# Removal of man-made fluvial barriers considering invasive alien species

Guidelines for decision-making

CIREF centro ibérico de restauración fluvial

Wetlands INTERNATIONAL

# River connectivity

***This document provides guidance for water managers who make decisions about measures to restore river connectivity in order to enhance the conservation status of migratory fish species in areas affected by the expansion of invasive alien species.***
***Ecological river restoration can significantly contribute to delivering good quality and to the conservation of freshwater species including fish populations. One of the key measures water managers must take to achieve the EU water Framework Directive objectives is the removal of man-made barriers to improve connectivity of rivers along their length.***

## *Connectivity and Invasive Species in the EU policy context*

The Water Framework Directive includes river continuity as one of the hydromorphological quality indicators that must be taken into account when evaluating the ecological status of surface water bodies. Restored connectivity enables upstream and downstream fish migration but could concurrently facilitate the dispersion of alien fish species in a catchment. These species can pose a threat to vulnerable endemic fish populations hindering the achievement of the objectives for freshwater species under the EU Habitats Directive. Therefore, both the Water Framework Directive and the Habitats Directive prioritize the reestablishment of the longitudinal continuity of rivers, although the latter also tries to prevent the actions that entail the introduction and expansion of invasive alien species.

## *To remove or not to remove*

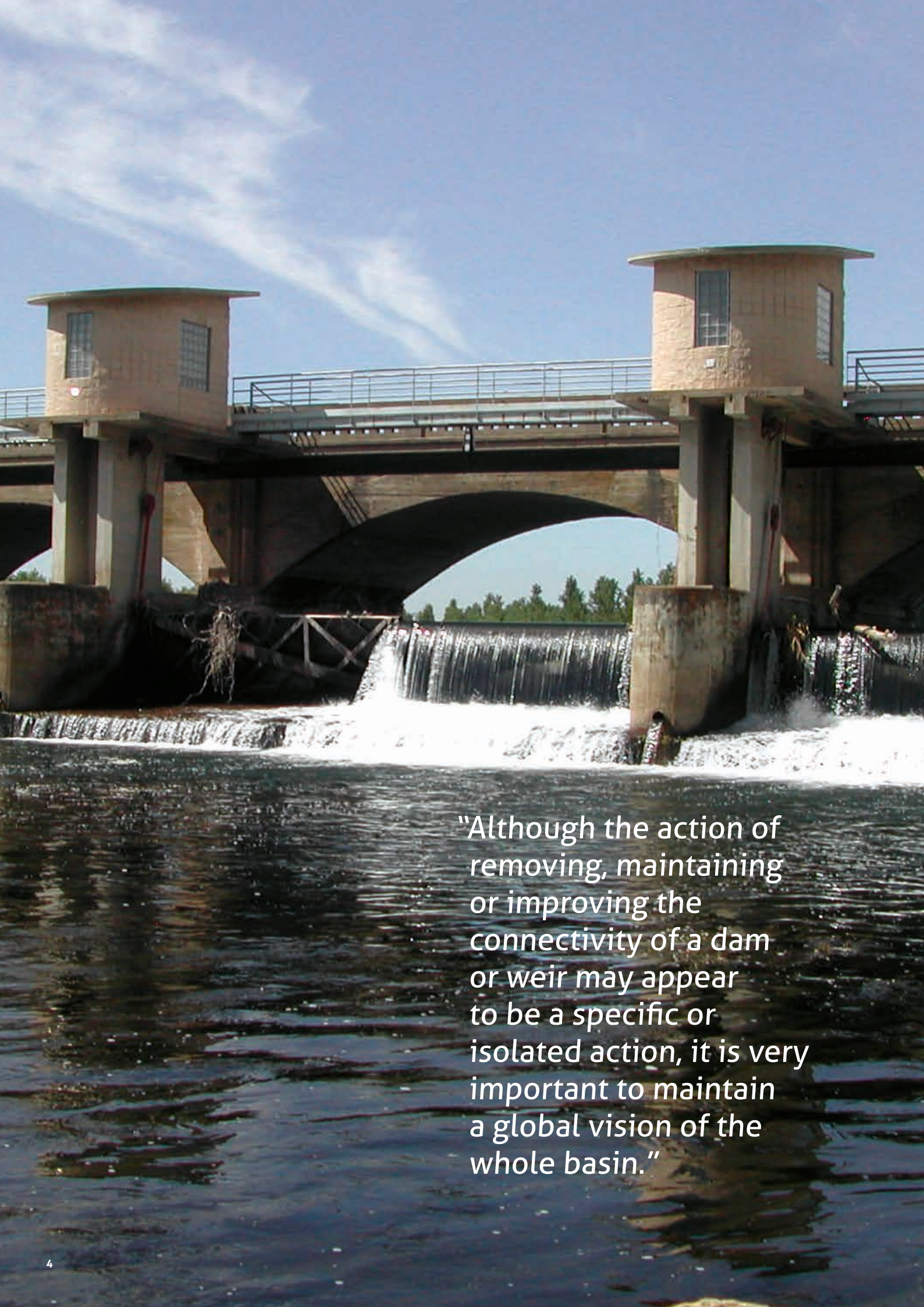
Although the action of removing, maintaining or improving the connectivity of a dam or weir may appear to be a specific or isolated action, it is very important to maintain a global vision of

