

Ecological and social restrictions to the restoration of river continuity: invasive species and other limitations



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Ecological and social restrictions to the restoration of river continuity: invasive species and other limitations

Overview

1. The two sides of connectivity recovery
2. Conservation status of freshwater fishes in Europe
3. Invasive Alien Species
4. EU legislation
5. State of the art
6. Practical example
7. Gaps of knowledge and future challenges

ECOLOGICAL EFFECTS OF TRANSVERSAL BARRIERS



Reduction of habitat heterogeneity
Changes in thermal regimen
Homogenization of flows
Increase substrate stability
Increase nutrients and sedimentation
Habitat Fragmentation



EFFECTS OF THE LOSS OF CONNECTIVITY ON FISH POPULATIONS

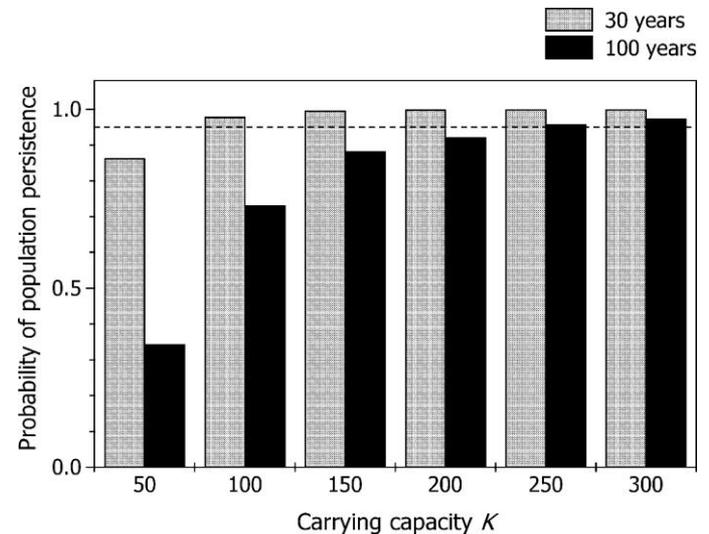
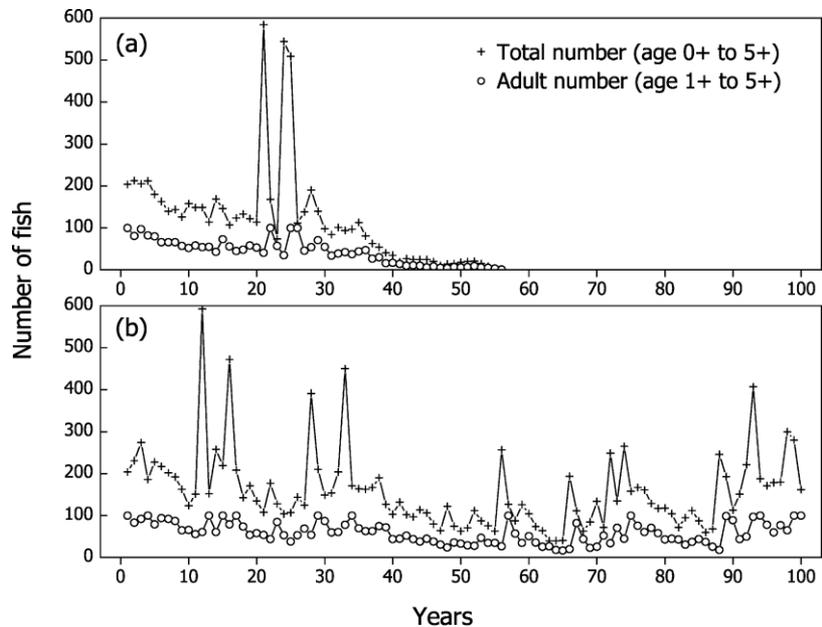
Isolation:

- Loss of genetic variation
- Increase risk of extinction

Loss of natural dispersion

Prevent individual from moving to feeding areas or shelters

Prevent or delay migrations



BENEFITS OF ELIMINATING UNNECESSARY DAMS

- Recovery of the river's natural flow regime
- Recovery of floodplain and adjacent wetlands
- Improvement of water quality
- Redistribution of sediments, improvement of fluvial dynamics and renewal of habitats
- Recovery of longitudinal connectivity



MAINTAINING OR RESTORING CONNECTIVITY CAN



- Enhance migratory fish populations
- Maintain genetic diversity in small, isolated populations
- Allow organisms to access complementary habitats to meet life-history needs
- Facilitate recolonization after local extirpations.

DAMAGES OF DAM OR WEIR REMOVAL

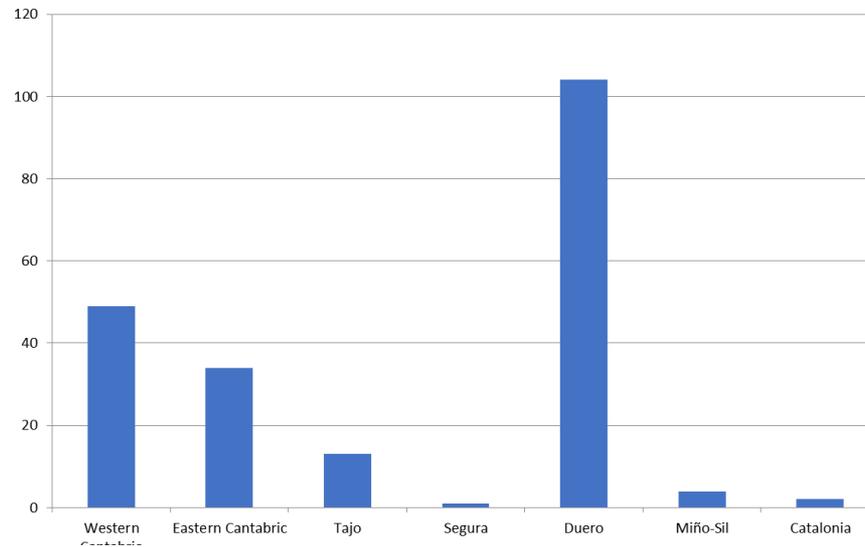
- Can mobilize toxics or cause sediment problems
- Facilitate the dispersion of parasites and diseases
- Facilitate the dispersion of invasive species
- Enable the hybridization of isolated populations with repopulation stocks



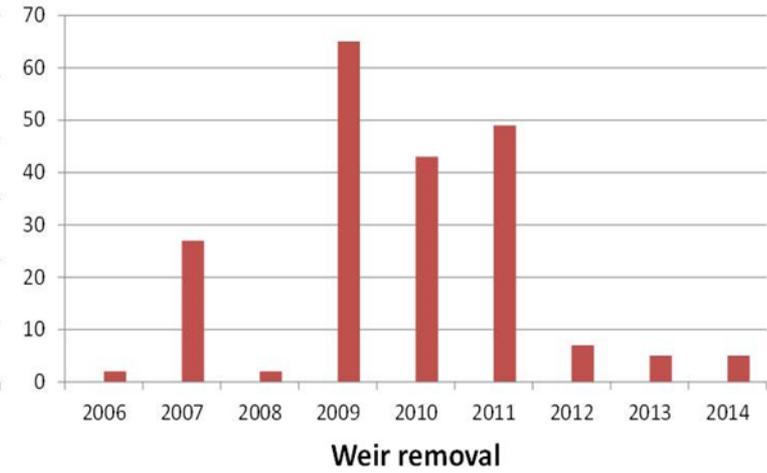
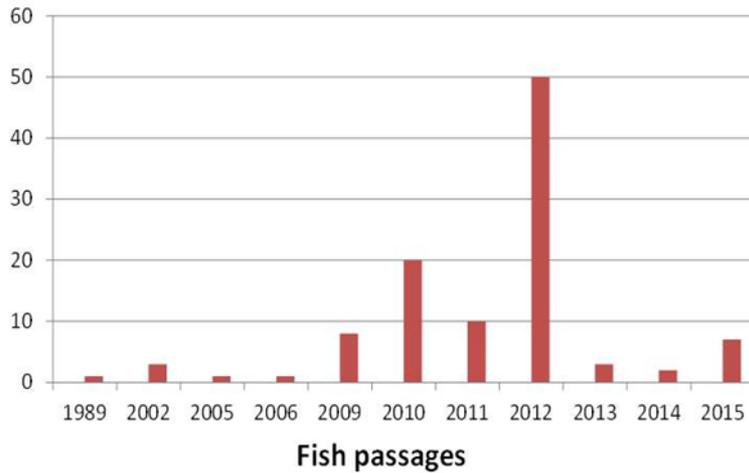
INTENTIONAL FRAGMENTATION MAY BE BENEFICIAL WHEN IT PREVENTS TO

