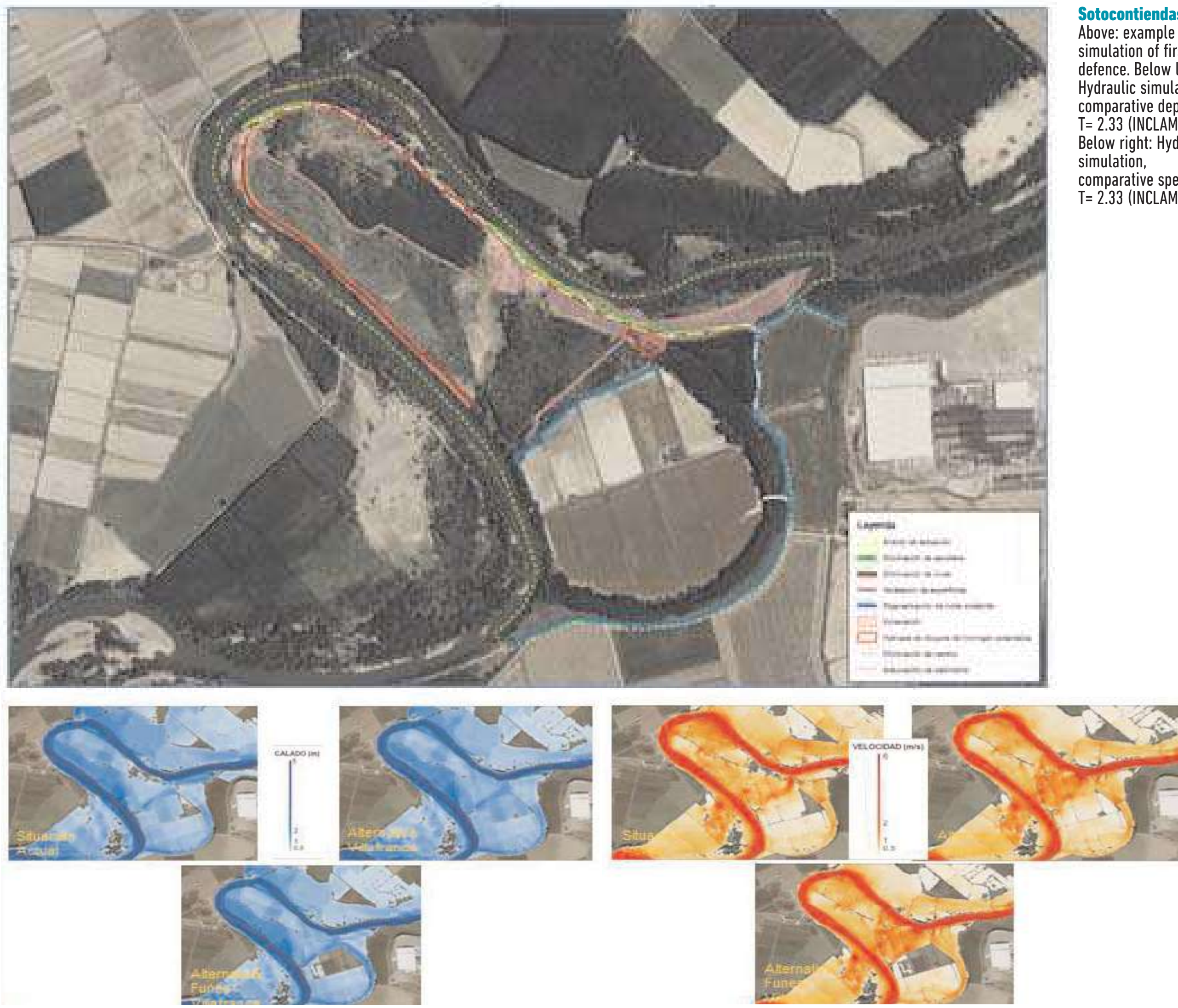
Of the 206 hectares initially contemplated, 116 ha have been included in the project, accounting for 56% of the surface area. All the same, the initial target was considered to be over-ambitious.

• Reversal of classification as common land

The problem of land availability does not end with a financial agreement. In accordance with the legislation of Navarra on common land, the Reversal of the classification as common land is required. This means that the resolution must be adopted at a plenary meeting of the council, followed by a public information process and then finally it must be approved by government agreement of the Government of Navarra. This requirement means that the administrative procedure is slow, leading to delays in the commencement of some projects.

• Privately owned land

With regard to the purchase of privately owned land, the process became more complex in some cases and legal difficulties arose with regard to the registration of the property with the CHE as the land was included in the Public Water Domain. We now have the paradoxical situation in which the LIFE+ MT project seeks to purchase a private plot of land, used for forestry purposes, and which is protected by a riprap. The project aims to remove the riprap and to increase the riverine territory. However, the land cannot be entered in the property register and, therefore, cannot be purchased in accordance with the provisions of LIFE +, because the CHE does not permit the registration of land coming within the Public Water Domain.



Sotocontiendas II.
Above: example of simulation of first-line defence. Below left: Hydraulic simulation, comparative depths T= 2.33 (INCLAM). Below right: Hydraulic simulation, comparative speeds T= 2.33 (INCLAM).

• Administrative

Despite the fact that the MAGRAMA, CHE and DRMAyAL are all involved in the LIFE+ MT project and that the project has management bodies for coordination purposes, it was not easy to quickly obtain the corresponding permits. Each project was subject to a number of administrative procedures in order to obtain the authorisations required.

The following authorisations were required for each project:

- Environmental authorisation from the DRMAyAL.
- Authorisation from the CHE.
- Authorisation from the council (approved in a Plenary session).
- Reversal of classification of the common land for the transfer of rights thereto, approved by the corresponding council at the Plenary Session and authorised by agreement of the GN.
- Permits for felling poplar groves, given by the GN Forestry Management section.
- Other environmental permits and authorisations (Environmental Quality Service).

• Critical period for the mink and other species

As this is a project with environmental objectives it is essential to strictly observe the limitations and restrictions imposed during the critical periods for the species involved, during which time they are most vulnerable to any actions and disturbances to their habitat. In the case of the European mink (*Mustela lutreola*), the critical period for the species is considered to be breeding and the dispersal of the young, from the 1st April until the 31st August.

This must be taken into account when programming the projects or, where appropriate, when taking preventive action in order to make it possible to execute the work in these areas without affecting the development of the species. In the LIFE+ MT project, thickets were cleared in order to prevent specific areas on which action was being taken, from being used by the species as breeding areas.

• Protection

For the local population and councils, a key issue is flood protection and safety, and much attention was paid to this in the drafting of the projects.

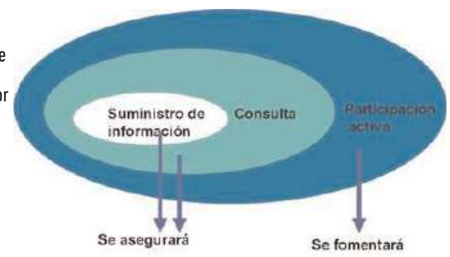
Projects have been implemented which included the removal or permeation of earth embankments and the increase of floodable zones in Caparroso, Mélida, Marcilla, Peralta, Carcastillo, Funes and Villafranca. In each case, recourse was made to the necessary hydrological studies in order to guarantee the maintenance of the levels of protection in the zones outside the project, reconstructing earth embankments in a second defence line, further away from the river banks.

This guarantee is necessary in order to convey confidence and assurance to the councils, thereby ensuring their readiness to progress in the drafting of the projects and the participation processes with the local community.

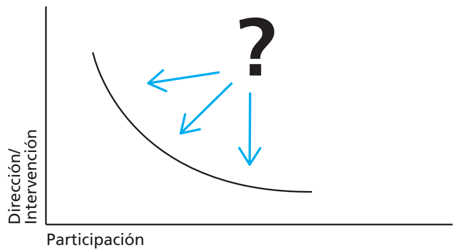
• Participation

The Water Framework Directive aims to promote active participation, particularly in the preparation of river plans. As an important challenge, the LIFE+ MT project took on the task of also promoting public participation in the preparation of the action projects. Public participation was established at three levels: public information, consultation and active involvement. The LIFE+ MT project implemented processes comparable to the 3 forms of participation established by the Water Framework Directive.

Esquema explicativo de los tres tipos de participación establecidos por la Directiva Marco del agua



There has been an ongoing debate throughout the LIFE+ MT project as to when and how to initiate these processes in order to combine the aims of the project and the management of the competent bodies with the active involvement of the local community. Although the LIFE+ MT project cannot provide an answer to this, it can share its experiences and considerations, to help reflect on and progress towards improving these processes. An initial reflection is that it may be necessary to adapt each level of participation to the different levels of action. The scale of preparation of a River Plan is not the same as the scale for a construction project. In this respect, an experience gained in the LIFE+ MT project is that projects and agreements have progressed at a faster pace when specific proposals are presented with actions that have previously been defined and agreed with the competent bodies (as explained above in the description of the project drafting process), instead of starting from more general questions on the need for a change of philosophy in the management of rivers. However, it is important to add that the "mink territory" had previously been dealt with in other projects. Therefore, a great deal of prior work had already been done in terms of information, awareness-raising and public involvement.



It should also be pointed out that councils are favourable to the incorporation in the project drafting processes of certain local associations and actors. The view is that they feel more secure with the decisions adopted if they have the support of the sectors of the community involved. Likewise, during the processes, information was obtained for the preparation of the projects and some very important contributions, which were decisive on occasions, for the execution and smooth running of the projects.

As has already been indicated above, flood protection is a key issue for the local community, which is extremely sensitive to the catastrophic phenomena produced by flooding. It is curious to see how those having the greatest contact with the river, such as farmers, irrigation users and environmental associations, have an increasingly greater technical knowledge and use the means available to obtain data on flow rates, return periods, etc. It is also curious to observe how, thanks to the participation processes, some of the actors in the sectors most opposed to new river management policies, such as the farmers, gradually became convinced of the inadequacy oft many aspects of current river management policies, seeing that many of the problems are associated with the lack of space and freedom for the river.
Conversely, the presence of an endangered species, such as the European mink, is a reason for rejection by sectors such as the farmers and, on occasions, it is a matter of outrage, that in these present times, money is being spent on the restoration of a species.