the whole basin. From the perspective of the fish community, and with knowledge of all the communities of living beings and the hydraulic conditions, different factors influence the decision whether or not to restore a river section affected by a barrier.

The choice of the most appropriate alternative between improving the connectivity of an obstacle or removing it should not only include the most appropriate engineering solution, but also an evaluation of its ecological implications. When invasive alien species are present, the most appropriate alternative may be to refrain from acting on the obstacle, or to act partially due to the negative consequences on the native ichthyofauna. Therefore, alternatives should be studied prior to designing the final measure for improving connectivity. In addition, developments must be monitored closely when the measure may compromise the conservation of threatened endemic species.

## Guidance:

- This guidance helps to assess the positive and negative impacts of restoring river connectivity and to prioritize actions.
- Particular attention is given to aspects of fluvial connectivity considering the risk of expansion of invasive alien species.
- The evaluation criteria and the manual in this guidance are based on a study by David Miguélez Carbajo (2017) who took as a reference the situation of freshwater fish fauna of the Iberian Peninsula.
- The study was commissioned by the Iberian Center for River Restoration and Wetlands International - European Association. The full report is available online.



*"Although the action of removing, maintaining or improving the connectivity of a dam or weir may appear to be a specific or isolated action, it is very important to maintain a global vision of the whole basin."*

# 1. Understanding the four determining issues regarding invasive and native species

**When faced with the decision to restore river connectivity or to maintain a barrier causing river fragmentation, water managers need to consider and understand four determining issues regarding invasive and native species in their river (Fausch et al. (2009)):**

### 1. Location in the river

First, the degree of threat to the native species targeted for conservation is paramount. If the **state of conservation of native species** is very vulnerable to a high risk of invasion, there are two options depending on the stretch of river they occupy: if native species are upstream, the a priori option would be to choose isolation or to maintain the obstacle. On the other hand, if the threatened native species are downstream, the best option is to remove the dam so that native species can recolonize upstream sections (for example, in the cases of eel and salmon).

### 2. Adaptation to lentic or lotic water

The second factor is the **adaptation of invasive species to lentic or lotic water**. In the case of the presence of invasive alien species adapted to slow waters, which carry out their life cycle in the reservoir's own body of water or in the downstream regulated flows, the elimination of the reservoir and restoration of natural flow or water temperature conditions, would allow natural control of many invasive species. On the other hand, if invaders are adapted to lotic waters, the decision on the intervention on the dam may be more difficult to take.

### 3. Diet

Another important issue is the **type of diet of the invasive species**, mainly if they are piscivorous or not. If invasive species are piscivorous, it is most likely to affect some endemism. For example, Iberian fish, from the evolutionary point of view, have developed with an almost total absence of predatory fish, for this reason they are very vulnerable to the presence of invasive piscivorous species.

### 4. Migration needs

Finally, the **migratory needs of native species and invasive species** are fundamental to make a decision. For example, the migratory requirements of the Iberian ichthyofauna are diverse, although a good part of them need to move to complete their biological cycles. It is very important to assess the migratory needs of the whole fish community of a basin as a whole before considering the possibility of removing an obstacle.

In order to make a sound decision, these four elements need to be determined. The following list of questions will help assess your situation.