- Spread of alien species or exotic diseases,
- Eliminate hybridization between hatchery and wild stocks
- Stop individuals from entering ecological traps

Weirs removed by demarcation during the Spanish National Strategy of River Restoration



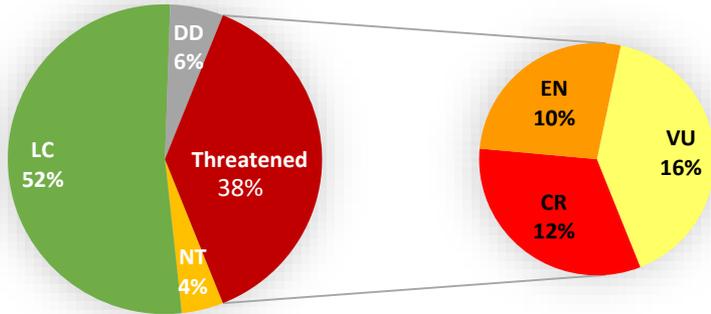
Permeabilization actions by year



CONSERVATION STATUS OF EUROPEAN FRESHWATER FISHES



Europe



EU

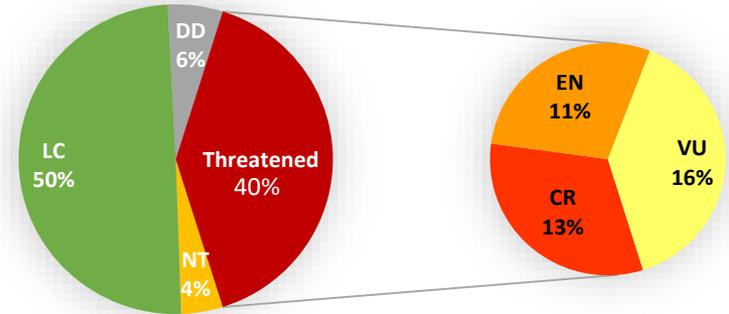
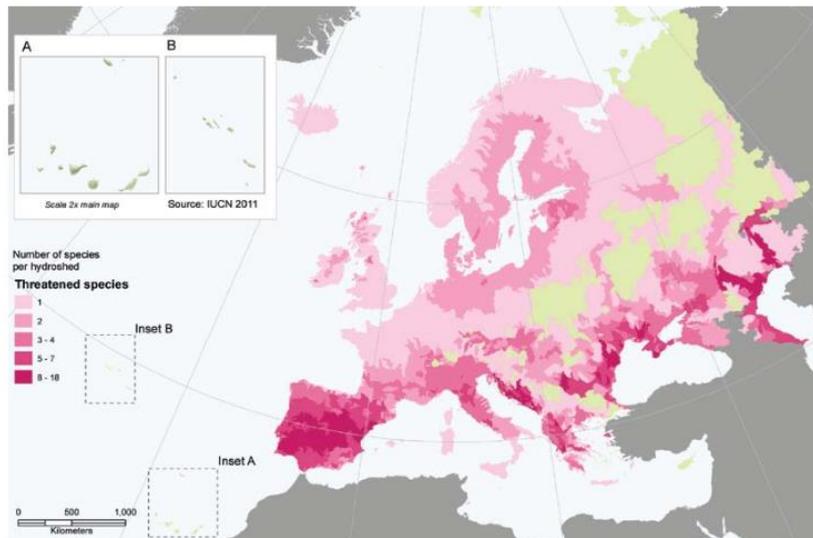
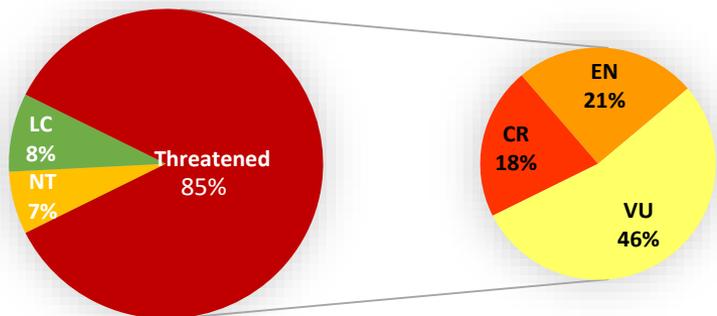


Figure 6. Distribution of threatened fishes in Europe



Spain



Freyhof, J. & Brooks, E. 2011 European Red List of Freshwater fish

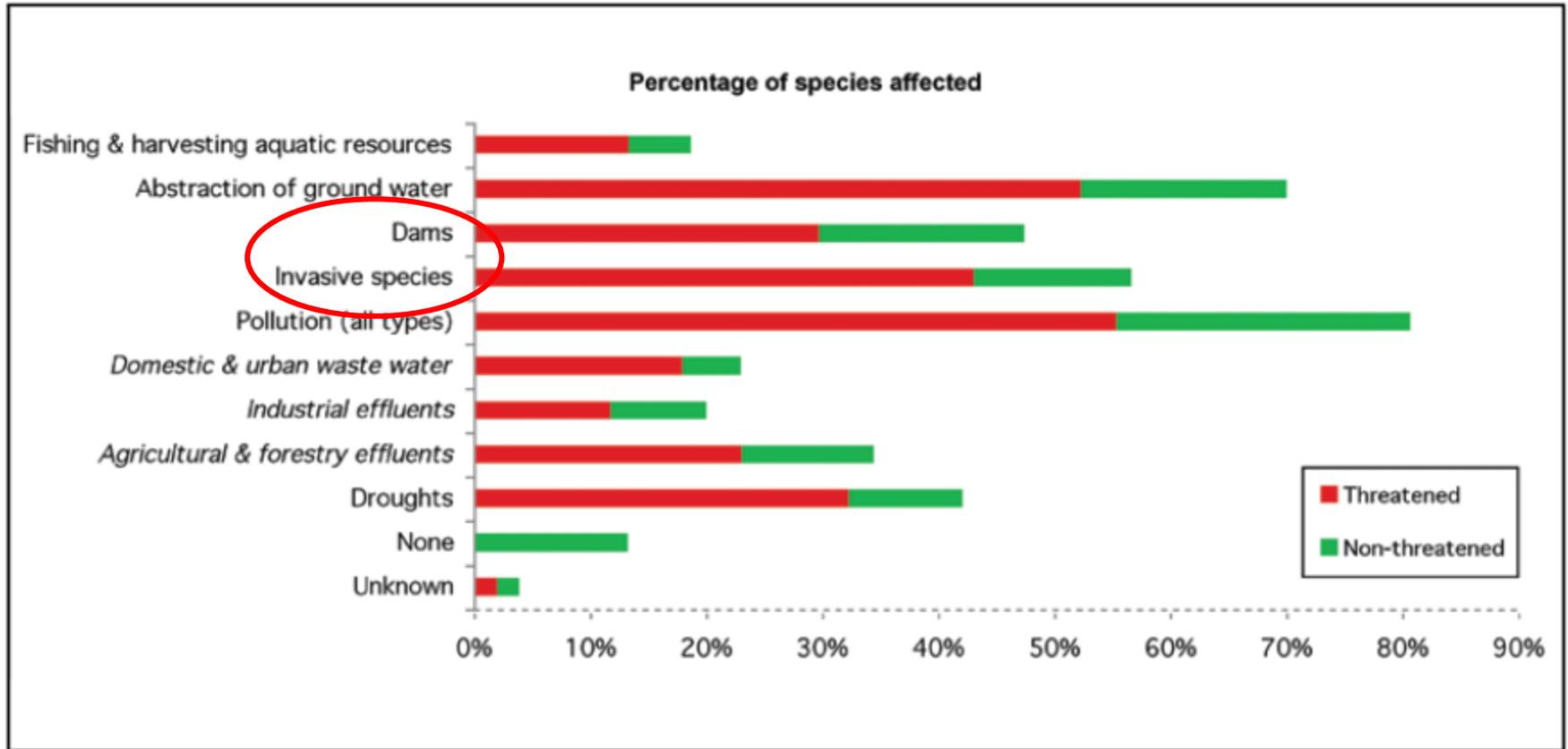
Table 3. IUCN Red List status (at the European level) of freshwater fishes by taxonomic family