5. Conclusion

The LIFE+ MT project was an ambitious, complex project. Here we've shared some of the experience gained and problems encountered in the hope that they can serve as lessons learned for other river restoration projects.

7

THE SILENT DISAPPEARANCE OF IBERIA'S FLUVIAL WETLANDS: PROGNOSIS OF THE DEVELOPMENT OF THE LOWER REACHES OF THE RIVERS ARAGÓN AND ARGA, AND THE CHALLENGES OF CONSERVATION

ASUN BERASTEGI, FERMÍN URRA / Environmental Management of Navarre.

ROGER PASCUAL, GUILLERMO GARCÍA, ODA CADIACH, DAVID CAMPIÓN, GARBIÑE TELLETXEA, CAMINO JASO / MN Conservation Science Consultants.

rpascual@mnconsultors.com

Abstract:

Like many middle and lower reaches of great Iberian rivers, the Arga and Aragon have suffered in recent decades a geomorphological simplification of their channels and lateral structures because of well-known causes acting medium to long term. In the LIC *Tramos bajos del Aragón y del Arga* those morphological changes threaten the survival of the most important European mink's population of southern Europe. The LIC offers a singular and paradigmatic case to reconstruct and asses the disappearance of fluvial-wetlands in relation with this riverine changes. In this paper the evolution of both rivers is analysed in relation to their ability to generate and maintain suitable habitat for the European mink and, for the first time, an "expiration date" is extrapolated for one of these systems. All evidence seems to support the need to return some of their old fluvial freedom to the corridor as a medium to long term solution.

Keywords:

European mink, wetlands, river dynamics, incision, river restoration

1. Introduction

Wetland areas are functional ecosystem units featuring a positive spatial and temporal water anomaly with regard to the surrounding environment – presence of lentic surface water. Such areas are the richest and most productive of all inland ecosystems and are, consequently, home to a high proportion of known biological wealth despite only covering a small surface area (Sala *et al*, 2000). They play key roles in arid and semi-arid climate contexts, in which many of the species which use them are exclusive to such environments. Nevertheless, they have become one of the most threatened ecosystems and their recent but marked recession in developed countries over the last few decades has meant they are now a priority focus for conservation in Europe and led to the adoption of international commitments concerning their protection, particularly the Ramsar Convention to protect the most important wetlands (more than 2000 worldwide), which came into force in 1975 and to which 160 countries have acceded to date.

Thanks to their lateral mobility, the middle and lower reaches of Iberia's larger rivers undoubtedly gave rise to an abundance of fluvial wetlands in the past as they wandered across the peninsula's sedimentary platforms, producing wetlands or lateral bodies of lentic water annexed to the main channel or in branches abandoned by the river as it developed. These biologically rich areas were extremely plastic and evolved quickly, constituting fluvial environments which worked in unique ways and harboured unique communities. They even formed meta-systems of wetlands interconnected by the fluvial continuum, providing them with a unique capacity to accommodate viable populations of aquatic vertebrates, particularly territorial species which require large habitat areas, such as the European mink (*Mustela lutreola*) or the European pond turtle (*Emys orbicularis*). Nevertheless, the Spanish list of Ramsar areas does not include a single fluvial wetland system. Very little is known about these environments, which are silently disappearing.

• Changes in the rivers

A range of factors has radically modified the conditions of Iberia's major rivers over the time span of a single generation: agricultural abandonment in mountainous areas and regulation by means of reservoirs, among other things, have reduced the system's solid flows and the hydraulic and morphodynamic action they exercise; the creation of rigid beds and the narrowing of channels has led to structural simplification and neutralized the lateral dynamics of geomorphological adjustment; the disconnection of meanders (cut-offs) has given rise to incision of the main channel and often led to wetlands clogging and drying up.

The Site of Community Importance Lower reaches of the Aragón and Arga Rivers (hereinafter, the SCI) contained one of Iberia's last perifluvial wetland systems. The unique structural and geodynamic conditions of the area (synsedimentary karstic subsidence) (Benito *et al*. 1998, 2000) favoured great fluvial dynamism (Pérez Martín *et al*., 2015), with the formation of a large sedimentary basin through which both rivers winded, constantly changing their courses up until the first half of the 20th century. As a result of this dynamic, a complex river landscape with a main channel and numerous lateral wetlands in different stages of development was formed in which the different habitats arising in the area over time have provided refuge for a significant proportion of regional biodiversity. It is no coincidence that the area constitutes a strategic site for the conservation of one of the world's most threatened species, the European mink (*Mustela lutreola*); the most important mink population on the Iberian peninsula lives within this territory.

• Different land uses

The fluvial corridors in the SCI were extremely dynamic areas until the first half of the 20th century. However, this gradually became less the case and the dynamic nature of the Aragón fell to a minimum as a consequence of changes in land use, the creation of defence systems, bank stabilization and the construction of major reservoirs, all leading in synergy to a fall in the frequency and intensity of floods and a reduction of solid flows, the bed subsequently becoming confined and rigid. The hydrogeomorphological action of the Arga, on the other hand, was simply suppressed when parts of the river were first channelized and its meanders cut almost four decades ago. Since then, it has operated as a system with a totally rigid main channel, leaving no room for the generation of new wetlands either on the main stem or through avulsion of the channel. Its old channels and meanders have been disconnected and are gradually clogging up with organic material since floods only break the banks in exceptional circumstances and, consequently, mineral sedimentation is practically null. (Acín *et al*., 2011; Martín-Vide 2010, 2012; Ibisate *et al*. 2013).

The retreat of wetlands in Navarre's Ribera region, protected by the SCI, represent a serious threat to the main nucleus of population of European mink on the Iberian peninsula. The situation also provides a paradigm through which to reconstruct and analyse the process of degradation of fluvial wetland systems of this kind in general. With this purpose in mind, and within the framework of the

LIFE+ Mink Territory Project [09/NAT/ES/000531], the development of the fluvial structures associated with such systems was quantitatively analysed by the photointerpretation of georeferenced aerial images of the sector, which now form a collection of digital data of great documentary value.

2. Methodology

The pressures described have acted differently on each of the two rivers analysed, the Arga and the Aragón, thereby conditioning the methodology followed:

The basin of the Aragón is regulated to a great extent by three reservoirs (Irabia, Itoiz and Yesa). Numerous stabilization and defence structures (riprap defences, levees, cut-offs) have been installed, but in some sectors these fail to contain the waters, which still regularly inundate the river's flood meadows and activate old channels, facilitated by the presence of transversal structures which have undoubtedly acted (upstream from Marcilla) as constraints on the known processes of headwater incision described (Martín-Vide *et al*. 2009; 2012), maintaining greater connection between bed and banks. Although the meanderization and formation of wetlands on secondary channels (oxbow lakes) has been neutralized, the fluvial space of the Aragón has actually changed slightly over recent decades, albeit much less and much more slowly when compared with changes occurring until the first half of the 20th century. Consequently, there are now fewer and more spatially limited stretches capable of maintaining or regenerating small wetland areas as fluvial annexes to the main channel through lateral adjustment, but they do exist. The old secondary channels have not been totally cut off from the water supply and are currently subject to a fairly natural mixed siltation process (mineral and organic).

The Arga is much less controllable (Eugui is the only significant reservoir), but it was channelized downstream from Falces when its meanders were cut. Therefore, not only were its hydraulic regime and solid flows altered, but its channel was also constrained and shortened, leading to the system being severely boxed in (Martin-Vide *et al*., 2010). On the Arga, the development of new wetlands by meanderization and avulsion or the formation of islands and bodies of water to the sides of the main channel is out of the question. Both the disconnection work performed and the process which synchronously accompanied the cut-offs led to disconnection between the channel and its oxbow lakes, these now filling up chiefly as a result of organic accretion (quantitatively, mineral sedimentation is of little relevance). While these wetlands are aging relicts, they are, nevertheless, of great ecological interest (they are home to the densest breeding population of European mink).

In the case of the Arga, therefore, our interest lies in learning the evolution of its lateral branches in order to arrive at a mid-term prognosis. To this end, the development of the meandering system of Soto Gil y Ramal Hondo on the left-hand bank of the river –Peralta- has been studied in detail in both time and space using photointerpretation and fieldwork techniques. Aerial images from 1966 (prior to the cutting-off work), 1982 (first images available following cutting work in 1979) and 1992, georeferenced to a precision of 0.5-1m, were used in conjunction with georeferenced orthoimages from 1998-00, 2003, 2006, 2009, 2012 and 2014. The image from 1966, prior to cut-off work, was not used in the calculations made to track the development of the river (records exist indicating that the river changed significantly between this date and the actual work, thirteen years later). It does, however, provide us with a reference point for the state of the river in "natural" conditions. Photointerpretation permitted the differentiation of different types of land cover:

Riparian woodland and shrubland: includes all types of forest and sub-forest formations associated with riverside areas (black poplar, silver poplar, ash, tamarisk, elm, willow and mixed woodland).

Helophyte and hygrophilous grass communities: groups together herbaceous and fistolous river- and lake-side formations (dallisgrass meadows, hygronitrophilous grasslands, reed beds, bulrush beds, cane beds, etc.) and areas dominated by brambles and thorns.

Farmland, buildings and road network: heterogeneous group spanning all types of urban and agricultural manmade cover which eliminates the original vegetation.

Mesoxerophilous grassland: includes herbaceous communities on soils subject to major summer drought, from areas with *Brachypodium phoenicoides* and/or *Elymus spp*. to ruderal formations appearing after cropland or pastures have been abandoned.

Open surface water: Surface water visible in the orthoimages. When the water spreads beyond such areas into reed and bulrush beds, the areas are considered flooded reed or bulrush beds.

Riparian tree plantations: this type of cover was differentiated from crops, buildings and the road network due to the importance it usually has in riparian environments (not the case in Soto Gil). The cover refers both to hybrid poplar forest crops and areas reforested for environmental purposes.