River Dobra in Spain

# 2. Assessing the situation through a list of questions on species and catchments

***This series of questions contains criteria for assessing the removal of a dam. The questions will help decision-making on restoration of fluvial connectivity considering the risk of expansion of invasive alien species. The questions in 'bold' refer to the important issues described in chapter 1.***

1. **What is the degree of threat of the native species that are intended to be conserved? Are the species endemic?**
2. What are the main threat factors? Think of: fluvial fragmentation, invasive species, habitat loss, climate change, etc.
3. **What are the migratory requirements of the native species? Are they diadromous species, or potadromous with strong or low migratory, sedentary or euryhaline needs?**
4. What is the importance of metapopulations of the native species? Does the viability of the populations of native species depend on the colonization of new river stretches and the dispersion of specimens between these metapopulations? Will isolation cause its disappearance in the medium or long term?
5. What is the location of the invasive species? Are they upstream of the dam or in the reservoir itself, or downstream?

-> The list continues on p. 8.

*"It is fundamental to assess the migratory needs of the whole fish community of a basin before considering the possibility of removing an obstacle."*

Rainbow trout is an invasive alien species in Spain (photo: C. Rodriguez, Bicho Prod.)

6. Which species live in the reservoir, native or invasive? Do only invaders live in the reservoir? Are they adapted to lentic, deep waters, with fluctuations in water level and margins without vegetation? Or are these habitats also important for some native species?
7. Does the reservoir have a potential ecological value as a refuge for native species? Would the lentic waters of the reservoir help to preserve endemic populations of threatened fish in the face of the situation of scarcity of precipitations due to climate change?
8. **What are the migratory requirements of invasive species?**
9. **What kind of trophic interactions exist between invasive and native species? Are the invaders piscivorous predators?** Do they compete for the same food, space and shelter?
10. What kind of reproductive interactions exist between invasive and native species? Is there a sexual competence on the part of the invasive species that causes hybrids or genetic contamination with native fish populations?
11. Are invasive species carriers of diseases or parasites that can be transmitted and affect native species?
12. **How could the restoration of natural flow affect native and invasive species? Would the restoration of the natural flow, the temperature of the water and the concentration of dissolved oxygen favour native and/or invasive species?**
13. Do invasive species present bioaccumulable toxic substances, or would the barrier removal favour the mobility of some types of pollutants in the upstream or downstream direction?
14. After a potential dam removal, would river continuity be favoured throughout the basin? Would the elimination of the dam greatly favour connectivity in the basin or would its contribution be limited? Dams generate a synergistic effect where the effect of two or more dams is higher than the sum of their individual effects. Is there a cumulative impact of river fragmentation with other obstacles?
15. Faced with the impossibility of removing the obstacle, what alternatives to recover connectivity and/or restore the natural flow regime exist? Is it possible to carry out improvement works on the obstacle such as ramps, ladders, height reduction, elimination of the reservoir, etc. without favouring the expansion of invasive species?
16. What other complementary measures are going to be adopted? Think of: the use of piscicides against invaders, habitat restoration, direct elimination or control of invaders, translocations between isolated native metapopulations, etc.
17. Are other threatened species affected, other than fish? In the case of the Iberian Peninsula, examples are the presence of species of *Margaritifera* sp. or of the autochthonous crayfish.
18. Are other invasive species, other than fish, present? For example, species of terrapins, crayfish and other invertebrates such as snails or bivalves.
19. Could the reservoir be a focus of attraction for new invasive species?

# 3. Decision table to weigh the decision on keeping or removing a dam

***The decision table below helps to assess the issues regarding invasive and native species in your situation and compares the criteria for keeping or removing a barrier or dam presented in the previous sections.***

**Table 1. General criteria in favour of removing or keeping a barrier or dam in a river. The most decisive criteria are in 'bold'.**