Family	Total*	EX	EW	CR	EN	VU	NT	LC	DD	% Threatened*
ACIPENSERIDAE	8			7		1				100%
ANGUILLIDAE	1			1						100%
ATHERINIDAE	1							1		0%
BALITORIDAE	8			1		1		6		25%
BLENNIIDAE	2			1				1		50%
CLUPEIDAE	18			3	1	3		10	1	39%
COBITIDAE	35			5	5	6	3	16		46%
COTTIDAE	16			1		2		10	3	19%
CYPRINIDAE	236	3		23	35	38	14	119	4	41%
CYPRINODONTIDAE	6			3	2			1		83%
ESOCIDAE	1							1		0%
GASTEROSTEIDAE	8	1		1				6		13%
GOBIIDAE	43			4	2	3	1	30	3	21%
LOTIDAE	1							1		0%
MORONIDAE	1							1		0%
MUGILIDAE	5							5		0%
OSMERIDAE	2							2		0%
PERCIDAE	15			3			1	10	1	20%
PETROMYZONTIDAE	13	1		1			1	10		8%
PLEURONECTIDAE	3							3		0%
SALMONIDAE	98	8	1	9	7	24	2	32	15	41%
SILURIDAE	2							1	1	0%
SYNGNATHIDAE	1							1		0%
UMBRIDAE	1					1				100%
Total	525	13	1	63	52	79	22	267	28	37%

IUCN Red List Status: EX – Extinct, EW – Extinct in the Wild, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern, DD – Data Deficient.

* Does not include species classed as Not Applicable (NA)

Figure 9. Major threats to freshwater fishes in Europe



Freyhof, J. & Brooks, E. 2011 European Red List of Freshwater fish

Regulation 1143/2014 on the prevention and management of the introduction and spread of invasive alien species

Article 3

Definitions

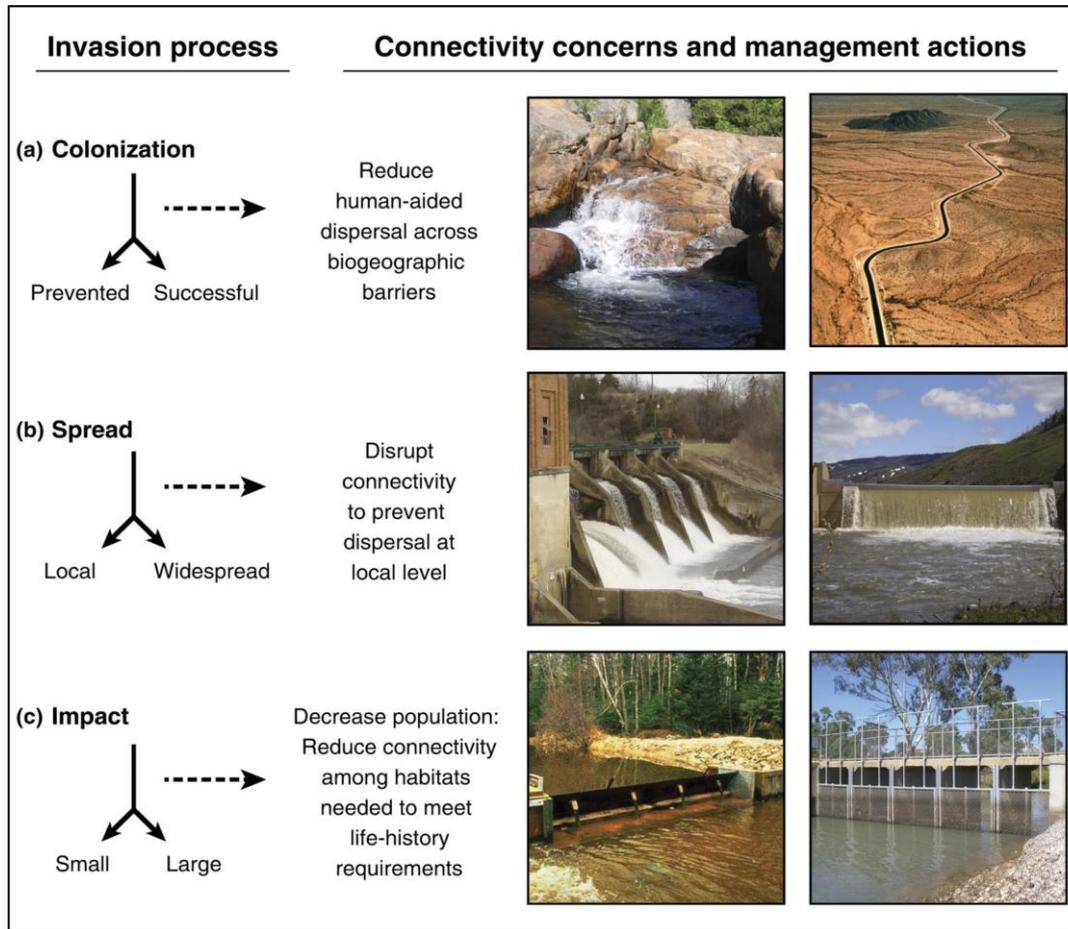
For the purposes of this Regulation, the following definitions apply:

- (1) 'alien species' means any live specimen of a species, subspecies or lower taxon of animals, plants, fungi or micro-organisms introduced outside its natural range; it includes any part, gametes, seeds, eggs or propagules of such species, as well as any hybrids, varieties or breeds that might survive and subsequently reproduce;
- (2) 'invasive alien species' means an alien species whose introduction or spread has been found to threaten or adversely impact upon biodiversity and related ecosystem services;