In order to study the development of the River Aragón, a set of structures related to the abundance of wetlands over the 54-km stretch between Carcastillo and its confluence with the Ebro included in the SCI were analysed, comparing two points in time: 1956 and 2012 (before most of the Life Mink Territory projects were performed). Given the size of the area to photointerpret and the difference in quality between the images compared, the fluvial structures which indicate the fluvial freedom necessary in order to create wetlands were digitalized. This was not, therefore, a direct evaluation of the wetlands, but of a set of structures correlated with their abundance. In addition to the main stem, the following elements were distinguished and delimited:

Islands: stabilized, emerged areas (not bars), completely surrounded by the river course.

Secondary channels: islands divide the river course and, normally, it is possible to distinguish between the main channel and the secondary channel.

Oxbow lakes and backwaters: side channels disconnected at one end from the main channel, normally as a result of a secondary channel clogging up, sometimes reduced to concavities on the bank with lentic waters.

Disconnected bodies of water: the last stage of water bodies before they clog up completely. These bodies normally start out as oxbow lakes which have been disconnected from the main channel at both ends.

Although river bars are also good indicators of fluvial dynamism and, therefore, of a system's capacity to generate new wetlands, they were not interpreted, chiefly because they are dynamic structures which cannot be associated with the presence of wetlands and also because of the difficulty involved in defining their boundaries (particularly in the image from 1956, for which no digital model of elevations is available to assist in the task). Digitalization considered a minimum polygon of $100m^2$ for both orthoimages - 1956 and 2014.

Photointerpretation of the SCI's fluvial areas was based on the collection of orthophotos on Navarre's Geoportal (SITNA, http://sitna.navarra.es/geoportal/), available online via its own viewer (http://sitna.navarra.es/navegar/) and a web map service (service URL: http://idena.navarra.es/ogc/wms).

3. 3 Results

• 3.1 Development of the wetlands associated with the meandering systems of the River Arga: the Soto Gil y Ramal Hondo model.

The areas included in the SCI (the current canal of the River Arga was not taken into consideration) were analysed from 1982 and 2014, meaning that only the disconnected meander system was reflected. The cover data from 1966 was also added as a reference image reflecting the situation prior to cutting.

The first consequence of cutting off and disconnecting the meandering system, as analysed by comparing data from 1966 and 1982, was a significant increase in helophyte communities, to the detriment of river bars, islands and surface water. These data must be interpreted with caution, however, because the location of the fluvial space in 1966 was somewhat different to that arising as a result of the cutting-off work, which is why a drop in cropland can be appreciated. After cutting, the main trends which can be appreciated include a gradual reduction in the area of open surface water, falling over the period under study from 10.45ha to 2.76ha (-73.6%), and an augmentation of riparian woodland and shrubland, which grew from 12.0ha to 22.2ha (+85.4%). The oscillations in riparian tree plantation cover are due to a combination of lopping cycles, plants which fail to take root, the size of the trees themselves and the limitations of photointerpretation. To a large extent, variation in the surface area covered by forest plantations is complementary to that of mesoxerophilous grassland. The deficit not covered by the latter is due, once again, to the proliferation of riparian woodland. The helophyte and hygrophilous grass communities maintain practically constant coverage thanks to their spatial displacement as a result of balance between the proliferation of such formations at the expense of areas of open water which are gradually clogged up and their disappearance due to the advance of the riparian woodland on the opposing bank. Finally, manmade cover (farmland, buildings and road network), located on the edges of the meanders and in the centre of one, shows no significant variation. Table 1 and the subsequent graphs (1, 2 and 3) record and illustrate the data derived from this analysis.

Table I. Evolution of land cover in Soto Gil y Ramal Hondo (SCI area), absolute values (ha).

Cover	Year								
	1966	**1982**	**1992**	**1998-00**	**2003**	**2006**	**2009**	**2012**	**2014**
River bars and islands	7.60	0.04	---	---	---	---	---	---	---
Riparian woodland and shrubland	11.87	11.97	17.63	15.73	16.70	17.36	19.63	20.64	22.19
Helophyte communities/hygrophilous grassland*	---	17.95	14.86	18.52	19.51	19.45	18.27	18.26	17.79
Herbaceous and helophyte communities*	5.49	---	---	---	---	---	---	---	---
Cropland, buildings and road network	24.68	17.74	17.19	17.04	17.12	17.13	17.31	17.27	17.22
Mesoxerophilous grassland*	---	4.92	7.60	4.32	6.14	6.07	5.74	5.00	4.26
Open surface water	13.55	10.45	7.28	6.91	4.98	4.43	3.73	2.99	2.76
Riparian tree plantations	2.17	2.29	0.80	2.83	0.92	0.92	0.67	1.20	1.13
TOTAL	65.36	65.36	65.36	65.36	65.36	65.36	65.36	65.36	65.36

* In the 1966 cartography, the categories "Helophyte communities and hygrophilous grassland" and "Mesoxerophilous grassland" are grouped together in "Herbaceous and helophyte communities"

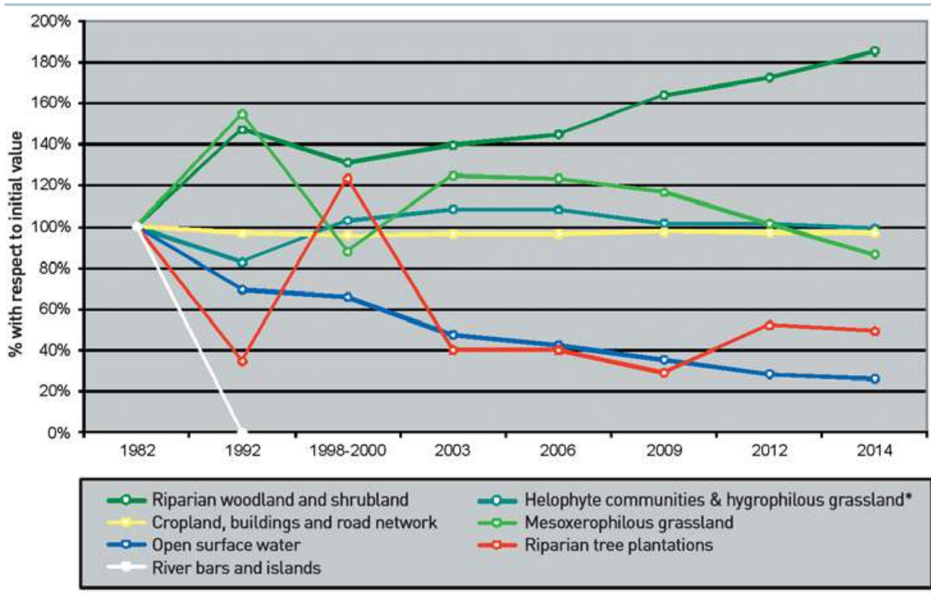


Figure 1. Development of the surface area of each of the types of land cover distinguished over the period 1982-2014. Values in % relative to initial situation.

Among the land cover types quantified, the area with surface water is a direct indication of the evolution of the wetland. The retreat of open surface water over the period under study was analysed from this perspective and is clearly shown in graph form in figure 3. A strong correlation is observed when this parameter is represented on the time scale ($r^2 = 0.979$). The data obtained in the present study indicate that should the current trend continue, the Soto Gil y Ramal Hondo meandering system will have a negligible area of open surface water by 2025 (figure 3).

Figure 2. Development of the Soto Gil y Ramal Hondo disconnected meandering system over the last 32 years.

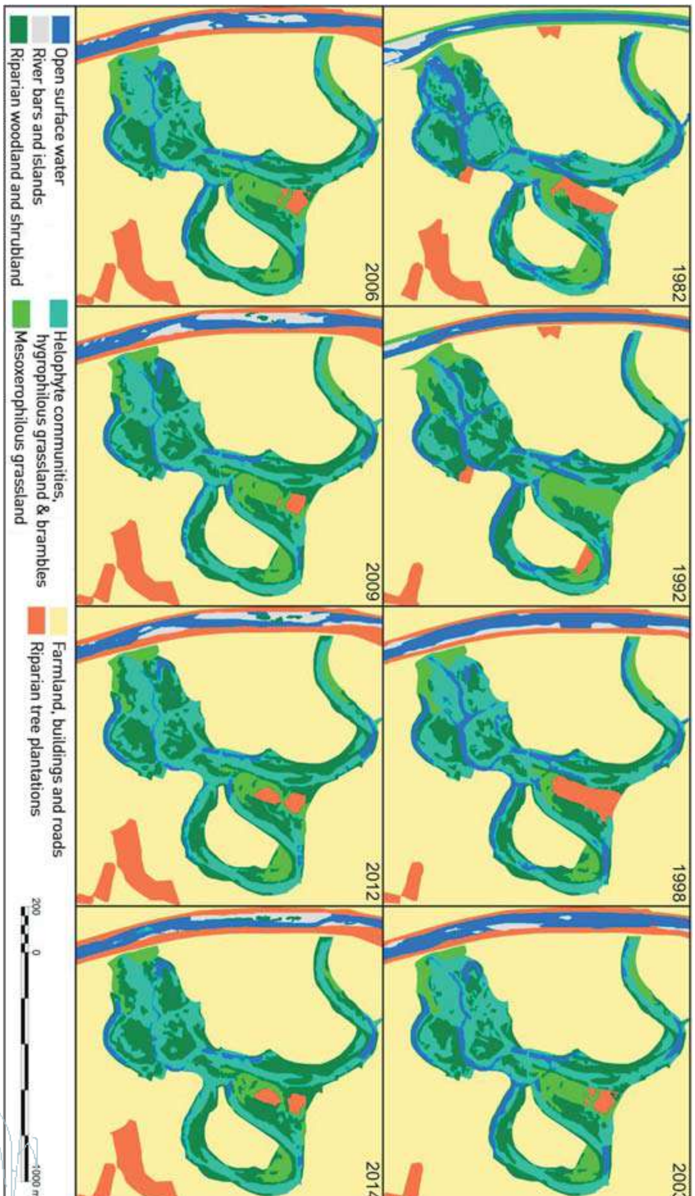
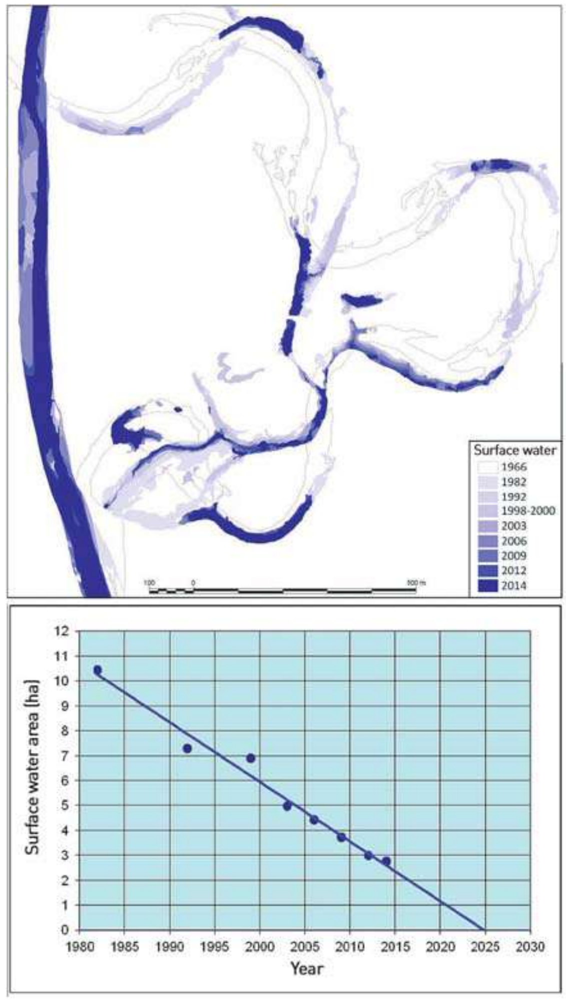