| Question? | Check | Remove the dam | Keep the dam | Check |
|---|---|---|---|---|
| **What is the degree of threat of the native species?** | | **Natives little threatened upstream or highly threatened downstream** | **Natives highly threatened upstream or little threatened downstream** | |
| **What are the migratory requirements of native species** | | **High migratory requirements** | **Low or no migration requirements** | |
| What is the importance of metapopulations of native species? | | High isolation. High need of contact or genetic flow. | Low isolation. Low need of contact or genetic flow. | |
| Where are the invasive fish species? | | Upstream | Downstream | |
| What are the migratory requirements of invasive species? | | Low migratory requirements | High migratory requirements | |
| What kind of trophic interactions exist between invasive and native species? | | Low competition for food resources, space and/or refuge between native and invasive species | High competition for food resources, space and/or refuge between native and invasive species | |
| **What kind of predation interactions exist between invasive and native species?** | | **Invaders low or no predation on eggs, juveniles and/or adults of native fish species** | **Invaders high predation on eggs, juveniles and/or adults of native fish species** | |
| What kind of reproductive interactions exist between invasive and native species? | | Invaders with low hybridization capacity or genetic contamination | Invaders with high capacity for hybridization or genetic contamination | |
| | | Invaders with low sexual competence | Invaders with high sexual competence | |
| Are invasive species carriers of diseases or parasites? | | No diseases or parasites associated with invasive species | Presence of diseases and/or parasites associated with invasive species | |
| **How does the recovery of natural conditions affect invasive species?** | | **Invaders not adapted to natural flows** | **Invaders adapted to natural flows** | |
| | | invaders not adapted to natural conditions of water temperature and oxygen | Invaders adapted to natural conditions of water temperature and oxygen | |
| Are there toxic substances in the reservoir? or Do invasive species present bioaccumulable toxic substances? | | No toxic substances in the reservoir neither Invaders transport bioaccumulated toxic substances | Toxic substances in the reservoir or invaders transport bioaccumulated toxic substances | |
| Does the reservoir have a potential ecological value as a refuge for native species under drought conditions? | | The lentic waters of the reservoir cannot preserve populations of threatened endemic fish against climate change | Reservoir can preserve populations of threatened endemic fish against climate change | |
| Does the removal of the dam significantly increase connectivity in the basin? | | The obstacle causes a high synergic effect and its elimination would be very beneficial for the entire basin | There are no synergistic effects or obvious benefits | |
| Faced with the impossibility of removing the obstacle, what options to recover connectivity and/or restoration of natural flow exist? | | No possibility of improvements in the passage of the obstacle | It is possible to improve connectivity and to safeguard a necessary isolation | |
| Faced with the impossibility of removing the obstacle, what options to recover connectivity and/or restoration of natural flow exist? | | No possibility of improvements in the passage of the obstacle | It is possible to improve connectivity and to safeguard a necessary isolation | |
| Are other, non-fish, invasive species present? | | No risk of expansion of other, non-fish, invasive species | Risk of expansion of other invasive species | |
| Are other, non-fish, threatened species affected? | | It favours other highly threatened, non-fish, native aquatic species | It harms other highly threatened native aquatic species | |
| What other complementary measures are going to be adopted? | | Habitat restoration, control of invaders, translocations between isolated native metapopulations, etc. | None | |
| Is the reservoir a focus of attraction for new introductions? | | Yes | No | |
| **Total checks** | | **Checks in favour to remove** | **Checks in favour to keep** | |

The next chapter will go one step further in the evaluation of possible actions. It provides a method to assess an additional possibility: to adjust the barrier to improve its permeabilization.