Azolla spp
Water fern

Invasion process stages



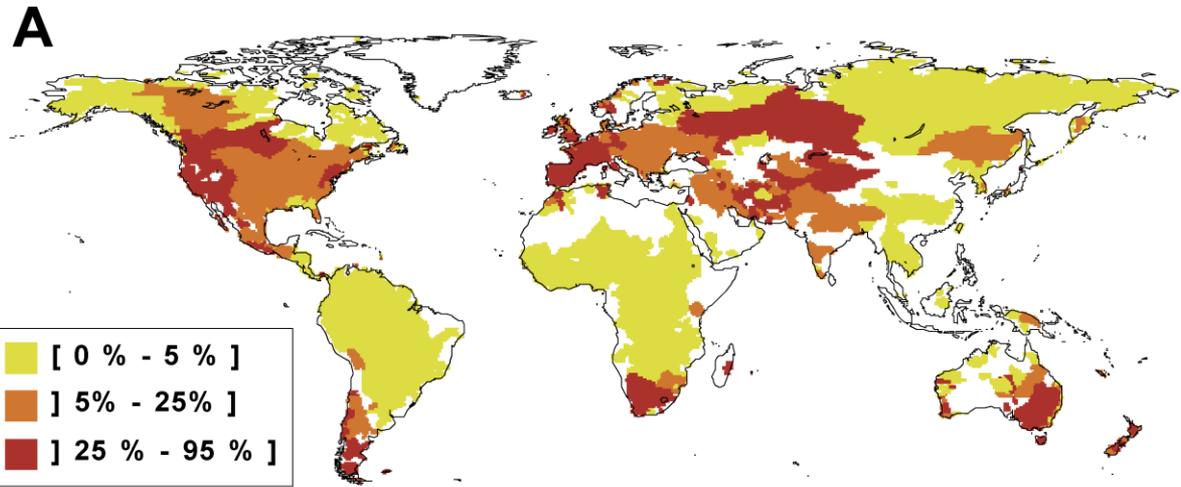
Rahel, F.J.

From: Intentional Fragmentation as a Management Strategy in Aquatic Systems

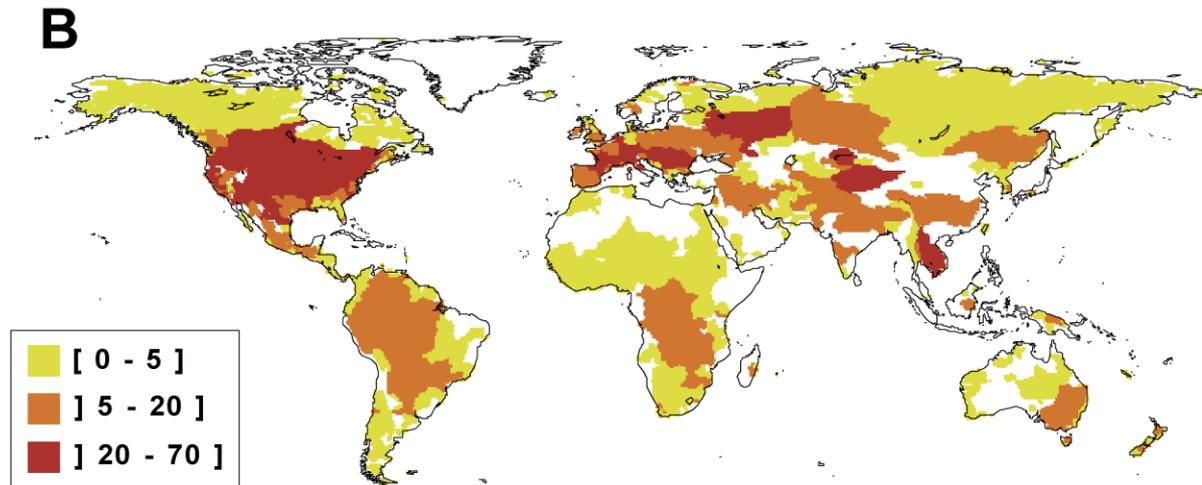
BioScience. 2013;63(5):362-372. doi:10.1525/bio.2013.63.5.9

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Percentage of non-native species per basin (i.e., the ratio of non-native species richness/total species richness)

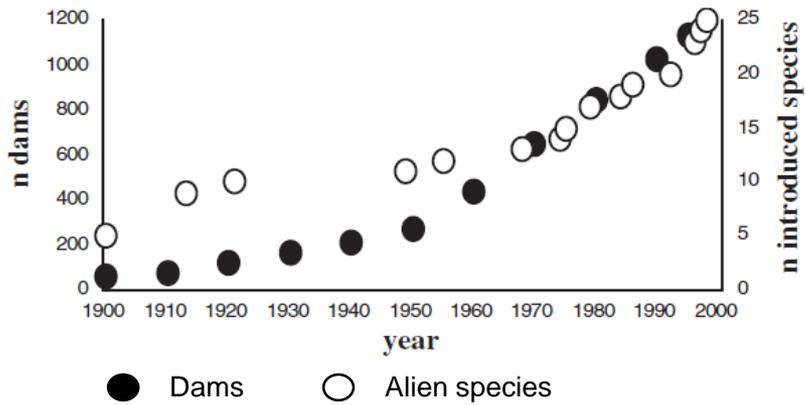
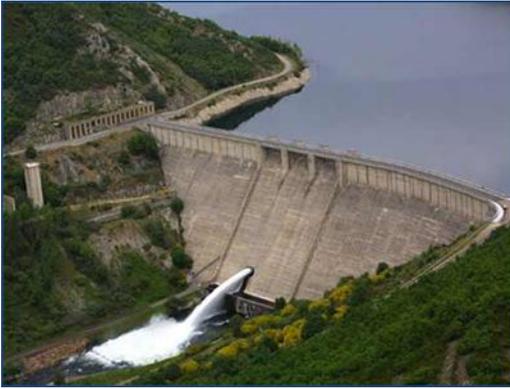


Non-native species richness per basin.