Figure 3. Left: Representation of the surface area occupied by open water in the Soto Gil y Ramal Hondo system over the period 1982-2014. The location of the meander prior to cut-off is that of its boundaries in 1966. Above: Rhythm of decrease of open surface water in the Soto Gil y Ramal Hondo system over the period 1982-2014.



• 3.2 Development of the wetlands associated with the meandering systems of the River Aragón.

As described in the methodology, the main structures associated with fluvial freedom (islands, secondary channels, oxbow lakes, etc.) have been digitalized and provide indirect indicators of wetland-generating capacity over the entire length of the section of the River Aragón included in the SCI (Carcastillo – confluence with the River Ebro). The data obtained are shown in the following table:

NUMBER OF WETLAND-ASSOCIATED STRUCTURES

Structure	No. polygons		difference 2012-1956	
	1956	**2012**	**abs**	**%**
Main channel	1	1	0	0.0%
Islands	71	48	-23	-32.4%
Secondary channels	67	48	-19	-28.4%
Oxbow lakes and backwaters	105	74	-31	-29.5%
Disconnected bodies of water	4	14	10	250.0%
TOTAL	248	185	-63	-25.4%

SURFACE AREA OF WETLAND-ASSOCIATED STRUCTURES

Structure	Surface (ha)		difference 2012-1956	
	1956	**2012**	**abs**	**%**
Main channel	329.56	205.43	0	0.0%
Islands	48.67	16.35	-23	-32.4%
Secondary channels	24.32	12.85	-19	-28.4%
Oxbow lakes and backwaters	19.04	8.53	-31	-29.5%
Disconnected bodies of water	0.61	3.60	10	250.0%
TOTAL	422.20	246.76	-63	-25.4%

Table 2. Development of the fluvial forms on the River Aragón between Carcastillo and confluence with the River Ebro between 1956 and 2012.

PROPORTION OF WETLAND-ASSOCIATED STRUCTURES

Structure	Surface (%)		difference 2012-1956	
	1956	**2012**	**abs**	**%**
Main channel	78.1%	83.3%	5.2%	6.7%
Islands	11.5%	6.6%	-4.9%	-42.5%
Secondary channels	5.8%	5.2%	-0.6%	-9.6%
Oxbow lakes and backwaters	4.5%	3.5%	-1.1%	-23.3%
Disconnected bodies of water	0.1%	1.5%	1.3%	908.5%
TOTAL	100.0%	100.0%	0.0%	0.0%

OVERALL DATA OF THE STRETCH

Parameter	Surface (%)		difference 2012-1956	
	1956	**2012**	**abs**	**%**
L: length of the axis of the main channel (m)	55142.7	53936.7	-1206.0	-2.2%
W: average width of the main channel (m)	59.8	38.1	-21.7	-36.3%
P: perimeter of the main channel (m)	113123.7	109637.2	-3486.5	-3.1%
S: Sinuosity of the bank of the main channel*	0.0257	0.0164	-0.0094	-36.5%

*S = (P/2L) - 1

Over this period, the mobility of the river has been fairly modest. However, its fluvial forms have changed significantly in both abundance and size. Although the length of the main channel has remained practically unchanged (from 55.1 to 53.9km), its surface area has decreased by 38% and it has narrowed on average from 60 to 38 metres. Meanwhile, the degree of sinuosity or irregularity of its banks, measured as the ratio between their length and that of the fluvial axis, has also dropped. Practically all the fluvial structures analysed show drops in both number and total surface area, not only in absolute figures, but also in relation to the main channel, with the exception of disconnected bodies of water, which are now clearly more abundant. Figure 4 represents a section of the River Aragón, between Soto Contiendas and Soto Nuevo, where the changes described are more than evident.

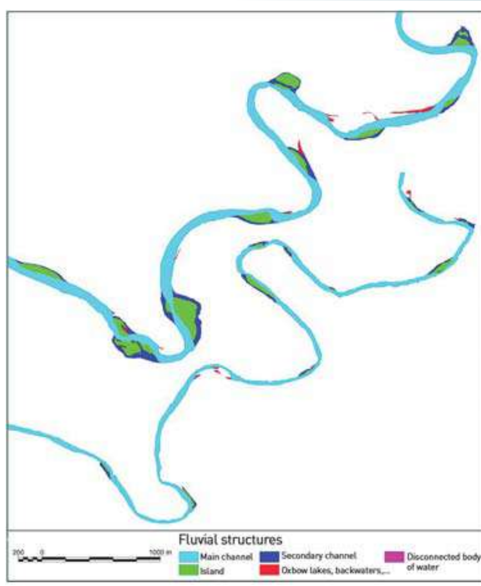


Figure 4. Development of the fluvial forms in the River Aragón between 1956 and 2014, Soto Contiendas-Soto Nuevo section.

4. Discussion

The hydraulic regulation and simplification of characteristic fluvial forms is a frequent phenomenon in the middle and lower reaches of Iberia's major rivers. This is the result of a range of causes (previously listed) and involves a significant loss of fluvial dynamism and geomorphological action. Different work related to LIFE+ Mink Territory (LMT) has tackled this situation in the area of the SCI Lower reaches of the Aragón and Arga Rivers, such as the Marcilla-Soto Contiendas project (Pérez-Martín *et al*., 2015) or the document *Estudio de alternativas de actuación de restauración de ríos y defensa frente a inundaciones en la zona de confluencia de los ríos Arga y Aragón: Estudio geomorfológico* (Study of alternatives for river restoration and flood defence action in the area of confluence of the Rivers Arga and Aragón: Geomorphological study) (Ibisate *et al*., 2010).

This paper specifically studies the development of fluvial complexity for each of the two main river systems in the SCI: the River Arga, channelized and with a set of meandering side systems disconnected from the main stem; and the River Aragón which, despite being extremely regulated, is still geomorphologically natural in certain sections.

• The River Arga

The River Arga is incapable of generating new wetland areas and its pre-existing wetlands forge on towards senescence and disappearance. For this reason, an in-depth study of its disconnected meandering systems, more specifically that of Soto Gil y Ramal Hondo, one of the most favourable sites for the European mink, has been undertaken for the first time. Analysis of the development of land cover over the last 36 years, following the channelization of the main stem, highlights the sustained contraction of surface water in the area and equivalent encroachment by riparian woodland. The trends observed point towards an end-stage situation for open surface water within a period of just 10 years. This prognosis could, of course, be affected by circumstances not taken into account in the analysis, such as the importance of the irrigation returns that feed the system, which could supply surface water in non-negligible minimum quantities, or methodological issues, such as precision in the digitalization of images of differing quality. Nevertheless, the trend would appear to be steady and the expected outcome is one of ever-increasing degradation of habitat conditions for the mink. It would be interesting to undertake similar analyses in all the other major meandering systems because they may all be evolving at different rates. This analysis has, however, provided us with preliminary data on clogging rates in meanders subject to a highly specific situation, but one which most of the isolated meanders on the River Arga within the SCI share: systems morphodynamically and hydraulically disconnected from the main channel and its alluvial plain, both laterally (cut-offs) and vertically (incision), in which organic material is chiefly responsible for clogging (they are only fed by agricultural return flows, "clean" of sediment).

• The River Aragón

Certain sections of the River Aragón are still fairly dynamic and geomorphologically natural. For this reason, an analysis of the development of fluvial forms related to wetland generation over the entire length of the part of the river included in the SCI was undertaken –again, for the first time-, although in this case, given the scale of the area to map, analysis was reduced to the situation of the river in 1956 (first aerial image of sufficient quality covering the entire area) and in 2012 (last orthoimage available of the situation prior to performance of LMT). The data obtained have allowed us to present specific figures for the variation of islands, secondary channels, oxbow lakes, backwaters and disconnected bodies of water in both number and surface area. The results indicate not only narrowing of the main channel and simplification of its banks, but also a clear diminution of the fluvial forms under study, indirect indicators of the dynamism of the river and its capacity to generate associated wetlands. The exception is with bodies of water disconnected from the main channel, of which there are now more (even though they represent a lesser proportion of all the forms taken as a whole): this indicates equilibrium of the system, one step nearer to senescence, because these structures represent the terminal evolutionary stage of oxbow lakes, i.e. the speed at which these forms are disappearing is greater than the speed at which they are being generated, which will under no circumstance involve the creation of any new oxbow lakes.