River Iregua in Spain

# 4. Determining actions based on the invasion-isolation trade-off

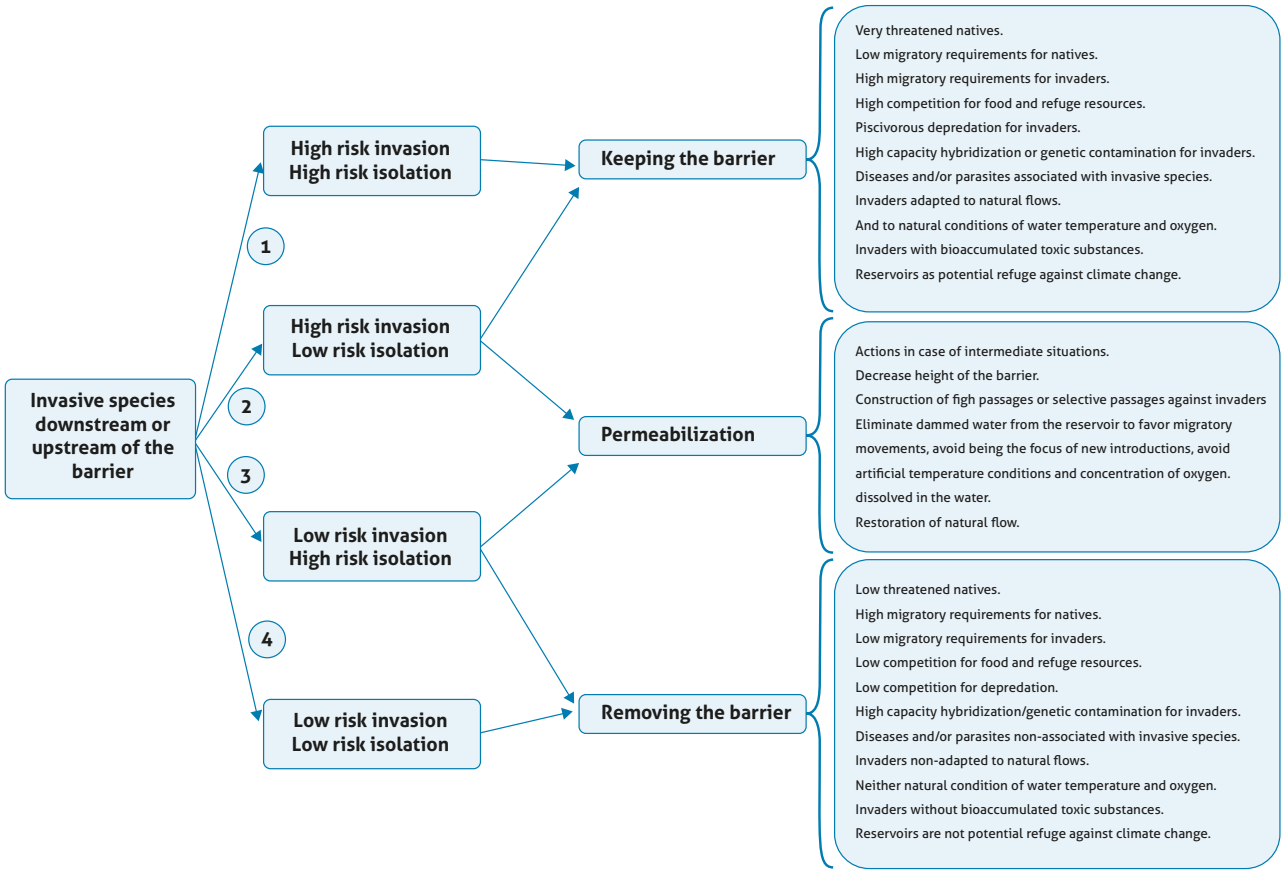
**When water managers try to address the problems of river fragmentation and invasive species, they are often faced with the trade-off, that managing ecosystems to address one problem precludes solving the other (Fausch et al. (2009)): on the one hand, habitat fragmentation isolates populations and increases their risk of extinction, and the solution may be to improve hydrological connectivity between river fragments; on the other hand, connectivity increases the risk of expansion of invasive species, so it may be decided to isolate those habitats.**

In a fragmented river, there may be a certain degree of invasion threat from alien species and a certain degree of isolation of native species. Fausch et al. (2009) describes four (theoretical) situations categorized by degree of invasion and isolation:

1. High risk of isolation and high risk of invasion
2. Low risk of isolation and high risk of invasion
3. High risk of isolation and low risk of invasion
4. Low risk of low isolation and low risk of invasion.

While in practice it may be challenging to determine the exact degree of threat and isolation, this model allows to make a decision on the most suitable action strategy: keeping the barrier, removing the barrier or adjusting the barrier. The decision flowchart below is based on the four situations pointed out by Fausch et al. (2009) (number 1-4) and can assist in the decision-making.

Improving the permeabilization of an obstacle may require the construction of selective fish passages. Note that information on the requirements for such structures to suit behavioural characteristics of certain fish species attempting to pass the barrier, may be lacking. This is the case for most Iberian species.




1. Fausch, K.D., Rieman, B.E., Dunham, J.B., Young, M.K. & Peterson, D.P. 2009. Invasion versus isolation: trade-offs in managing native salmonids with barriers to upstream movement. Conservation Biology, 23:

# Full report

This document attempts to serve as a guidance to make the recovery of river connectivity in Europe compatible with the conservation of biodiversity. The guidance is based on the study and collection of best practices set out in the report by David Miguélez Carbajo (2017) 'Criteria for decision-making towards the improvement of river connectivity and dam removal considering the impacts of invasive fish species in the Iberian Peninsula.'

We highly recommend to read the full report for a more comprehensive analysis of fluvial connectivity and the expansion of invasive alien species, with special reference to the situation in the Iberian Peninsula; a compilation of main papers and projects about connectivity versus invasive alien species; and the evaluation criteria and a manual of good practices to address recovery of the connectivity in Iberian rivers considering the presence of invasive alien species.

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