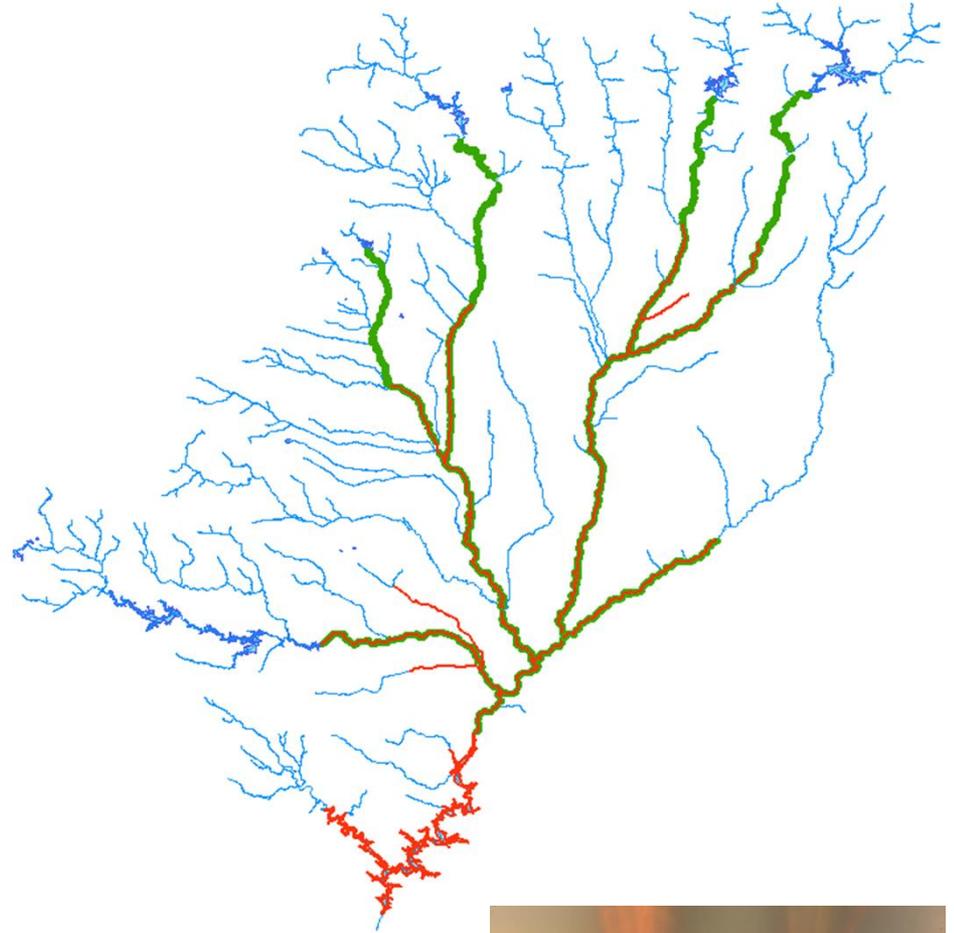


Leprieur F, Beauchard O, Blanchet S, Oberdorff T, Brosse S (2008) Fish Invasions in the World's River Systems: When Natural Processes Are Blurred by Human Activities. PLOS Biology 6(2): e28. <https://doi.org/10.1371/journal.pbio.0060028>
<http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.0060028>

Invasion hotspots are defined as areas where more than a quarter of the species are non-native



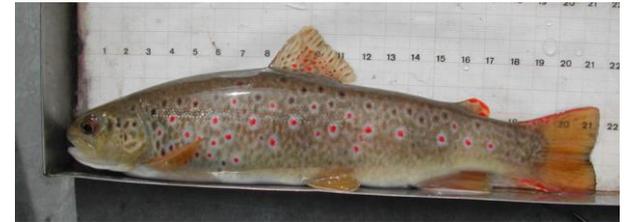
Clavero et al. (2004).



INDIGENOUS INVADERS



Parachondrostoma arrigonis



Pseudochodrostoma polylepis

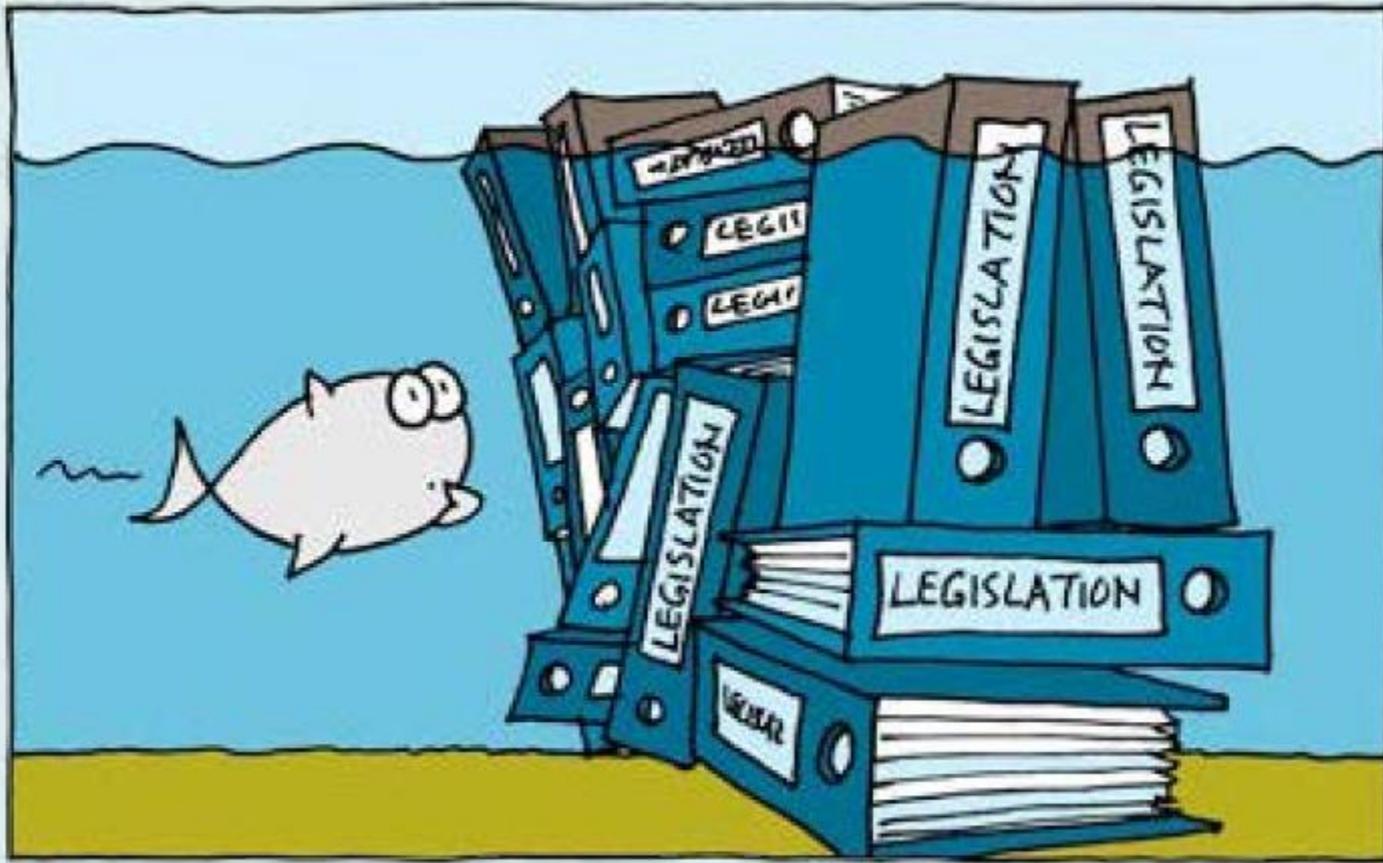
Water Hyacinth



Eichhornia crassipes



LEGISLATION



(From sea to source. International guidance for the restoration of fish migration highways. 2012)

Directive 92/73/EEC on the conservation of natural habitats and of wild fauna and flora

Article 10

Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora.

Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.

Article 22

In implementing the provisions of this Directive, Member States shall:

- (a) study the desirability of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such re-introduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned;
- (b) ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider it necessary, prohibit such introduction. The results of the assessment undertaken shall be forwarded to the committee for information;
- (c) promote education and general information on the need to protect species of wild fauna and flora and to conserve their habitats and natural habitats.

Water Framework Directive (2000/60 / EC)

Hydromorphological quality elements

Element	High status	Good status	Moderate status
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally, undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
River continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological conditions	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Biological quality elements

Element	High status	Good status	Moderate status
Fish fauna	<p>Species composition and abundance correspond totally or nearly totally to undisturbed conditions.</p> <p>All the type-specific sensitive species are present.</p> <p>The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of a particular species.</p>	<p>There are slight changes in species composition and abundance from the type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements.</p> <p>The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.</p>	<p>The composition and abundance of fish species differ moderately from the type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements.</p> <p>The age structure of the fish communities shows major signs of disturbance, attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.</p>

Regulation 1143/2014 on the prevention and management of the introduction and spread of invasive alien species

- (26) Invasive alien species generally cause damage to ecosystems and reduce the resilience of those ecosystems. Therefore proportionate restoration measures should be undertaken to strengthen the ecosystems' resilience towards invasions, to repair the damage caused and to enhance the conservation status of species and their habitats in accordance with Directives 92/43/EEC and 2009/147/EC, the ecological status of inland surface waters, transitional waters, coastal waters and groundwater in accordance with Directive 2000/60/EC, and the environmental status of marine waters in accordance with Directive 2008/56/EC. The costs of such restoration measures should be recovered in accordance with the polluter pays principle.