To date, different LMT projects have involved digging out pools on the fluvial terraces alongside the river, fed by irrigation return flows, in order to create habitats propitious to the European mink, a measure which has enjoyed a certain degree of success, judging from the results of monitoring the species. These small-scale actions, however, need to be kept up continually due to the tendency of these areas to clog up quickly with organic matter or the insufficient impermeability of the basin. They are not restoration actions which draw the system any nearer to a more natural scenario. Consequently, such actions may be valid in the short term, but do nothing to alter the fluvial system's tendency to lose suitable natural habitats not only for *Mustela lutreola*, but also for other priority species, such as the European pond turtle (*Emys orbicularis*), the European otter (*Lutra lutra*) and water birds.

• Functional and structural degradation

For some time, experts in different areas have highlighted the causes of the current functional and structural degradation of Iberia's rivers, particularly regarding the middle and lower reaches of major channels, and insisted that any action taken should chiefly focus on measures to increase fluvial freedom. Although the regulation of basins by means of reservoirs and changes in land use in mountainous headwater areas are processes which it is very difficult to act against, there do exist ways to reduce the effects on the system of other causes, such as channelization, defence systems (levees and riprap defences) and dredging, and return areas to the river which were stolen from it in the past. Many of the LMT projects consider the removal or setting-back of levees and riprap defences as methods through which to regenerate the fluvial system. In the case of the Rivers Arga and Aragón, however, incision of the main channel is an impediment to the effectiveness of methods of this kind. The SotoContiendas project (Pérez-Martín *et al.*, 2015) is a pilot experiment which should lay the ground for fluvial restoration in particularly complex situations of this kind. These structures have been removed and the geomorphology of the section has been reconstructed by topographically reconnecting the banks with the flood meadows, returning extracted sediment (much of it from old dredging dumping sites) and providing areas capable of generating new wetlands.

The situation is much more complex in the case of the River Arga; the main channelized stem is significantly lower than the flood meadows and flood waters are only capable of surmounting the defences in exceptional circumstances. In this case, the only viable way to maintain a certain degree of dynamism in the disconnected meandering systems and reverse their senescence-bound trend would be to hydraulically reconnect them with the main channel. The heights of the connecting and drainage brims (activation flows and gradient), and their cross sections would determine the frequency and intensity of expected future flooding. This idea has been put into practice in LMT on the meander system in the Muga-Santa Eulalia area. Careful selection of the water entry and exit heights should make it possible to maintain a water-input rhythm in the meander capable of producing a certain degree of morphodynamic action, while maintaining the stability of the system when the water is at non-flood level. It is hoped that this will maintain a balanced river ecosystem in some of the riparian copses disconnected from the river and thwart the loss of habitat suitable for the European mink.

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A PROPOSAL FOR THE EARLY MONITORING AND ERRADICATION OF THE POND SLIDER (*TRACHEMYS SCRIPTA SPP.*) AND OTHER INVASIVE TURTLES WITHIN THE SCOPE OF THE LIFE MINK TERRITORY PROJECT

David Campión, GarbiñeTelletxea, Fèlix Amat, Juan Manuel Roig, Oda Cadiach, Jaume Solé / MN Conservation Science Consultants
http://www.mnconsultors.com/

Fermín Urra / Environmental Management of Navarre.

dcampion@mnconsultors.com

Abstract:

Results of monitoring and eradication Pond slider (*Trachemys scripta*) framed in the LIFE+ 'Mink Territory' (LIFE09/NAT/ES/000531) project are presented.

By means of GIS analysis 339 locations suitable to host freshwater turtles were identified. Among these we selected 65 monitoring points which were submitted to 40 hours of direct observation. After this sampling effort four exotic individuals in three different locations -two of which unknown before- and five European pond turtles were detected. Additionally both ten sundeck traps and eleven hoop nets with corresponding sampling efforts of 808 and 102 day-trap were set up in some of the selected locations. No exotic specimens but two European pond turtles were captured. The results indicate a very low density of *Thrachemys scripta spp.* specimens suggesting an early stage of colonization of riverine wetlands. Taking into account these low density values, the most efficient management strategy would imply an early detection and selective removal by expert shooters. An awareness campaign focused to the local population is also proposed.

Keywords:

Trachemys scripta, exotic turtle, invasive species, SCI

1. Background

The work described in this paper was carried out within the framework of the technical support "Methodological protocol for the control and handling of the Pond Slider (*Trachemys scripta*, Schoepff, 1792) and the experimental application in the SCI Lower Reaches of the Aragón and Arga Rivers (LIFE+ "Mink Territory - NAT/ES/00053. Specifically, this work comes within the framework of action C5: Assessment of the presence of invasive non-native species within the scope of the project, for subsequent elimination.

2. Introduction

The introduction of invasive non-native species is, according to the IUCN, the second cause of the global extinction of species, only behind the direct destruction of habitats (Lowe *et al.*, 2004). Within the scope of this LIFE project, there are at least five aquatic fauna species included amongst the hundred most dangerous species in the world, due to their ability to affect the ecosystems and/or human economic interests (Lowe *et al.*, 2004). These include the Asian clam (*Corbicula fluminea*, Müller, 1774), the black-bass (*Micropterus salmoides*, Lacepede, 1802), the mosquitofish (*Gambusia holbrooki*, Agassiz, 1895), the carp (*Cyprinus carpio*, Lynnaeus, 1758) and the pond slider itself (*Trachemys scripta*).

This work focussed on clarifying the population status of one of these species, namely the Pond Slider, along the 50 kilometres of the watercourse included in the SCI of the Lower Reaches of the Aragón and Arga rivers. *Trachemys scripta* has a wide ecological valence, with breeding detected in northern Europe (Germany and Austria), although it is particularly abundant in lower latitudes such as France, Spain and Portugal (Lowe *et al.*, 2004; Bringsøe, 2006; Martínez-Silvestre *et al.*, 2011; Vamberger *et al.*, 2012).

Today, this species is not the only exotic turtle present in Europe, with the presence of a wide range of taxa in response to the commercial demand for these animals, regulated by ever-changing legislation which is progressively restricting the number of species that can be imported. The number of these American and Asian species is high, amounting to several dozen, to which we need to add the various known varieties and even the hybrids - refer to (LIFETrachemys, 2012b) for an example of those known in the Iberian Peninsula. In any case, a specific species, the *Trachemys scripta*, is the one introduced in the largest number. This species has managed to reproduce and to form important colonies in some areas, particularly in the Iberian Levante region, where specific elimination programs have removed more than 20,000 specimens since 2003 (LIFETrachemys, 2013b).

The specific conservation problems posed by these species are related to a number of factors such as competition with native turtles for basking sites (Cadi y Joly, 2003; Franch i Quintana *et al.*, 2007) and food. Some studies predict a future scenario in which the European turtle will be displaced by the exotic ones, due to a more successful conformation of the former with regard to thermoregulation, ethology, trophic habits and even due to the inability of certain potential prey to detect these turtles as predators (Polo, 2009). Finally, the reproductive parameters for the *Trachemys scripta* in the Iberian Peninsula are similar, or even higher, than those for their place of origin, and are clearly higher than those for the native chelonians (Perez-Santigosa *et al.*, 2008), given the fact that they reach maturity earlier and produce more eggs and are more fertile.

On the other hand, exotic turtles are a vector for new pathogens and it has been demonstrated how these are associated with clinical cases of *Salmonella* in humans. A recent work has shown how the prevalence of this bacterium is extremely high in specimens of *Trachemys scripta* released into the natural environment, and that the wetlands in which these turtles are present have a significantly greater prevalence of Salmonella (Vega *et al.*, 2010).

In any case, there is an undeniable expansion of these exotic aquatic turtles in Europe and, as such, it represents a problem in itself, regardless of whether it is possible to quantify, at this initial stage, a specific impact on certain species.

•2.1 State of prior knowledge with regard to the *Trachemys scripta* in Navarra

According to the only review made (Valdeón *et al.*, 2010a), which gathers information from a number of sources over a period from 2005-2010, 25 records were compiled

(which may cover different individuals) of *Trachemys scripta* in Navarra, concentrated in the vicinity of large towns and cities (Pamplona, Tudela, Estella) and lagoons and reservoirs in the south of Navarra.
Until this present work was started in the study area (SCI lower reaches of the Arga and Aragon rivers) exotic turtles had only been detected at one location in the vicinity of Funes, in the area of the Arga river known as "Soto Sardilla".

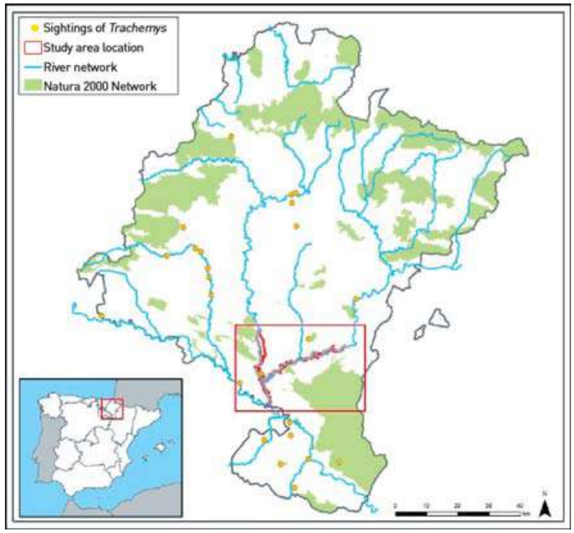

Figure 1. Sighting of *Trachemys scripta spp.* in Navarra up to this present study. Prepared on the basis of (Valdeón *et al.*, 2010a).