Article 20

Restoration of the damaged ecosystems

1. Member States shall carry out appropriate restoration measures to assist the recovery of an ecosystem that has been degraded, damaged, or destroyed by invasive alien species of Union concern unless a cost-benefit analysis demonstrates, on the basis of the available data and with reasonable certainty, that the costs of those measures will be high and disproportionate to the benefits of restoration.
2. The restoration measures referred to in paragraph 1 shall include at least the following:
 - (a) measures to increase the ability of an ecosystem exposed to disturbance caused by the presence of invasive alien species of Union concern to resist, absorb, accommodate to and recover from the effects of disturbance;
 - (b) measures to support the prevention of reinvasion following an eradication campaign.

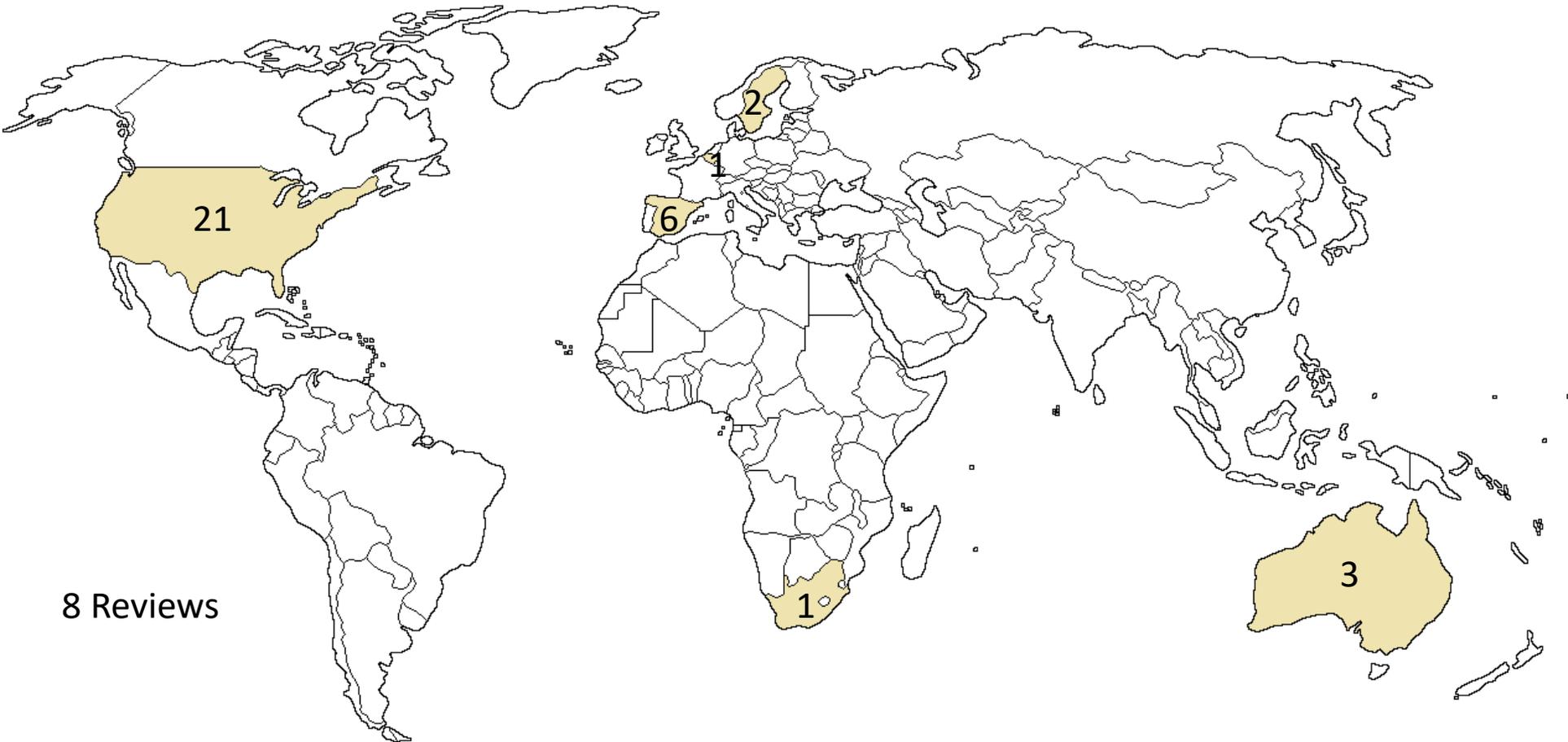
Spanish catalog of invasive alien species (RD 630/2013)

Article 10.3

Competent authorities will require promoters of works in river courses to inform about the presence of species in the catalog in those waters that will be the source of water transfers or temporary or permanent deviations. In case of presence of these species, the project will be reviewed to study alternatives and preventive measures that do not imply dispersal of these species, or the **suspension of the project will be assessed.**

Similarly, if work is carried out in river courses affected by species in the catalog, preventive protocols for the dispersion of species to non-affected courses should be applied.

STATE OF THE ART



Most of them only refer the problem but don't analyze consequences or measures to be taken
Most of them are carried out with salmonid

EFFECT OF KEEPING THE DAM

1. What fish and wildlife species benefit from the dam? Are these species of concern?
2. What fish and wildlife species does the dam negatively affect? Are these species of concern?
3. Can riverine species reproduce at a sustainable rate in the impoundment? Are they threatened by non-native species?
4. Are contaminated sediments built up behind the dam currently harming fish and wildlife or likely to in the future?
5. Is the current condition of fish and wildlife consistent with published river or fisheries management plans applicable to the area?

EFFECT OF REMOVING THE DAM

1. What fish and wildlife species will benefit from dam removal? Are these species of concern?
2. What fish and wildlife species will suffer from dam removal? Are these species of concern?
3. Will the process of removing the dam negatively impact fish and wildlife populations in the short-term? Long-term?
4. If any contaminated sediments are built up behind the dam, will their release be harmful to fish and wildlife?
5. Will dam removal be consistent with published river or fisheries management plans applicable to the area?
6. Could any negative impacts to fish and wildlife that are attributed to the removal process be reduced or eliminated by altering the project's timing or design?