3. Aims

The general aim of the work was to assess the situation of the exotic turtles in the area and to prepare and apply a protocol to eradicate them. This general objective was put into effect with the following specific objectives:

a) To determine and quantify the exotic turtle populations and/or individuals present in the area under study.

b) To compile and test different trapping systems.

c) To map and characterise the places that are likely to be occupied by exotic turtles in order to make these a monitoring priority.

d) To prepare a protocol for locating and removing exotic turtles from the study area.

4. Methodology

•4.1 Location of individuals

In order to detect individuals, we decided on a two-fold strategy of establishing observation points and installing basking platforms. The initial hypothesis on which the work was based, assumed a low density of exotic turtles. For this reason a prior multivariate study was conducted using Geographic Information Systems (GIS). This made it possible to identify 339 locations suitable for hosting turtles (native and exotic alike). Subsequently a sampling prioritization was made of these locations, based on a number of variables, such as closeness to urban centres and/or leisure areas (Perez-Santigosa *et al.*, 2008).
Finally, 65 observation points were established at locations with a high probability of the presence of turtles and with considerable visual detectability. We also ruled out locations suitable for turtles but with thick reed beds which hindered monitoring, even though there was confirmation of the presence of the European turtle there (Valdeón *et al.*, 2010b). In these locations, it is easier to locate turtles through trapping than by direct observation (Martínez *et al.*, 2012).
The observation time was approximately fifteen minutes per point and visit, depending on the complexity of the surroundings and the basking points to be monitored. A single visit was made to 51 of these sighting points, whilst 68% of the observation time was dedicated to14 points with the greatest potential or estimated risk potential (1,665 minutes). The observer had suitable optics to carefully explore any possible basking points (rocks, trunks, river banks, reeds, etc.). The final effort or total effective monitoring time employed was 2,445 minutes (approximately 40 hours).

Table 1. Number of observation points established in the vicinity of the Arga and Aragon rivers and areas of influence. The monitoring time at each location is indicated.

	Arga	Aragón
Total No. of observation points	24(1680)	38(765)
No. of points with a high risk *Trachemys scripta*	12(1500)	2(165)

In order to increase the effectiveness of the observation points in detecting turtles, 10 floating platforms were installed at those points which appeared to be lacking in natural basking places. The combination of these platforms with floating traps is considered to be an optimal cross strategy to deal with the problem of exotic turtles in wetlands (Pérez Santigosa *et al.*, 2006).

The basking platforms consisted of grey sheets of high density expanded polystyrene (*Porexpan)*, measuring one square meter and sited in sunny spots visible from the bank. These sheets were secured with two embedded vertical rods or canes, allowing the platform to move vertically, depending on the changes in the water level.

•4.2 Trapping of individuals. Capture devices

A number of projects are underway in Europe, directed at capturing exotic turtles in order to limit their populations and/or to study different aspects of their biology. The trapping methodology is based on the review of the various trapping systems used and tested in works conducted in different areas of Europe. The presence in the area of endangered species of fauna such as the European Pond Turtle (*Emys orbicularis*, Linnaeus, 1758), the Eurasian Otter (*Lutra lutra*, Linnaeus, 1758) and the European Mink (*Mustela lutreola*, Linnaeus, 1761) led us to rule out any trapping methods which, although effective, might also harm these species. Some works, particularly those conducted within the framework of the LIFE Trachemys project in the Community of Valencia, indicate that pots are the most effective method of capturing exotic turtles (LIFETrachemys, 2011; LIFETrachemys, 2012c). In our case, these were only used at the Soto Sardilla (Funes) location and under twice-daily monitoring.

10 traps specially designed to capture turtles were used, and with some changes in their construction compared to those referenced in the various works (Pérez Santigosa *et al.*, 2006; Valdeón *et al.*, 2010a; LIFETrachemys, 2012c). As in the case of the basking platforms, these were based on the principle that turtles actively seek out floating basking sites. These are floating structures measuring one square metre which the animals can climb onto. A net covers the base of the trap, which is submerged, so that those turtles climbing onto the structure and jumping inside the trap are unable to get out. For increased attraction, all traps contained baits of tinned sardines and also fresh fish, as fish is considered to be the most appealing bait to turtles (LIFE-Trachemys, 2013a).

•4.3 Characterisation of the locations

Photo-interpretation and GIS analysis were used to identify 322 locations that had potential for hosting the different species of turtles. These locations corresponded to lagoons, backwaters, oxbow lakes and, in general, to habitats that are apparently suitable for exotic and native turtles. The field work made it possible to individualise 19 new locations, giving a total of 341 selected locations.

These locations were subsequently visited in order to make an "on site" record and to classify them as either suitable or unsuitable for these species. This field record includes a number of descriptor variables for the habitat available at each location, as well as the monitoring possibilities, ease of access, etc. Priority was given to the characterisation of locations with a high potential for hosting turtles and with a risk of finding *Trachemys scripta* (urban and/or leisure areas) and with the ultimate goal of establishing a network of monitoring points in the Protocol for the control of the species at the SCI.

5. Results

•5.1 Location of individuals

The results obtained by setting up observation points in suitable places, are shown in Table 2. The total effective observation time was 40.7 hours, 68% of which was focussed on areas with a high risk of the introduction of *Trachemys scripta*. A total of nine different individuals were detected during the work, five of which were native turtles and four were exotic. All the exotic turtles were located in the wetlands around the river Arga and with considerable public use. The detection rate was 0.12 native specimens/hour and 0.09 exotic specimens/hour.

Two specimens of the *Trachemys scripta* were located at the site already indicated as "Soto Sardilla". In addition, another specimen was located in one of the lagoons of La Muga (*Trachemys scripta*) and in the Soto de Santa Eulalia (probably a hybrid of *Trachemys scripta scripta* x *Trachemys scripta elegans*), extending the known distribution of these species in the SCI of the lower reaches of the Arga and Aragon rivers (Figure 2).

Despite the effort put into mounting the basking traps, no turtles were observed in any of them. Most of these platforms did not withstand the adverse weather conditions and either disappeared, or else were found unsuitably positioned, preventing them from being used by the turtles. Apparently, and unlike other areas, they are not suitable for the study area, which suffers from frequent summer storms and days with very strong winds.

Species	No.	Municip..	Site	Habitat type
Emys Orbicularis	3	Carcastillo	La Biona	Oxbow lake
Emys Orbicularis	1	Funes	Las Rozas	Oxbow lake
Emys Orbicularis	1	Funes	Sardilla	Oxbow lake
Total *Emys*	5	(0,12 spec/h.)		
Trachemys scripta	2	Funes	Sardilla	Oxbow lake
Trachemys scripta	1	Peralta	La Muga	Lagoon
Trachemys sp.	1	Peralta	Santa Eulalia	Oxbow lake
Total *exotic*	4	(0.09 spec/h.)		

Table 2. Location and habitat of the exotic and autochthonous turtles located.

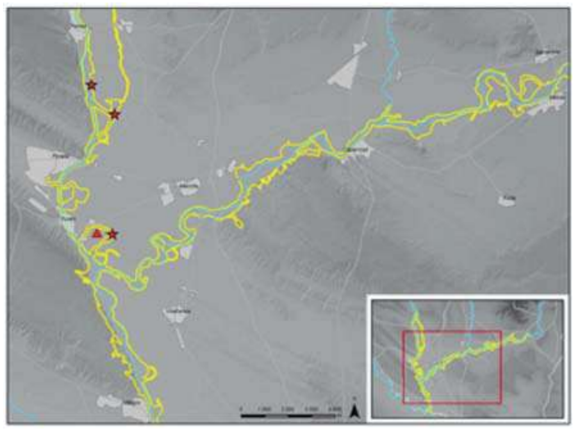

Figure 2. Location of exotic turtles in the study area (SCI, lower reaches of the Arga and Aragon rivers). The asterisks indicate the sightings contributed by this present work. The triangle indicates the only known sighting until this study was conducted (Valdeón *et al.*, 2010a).

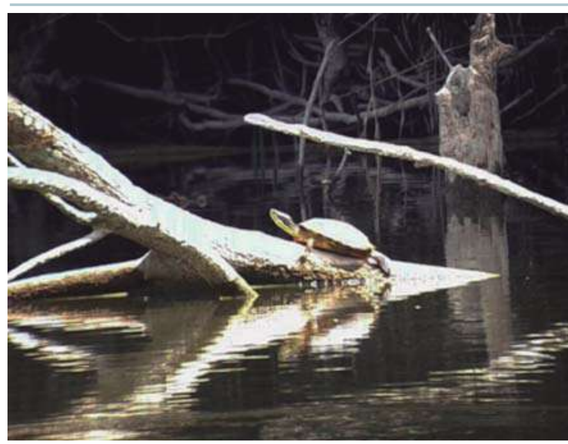

Figure 3. Specimen of a *Trachemys scripta* at the Soto de la Muga (Peralta) in a typical basking position.

•5.2 Trapping of specimens

The positioning of the first floating traps commenced on the 19th May and the last traps were withdrawn on the 29th September. In total, a maximum of ten floating traps were used simultaneously each day. These were moved between different locations based on the detection of specimens and other circumstances such as floods, vandalism, etc. The total number of trap-days used with this method was 808, particularly focussed on places with sightings of the Trachemys scripta. No exotic turtles were captured and just one European turtle was captured using a floating trap. The capture success rate is therefore 0.0012 specimens / trap day).

A capture test was conducted using pots in Soto Sardilla (102 days/trap), capturing a female *Emys orbicularis* in Soto Sardilla. The success of the capture was 0.01 specimens/trap day, eight times higher than the floating traps.

•5.3 Characterisation and prioritisation of the monitoring of the locations

Of the 341 locations with the potential for the presence of turtles, 220 were visited (64.5%). Finally, 13 locations were considered to offer the highest risk, due to their closeness to population centres, high recreational use and physical characteristics (10 in the river Arga and 3 in the river Aragon). Non-optimal locations were considered to be those that are unsuitable for these species or cannot be visually explored.

6. Discussion

•6.1 The exotic turtle populations present in the area under study.

Four specimens of exotic turtles were detected in three locations in the work area during the period from June to September 2014.