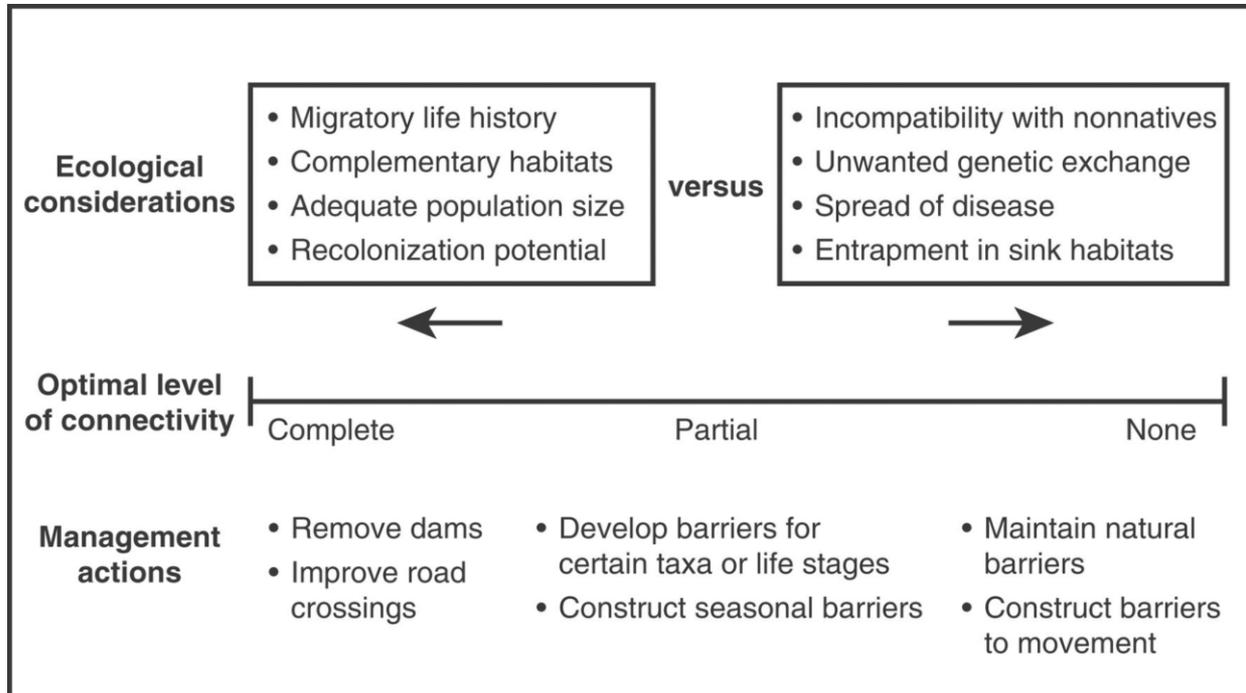
American Rivers & Trout Unlimited, 2002. Exploring dam removal: A decision-making guide.

EFFECT OF KEEPING THE DAM

1. Does the dam prevent undesirable, non-native, diseased, or contaminated species from spreading throughout the river system?
2. Does the dam block movement or migration of fish or other wildlife (such as shrimp or mussels)? Are any of these species of concern?
3. Does the dam have effective fish passage devices, or could they be installed, to aid passage of fish and wildlife species? Will the devices be effective at passing all species and "life stages" of concern? What species mortality rates are associated with these devices? What is the cost of installing and maintaining the fish passage devices?
4. What kind of impact does the impoundment have on fish migration (e.g., affecting upstream and/or downstream migration as the species navigates a lake-like as opposed to a river environment)? Can this impact be reduced or eliminated?
5. What is the cumulative impact of all of the river's dams on fish migration? Can these impacts be reduced or eliminated?

EFFECT OF REMOVING THE DAM

1. Will dam removal result in an increased survival rate for species of concern by allowing these species to reach appropriate spawning, rearing, and foraging habitat?
2. Will dam removal restore access to any species' historic range?
3. Will removing the dam encourage the spread of undesirable species? Could measures be taken (e.g., building another smaller barrier) to prevent the spread of undesirable species?
4. Will removing the dam allow contaminated or diseased fish to move into sections of the river not currently contaminated?
5. Will the physical deconstruction of the dam have a negative impact on the movement of fish and other aquatic species (e.g., mussels)? Can the removal process be timed to avoid negative impacts or will temporary fish passage be necessary?

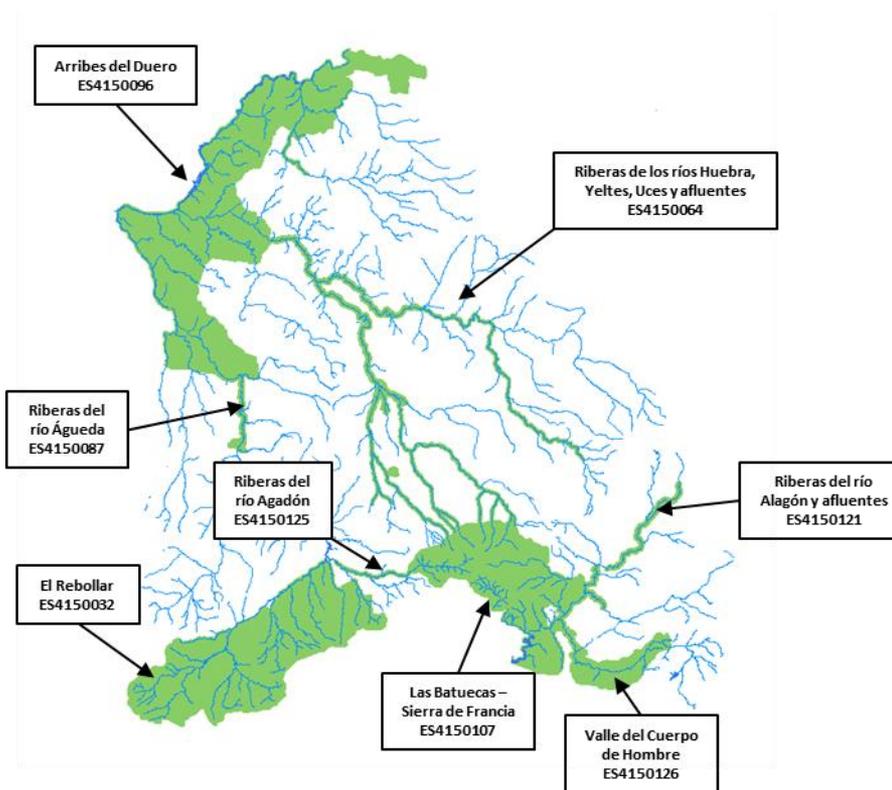


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LIFE13 NAT / ES / 000772 : "ACTIONS FOR THE PROTECTION AND CONSERVATION OF IBERIAN CYPRINIDS OF COMMUNITY INTEREST"



Habitat Directive names

Actual denomination

Rutilus arcasii



Achondrostoma arcasii



Rutilus lemmingii



Achondrostoma salmantinum



Iberochondrostoma lemmingii



Rutilus alburnoides



Squalius alburnoides



Chondrostoma polylepis



Pseudochondrostoma duriense



Pseudochondrostoma polylepis



Parachondrostoma toxostoma



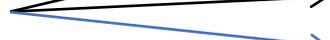
Cobitis taenia



Cobitis paludica



Cobitis vettonica



Cobitis calderoni



ACTIONS

Initial situation diagnosis: starting point for the comparison of fish population evolution and habitat status.

Performance Framework Document in Rivers: assessment of the initial situation regarding the ecological status and the river connectivity

Fish Farming Action Plan: develop an innovative captive breeding protocol based in natural conditions

Making a native fish resource stock in Galisancho: captive breeding for reintroduction of the species listed in Annex II of the Habitats Directive.

Monitoring of fish species: assessment of the evolution of the fish community. This protocol will be as well as an early warning system for invasive species.



Protocol for action against invasive species



Habitat restoration: improvement of river connectivity by demolition of barriers and construction of fish passages, and restoration of degraded river areas.

Water Management Plan and Fish Management Plan: establish a framework for actions in order to guarantee conservation goals and future sustainability of the project.