In our opinion, the results indicate a real low density status with regard to exotic turtles, despite the poor weather conditions in the summer of 2014 for detecting the species.

The number of European turtles detected basking in the sun (5 in three localities) was similar to that for exotic turtles (4 in three localities). The exotic turtles are far easier to detect than the European ones due to the fact that they are less specific in selecting basking substrates and are more trusting in their relations with human beings (Martínez *et al*., 2012). It is therefore considered that the sighting of five native specimens may be a good indicator that the sampling was sufficiently intense. The months of July and August 2014 were classed as having unfavourable, atypical weather with fewer days of sunshine and temperatures below the mean, throughout Navarra (Gobierno Navarra, 2014). This fact must have affected the mobility and detectability of the turtles, dependent on sun basking.

The southern area of Navarra is located right in the Ebro basin and it clearly appears to be a suitable place for the establishment and reproduction of these invasive species. We have already mentioned the adaptability of the *Trachemys scripta* to different habitats. It seems clear that the SCI on the Lower reaches of the Arga and Aragon rivers holds numerous wetlands with the potential to host exotic turtles. There are also a number of potential entry routes: areas with a high social use, fishing areas, river picnic areas, parks, etc.

In view of this, we consider it a priority to establish a system to monitor and eradicate these species. It is in these initial stages of a potential biological invasion when the means of control are more effective, before an explosion of individuals, which would be extremely complex and costly to control.

•6.2 The removal (or eradication) of *Trachemys scripta* individuals

Given the lack of suitable places, it would be a good idea to establish basking sites to monitor this species. We would suggest trunks of a certain size, anchored to the river bed with weights, given the fact that the conventional basking platforms are not suitable here. When deciding on the design, it is also important to consider the intense social use of the area, which includes the normal use of small boats and the visual impact.

As far as trapping methods are concerned, the effectiveness of floating traps for capturing turtles was seen to be extremely poor. Very similar traps were also used on the Arga river in Pamplona, although it is impossible to infer comparable values with the data from the publication available (Valdeón et al., 2010a). If we compare the number of specimens captured with other studies (Table 3), it can be seen that the capture rate obtained with pots in this study is six times lower than that obtained in Valencia. However, with regard to floating traps, this rate is twenty-five times lower than the minimum capture rate in that project (LIFETrachemys, 2012a). This is most probably due to the small size of the exotic turtle population in the study area.

Table 3. Comparative table of the effectiveness (captures/trap days) for pots and floating traps in various studies. The existence of various values indicates that a number of sampling batches were taken. The individuals captured are shown in brackets.

	Pot	Floating trap
(LIFETrachemys, 2012a)	0,06-0,09 (34)	0,03-0,17 (13)
(Valdeón *et al*., 2010a)	--	? (7)
(Glanaroli *et al*., 2001)	--	0,06-0,198 (88)
(Gonzalez, 2013)	--	0
Present work	0,01 (1)	0,0013 (1)

In any case, all the studies reviewed point in the same direction: it is extremely difficult to capture *Trachemys scripta* in situations with low density populations, in which all types of traps show poor effectiveness. For this reason, a number of works recommend the combined use of basking platforms and the use of expert shooters in these situations (Pérez Santigosa *et al*., 2006; Díaz-Paniagua y Pérez, 2010; LIFETrachemys, 2013a).

7. Strategy proposed for the management of exotic turtles in the SCI.

Due to the evident causality of the problem studied, related to avoidable human conducts, an awareness raising campaign needs to be conducted on the effects of releasing these species into the natural environment. This campaign must consider including information boards regarding some of the improvements in habitats made within the framework of the LIFE projects conducted, given the fact that there is a high risk of introducing exotic turtles into these habitats. It is also necessary to influence key sectors, such as pet shops, vets, or schools within the area of influence of the SCI.

Finally, we would propose applying a monitoring, control and eradication protocol for the early detection and elimination of exotic turtles. Given the scant presence of individuals in the SCI, medium - low monitoring appears adequate, maintained over time. For this purpose, we would propose a series of observation points with different risk categories for monthly monitoring in the summer months. Whenever turtles are observed basking in the sun, then photos shall be taken using the telescopes in order to determine which species are using the platform. Once the specimens have been identified and the condition of the exotic turtles has been checked by qualified technicians, the turtles shall then be eliminated using expert shooters.

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9

MANAGING THE EUROPEAN MINK IN NAVARRE

GLORIA GIRALDA / Government of Navarre Biodiversity Conservation Service

ggiraldc@navarra.es

ABSTRACT

The article describes some of the chief management measures applied to the species in Navarre. Following the detection of a high-density population in the SCI Lower reaches of the Arga and Aragon rivers, the main measures taken by the Government of Navarre have consisted of:

- increasing the area included in the Natura 2000 network
- improving habitats in two specific LIFE programmes and using own funds and agreements reached with different entities
- taking the species into consideration in agricultural transformation projects
- reducing unnatural deaths.

Monitoring the species in the area has chiefly consisted of the systematic trapping of the species every year after breeding. Biological samples have also been taken from the individuals trapped and individuals found run over. All this work has led to the identification of the chief dangers to the species as the expansion of the American mink, the loss of habitat and low genetic variability. The latest work performed to control the American mink is also described.

1. Introduction

The European mink (*Mustela lutreola*) is a semi-aquatic mustalid that is small in size, with short legs and a long body (image 1). Along with the Iberian lynx, it is the most threatened carnivore in Europe, placing it in the In Danger of Extinction category on a national scale. The International Union for the Conservation of Nature considers it to be "In Critical Danger" and it is listed in Appendices II and IV of the Habitats Directive as a species requiring the designation of Special Conservation Zones under strict protection. It has also been declared a Priority Species, making it one of the most threatened species in the Palearctic. But how did this situation arise?

Figure 1. European mink. Author: Eduardo Berián.

In the 19th century it could be found throughout Europe, but throughout the 20th century it began to disappear: it disappeared from countries as diverse as Finland, Hungary and the Netherlands, mainly due to a loss of habitat and the direct persecution for its pelt. Today it only inhabits two areas: one is Eastern Europe in fragmented and isolated areas of western Russia, the north of Belorussia and Romania, and the other is Western Europe (1). The western population is distributed across France and Spain, in the latter it can be found in the areas of Navarre, the Basque Country, Castile and Leon, La Rioja and Aragon. 70% of this population is concentrated in Navarre, placing a huge responsibility on the area for its conservation (2).

2. The European mink in Navarre

European mink populations in Navarre are around 400 to 600 specimen (3). In 2004 a thorough census of the species was carried out and systematic trapping began in the Site of Community Importance on the Lower Stretches of the Aragon and Arga Rivers, where the highest population numbers in the world of the European mink were discovered. Since then, the Government of Navarre has taken important measures for the conservation of the species:

- The total area covered by these stretches has increased by 35% within the Red Natura 2000.
- Many restoration and habitat creation activities have been carried out for the European mink financed by Government of Navarre, the European Union (firstly with LIFE GERVE and then with LIFE Mink Territory), the Ministry of Agriculture, Food and the Environment and via agreements with the Fundación Caixa.
- This species has been considered when undertaking projects in the area, especially modernising irrigation which could have an impact on minor river ways and the irrigation channels in which they live: temporalisation has been established as a habitual norm (i.e. certain actions cannot be undertaken on the stretches of river or irrigation channels where this species can be found between 1st April and 31st August so as not to interfere with breeding); new environmental corridors and wetlands have been planned to compensate for the loss of habitat in other areas.
- Improvements have been made to siphons and roads to reduce deaths by drowning or traffic, two of the main causes of human-induced mink deaths.

3. Monitoring

Since 2004 a continuous monitoring of the species has been undertaken in Navarre (4).

- On the one hand systematic trapping is carried out annually along the Arga and Aragon rivers; post-breeding trapping, with which the success rate of breeding can be established, is carried out every year, but occasionally pre-breeding trapping is also performed after winter. Blood and secretion samples are taken from the captured animals to assess their condition. Image 2.
- Other trapping is also carried out in specific areas, both conventional and photo-trapping and tracks.
- Finally, all European mink found deceased are kept for later analysis. The cause of death is established as well as the bio-sanitary condition of the specimen, paying particular attention to possible indications of the Aleutian disease (spread by the American mink) and the canine distemper virus, responsible in 2008 for the drop in population numbers.

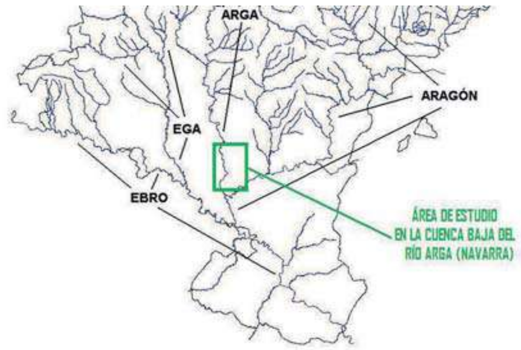

Figure 2. Parts of Navarre where systematic trapping is carried out.

4. Main problems

This continuous monitoring has led to the identification of the main problems faced by the species:

- The expanding American mink population.
- Loss of habitat.
- Low genetic variability.

The third problem, low genetic variability is a theory based on some of the data collected, mainly the low number of offspring per female, the high prevalence of some diseases and the high accidental mortality rate. As a result, a study was commissioned at the University of the Basque Country, pending publication, which confirmed a low genetic variability across the entire western population. The only way to increase this variability would be to cross specimen from the western and eastern populations, given that the latter has a higher variability rate.

The second issue, loss of habitat, has been an on-going concern for the Bio-diversity Conservation Service. Since 2004, numerous restoration activities have been implemented, financed by the European Union and personal funding as well as from other sources such as La Caixa. The studies carried out reveal that males and females have different territorial requirements or occupy different environments, allowing for a more focused approach orientated towards the creation of breeding grounds and quality feeding sites. Data obtained from the radio-monitoring of females raising offspring in restored wetlands confirms that our activities are achieving positive results for the species.

Figure 3. Platform for American mink, stationed in a river in Navarre

Finally, the first issue of the expanding American mink population as a result of accidental escapes and massive liberations from fur farms by animal-protection groups constitutes the greatest short-term threat to the conservation of the European mink. Trapping work is currently underway with conventional cages and trapping platforms (Image 3), in an effort to keep this species out of the basins that are home to the European mink.

In winter 2015, platforms were placed in the Ebro, Ega, Aritzakun, Urritzate and Valcarlos rivers, in the Las Cañas reservoir and in isolated points along the river Elorz. Despite heavy rainfall and subsequent flooding preventing systematic trapping, results revealed a lack of mink tracks on all rivers apart from the Ega, the river in which the first

positive find of tracks led to the laying of traps and the capturing of 8 American mink. The situation therefore is extremely serious, and calls for heavy trapping along the Ega, at least throughout August, September and October.
Finally, it is worth emphasising that in October 2014, the II Workshop of European Mink Conservation Experts was held. Here the current situation of the species was analysed and various recommendations were put forward, in particular stressing the need to undertake monitoring tasks in order to control the presence of American mink, as well as undertaking bio-sanitary monitoring of the European mink population.

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10

CONCLUSIONS

10 CONCLUSIONS

The LIFE+ MINK TERRITORY (LIFE+ MT) final seminar was held within the framework of the "Restauraríos 2015" 2nd Iberian Congress on River Restoration, which took place in Pamplona on the 9th, 10th and 11th June. Detailed below are the conclusions drawn from this seminar.

I. LIFE+ MINK TERRITORY is an innovative, complex and ambitious project that is improving the conservation status of the European mink (*Mustela lutreola*) in the SCI of the Lower Reaches of the Arga and Aragon rivers, which is home to the highest population density of European Mink in western Europe.

This improvement has been achieved through the restoration of habitats used by the species at certain stages of its life cycle. These habitats are either directly restored by specific actions, or indirectly by the integrated improvement of the river ecosystems, whilst also ensuring that all the work is compatible with improving the interests of local communities. Therefore, the restoration of the river territory is established as a sustainable management model.

II. The American mink (*Neovison vison*) is one of the major threats to the species, due to the rapid expansion of this exotic species which eliminates and occupies the habitats of the European mink, as demonstrated in the paper entitled "Intervention addressed to European mink conservation" by Madis Pödra.

III. The LIFE+ MT project has initiated far-reaching measures in areas ranging from the hydro-geo-morphological restoration of river sections, to the restoration of habitats of interest, the recovery of habitat specific to the mink and the eradication of exotic or invasive species. These measures are of scientific and technical interest and can provide lessons to other restoration and conservation projects.

For the correct management and conservation of protected areas, it is essential to follow-up and monitor all the environmental aspects forming part of the conservation project. This is a particular requirements for the Natura 2000 Network where, in compliance with article 17 of the Habitats Directive, the updating of information on the status and evolution of natural values must be carried out regularly. Likewise, throughout the Congress, a number of speakers highlighted the importance of monitoring with regard to restoration projects.

Given the fact that the LIFE+MT is a project directed at the conservation of species and habitats included in the Directive, there is a need to establish processes for monitoring the measures implemented, both with regard to specific conservation actions and the assessment of the results obtained. This is part of the POST-LIFE Action Plan for the LIFE +MT project.

IV. In order to meet these objectives, a follow-up and monitoring program must be established to encompass the actions taken in the project.

The monitoring processes cannot solely be funded by the current budgets of the authorities. In this respect, for monitoring certain actions, it will be necessary to make use of the networks of indicators and censuses that are routinely performed by the Government of Navarra, and also to seek other funding lines, whilst use should be made of other actors (ranging from volunteer schemes to university research projects). These actors can be given a "zero status" of the projects and, at a low cost, a twofold objective is achieved: monitoring and also making people aware of the project and the natural values of the Natura 2000 Network. Likewise the protocol could be integrated into the corresponding SCI Management Plan in order to guarantee continuity over time.

Therefore, a Protocol shall be established to monitor the LIFE +MT project measures, making it possible to assess progress over time in order to determine whether the initial goals have been met or whether it is necessary to intervene, if progress is not as desired.

V. Likewise, the LIFE+ MT project has implemented an important public participation process and has counted on the collaboration of the local entities involved. It is considered necessary to continue with the work performed and to monitor the social impact. The following conclusions can be highlighted from the Workshop specifically dedicated to this matter:

- To integrate public participation as yet another part of the project, as was the case with the EIA in the past.
- To promote public mobilisation to push processes bottom - up.
- To involve the authorities in the processes to participate in the monitoring. In the results and giving continuity to the commitment.
- To guarantee returns to citizens of the work conducted with participation.
- To encourage participation based on demonstration projects - luring.
- To integrate participation throughout the process; including diagnosis, alternatives and works.

VI. Finally, we would like to conclude with an idea that arose in the course of the seminar. In the same way as other endangered species have become emblematic for the ecosystems in which they inhabit, such as the Iberian lynx (*Lynx pardinus*), which has become the image of the Mediterranean woodlands, or the bearded vulture (*Gypaetus barbatus*), which is the image of the Pyrenees, we should seek to ensure that the European mink (*Mustela lutreola*) becomes the image recognised by society for restored rivers.

Pamplona,10th June 2015

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CONCLUSIONS OF THE RESTAURARÍOS 2015, 2ND IBERIAN CONGRESS ON RIVER RESTORATION

- River restoration is now a consolidated scientific-technical discipline and as an environmental improvement and management tool. River restoration work in the Iberian peninsula is in line with that carried out in the rest of Europe.

- Despite a shortage of funding and regulations for restoration, together with the deterioration and economic interests that take precedence over our rivers; many people, groups and authorities are showing the utmost interest in the valuation, conservation and restoration of river ecosystems.

- The prevention of deterioration continues to be the most effective and cheapest way to maintain the good ecological status of rivers. The prevention of actions such as dredging, channelling, removal of riparian vegetation, water abstraction, dam construction, etc., is the most effective investment that society can make in order to preserve the rich and varied river heritage of the Iberian Peninsula for generations to come.

- The first water planning cycle has not generated sufficient change to allow river management to be based on the Water Framework Directive. In the new planning process, 2015-2021, river restoration must be promoted in order to achieve the improvements required.

- Little has been achieved by the WFD in the Peninsula: a diagnosis has been made, but specific measures have not been addressed. Good ecological status has not been achieved due to hydromorphological pressures and pollution.

- Our rivers are subject to simplification processes which reduce their space, water and sediment availability, and their biodiversity. The priority restoration targets should continue to be the achievement of river space, water volume and banks and a reduction in pollution.

- Regulation is the source of many negative processes and the principle of "the regulator should pay" ought to be established. There is a need to progress in the analysis of hydrological alterations, environmental flows and bankfull discharge, at technical and implementation levels alike.

- The delimitation of flood areas and the adaptation of land use are essential in order to prevent unsuitable occupation and to achieve sustainable spatial development. New risk situations, which have been tolerated up to now, must not be permitted. There is a need to promote boundaries, natural retention measures, the functional recovery of floodplains, and to regulate activities and promote insurance.

- The restoration efforts must not be reversed with emergency actions that would damage the self-restored floodplain.

- Riverbed maintenance has continued to invest in "clean-ups", dredging and defences without evaluating their effects. However, it should be based on conservation with integrated measures and it is essential to train workers and technicians in the principles of river restoration.

- There is a need to continue to disseminate the dangers of invasive species and to strive to eradicate these species.

- Restoration projects come increasingly within the framework of the Water, Floods and Habitats directives. LIFE projects are a good tool for taking action. River restoration needs to be part of green infrastructures, yet without being included in river park projects, which are too artificial.

- There is a need to adopt a broader approach to restoration, with regard to space, by considering the river basin as a whole, and to time, by observing the past in order to define future goals and by being aware of the course of development in order to restore processes. Self-maintaining actions need to be sought.

- Hydro-geomorphology has gained scientific-technical importance, due to the key role it plays in the restoration of processes and habitats. The authorities have also become aware that it is a key factor in dividing the river into sections, diagnosis, with simpler protocols, and monitoring. However, few hydromorphological restoration actions have been taken. The problems of incision are serious in many rivers, and the introduction of sediments needs to be considered as a solution.

- Temporary and short-lived rivers, which take on considerable importance in Mediterranean environments, are also capable of re-adapting to pressures and changes and also have restoration capacity.

- The problem of the icthyofauna in the Iberian Peninsula is very important. Migration is necessary in order to conserve all the Iberian fish species. Priority should be given to the removal of obstacles and to evaluating the effectiveness of the fish passes. These measures which achieve longitudinal continuity are the most common river restoration actions. Work needs to be performed in order to maintain and monitor these measures.

- There is a need to jointly work with rivers and society, from planning to monitoring. Public participation must play a fundamental role in each project and must be increased in the diagnosis, alternatives and the implementation of the river restoration work. The involvement of stakeholders, owners and volunteers is key to achieving the objectives. Custody agreements are an essential tool, although they are little used.

- A knowledge of the economic and social value of the environmental services of a restored river system may prove highly useful when giving priority to projects. It is recommended to make more widespread use of cost-benefit analyses, given the fact that we have no precise knowledge of the economic or social return on the investments made. The environmental services framework could help us to quantify some of these benefits.

- In all these respects, a greater knowledge of rivers is required and the functions and benefits provided. And social mobilisation must be promoted, including problem identification, community building, involvement and commitment. It is essential to ensure that demonstration projects are available.

- The LIFE+ Mink Territory project is an innovative example of the possibilities offered by river restoration for the restoration of biodiversity and emblematic species such as the European mink. The measures to restore the mink habitats with direct actions (creation of wetlands and shelters) and indirect actions (restoration of river dynamics and territory) have helped recover the environmental quality of important areas of the Arga and Aragon rivers. The public participation processes and involvement of all competent authorities, working together, have not only made it possible to improve the functionality of the river, but have also changed the way of thinking of those living alongside the rivers, who can now appreciate these rivers and their fauna and flora as a real ecological treasure.