Assessment of the river connectivity

To assess river connectivity the following index have been used:

Overcoming index

Partitioning index

Longitudinal integrity index

(Gonzalez et al, 2011)

Masa de Agua 535

Nombre Río Huebra desde aguas abajo de San Muñoz hasta confluencia con el río Yeltes, y arroyos de la Saucera y de Caña

Ecotipo 3 Rios de las penillanuras silíceas de la meseta norte

Codigo Lic ES 4150064 Riberas de los ríos Huebra, Yeltes, Uces y afluentes

Reserva fluvial

Longitud 62165 m N° de segmentos 13 IC 10,30

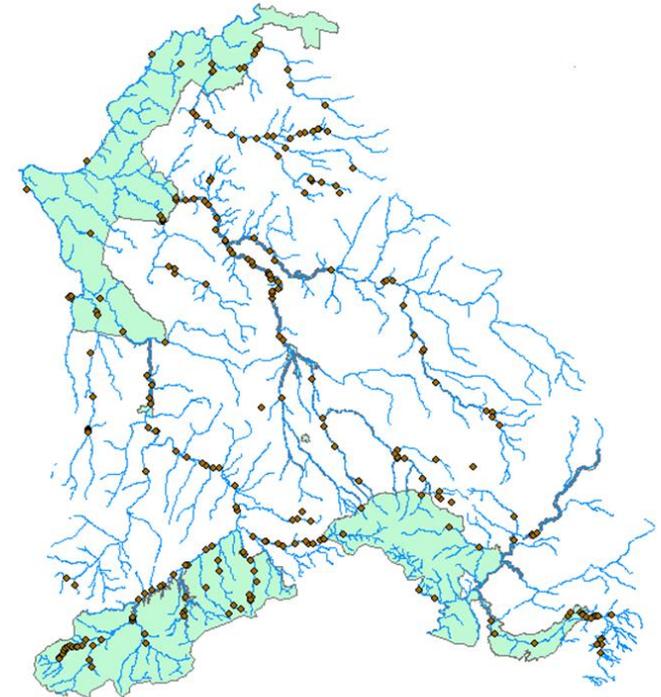


Presas y Azudes

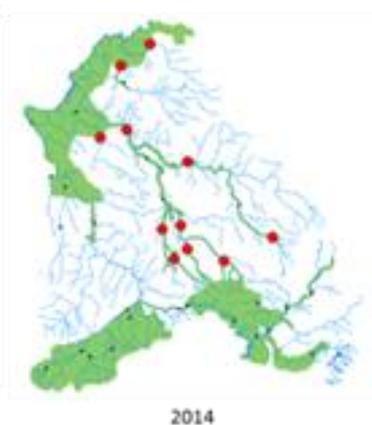
Codigo	Cauce	Huso	X	Y	Altura	Longitud	IF
1086	HUEBRA	30	220389	4532635	3,1	120	95
1087	HUEBRA	30	232421	4526738	8	110	100
1088	HUEBRA	30	230542	4530979	2,1	150	80
1089	HUEBRA	30	229272	4530736	1,2	100	0
1097	HUEBRA	30	234009	4521870	1,5	12	45
1118	HUEBRA	30	207729	4538001	7	50	100
1121	HUEBRA	30	211145	4534281	3,5	90	90
1122	HUEBRA	30	210267	4535937	3,2	30	80
4520	HUEBRA	30	201711	4541499	1,3	40	50

Extracciones de agua

Nº segmento	Extracciones de agua	Extracciones sin conexión
501249		10049749 10044318
501254	10049836 10043792 10055828	10043779 10043768 10043871
501257	10043816	10044343 1004433
501262	3825 10043827 10043805 10043807 1004	28 10043822 10044171 10044168 100
501271	10087791	10043789
501268	10044337 10044336 1004434	



260 barriers (162 in SICs)



Achondrostoma salmantinum



Squalius alburnoides



Squalius carolitertii

Invasive Alien species

Gambusia holbrooki: in all rivers



Alburnus alburnus: first references in 2014 in the basins of rivers Huebra and Alagón



Micropterus salmoides: first references in 2014 in the basins of rivers Huebra and low part of river Agueda

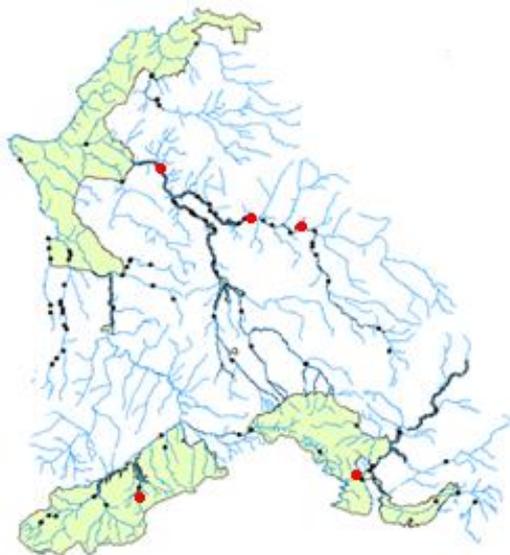


Lepomis gibbosus: first references in 2009 in the low part of river Agueda

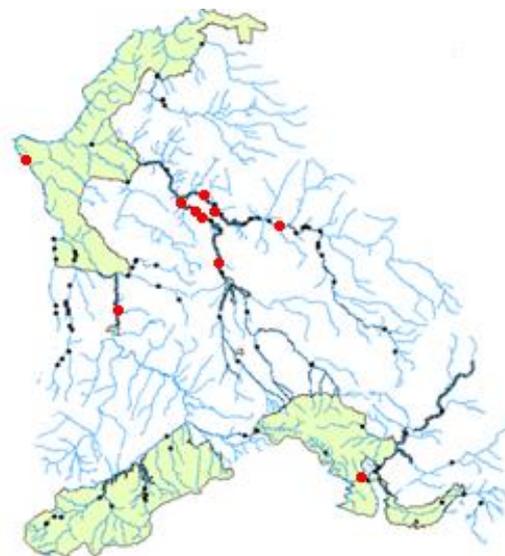


Esox lucius: first references in 2014 in the low part of river Agueda

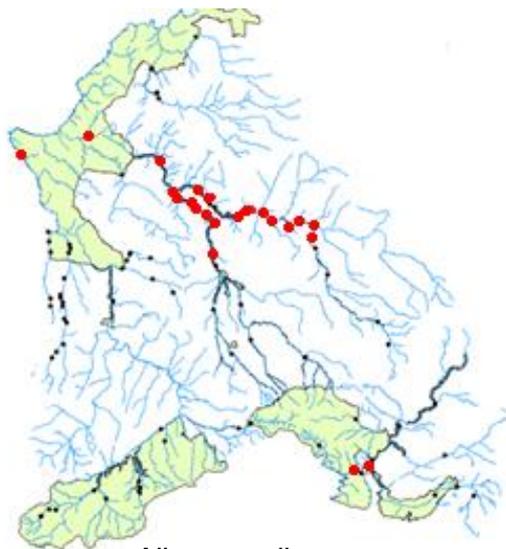




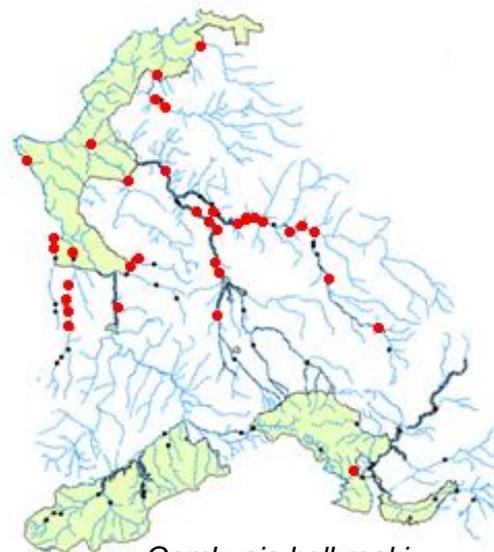
Micropterus salmoides



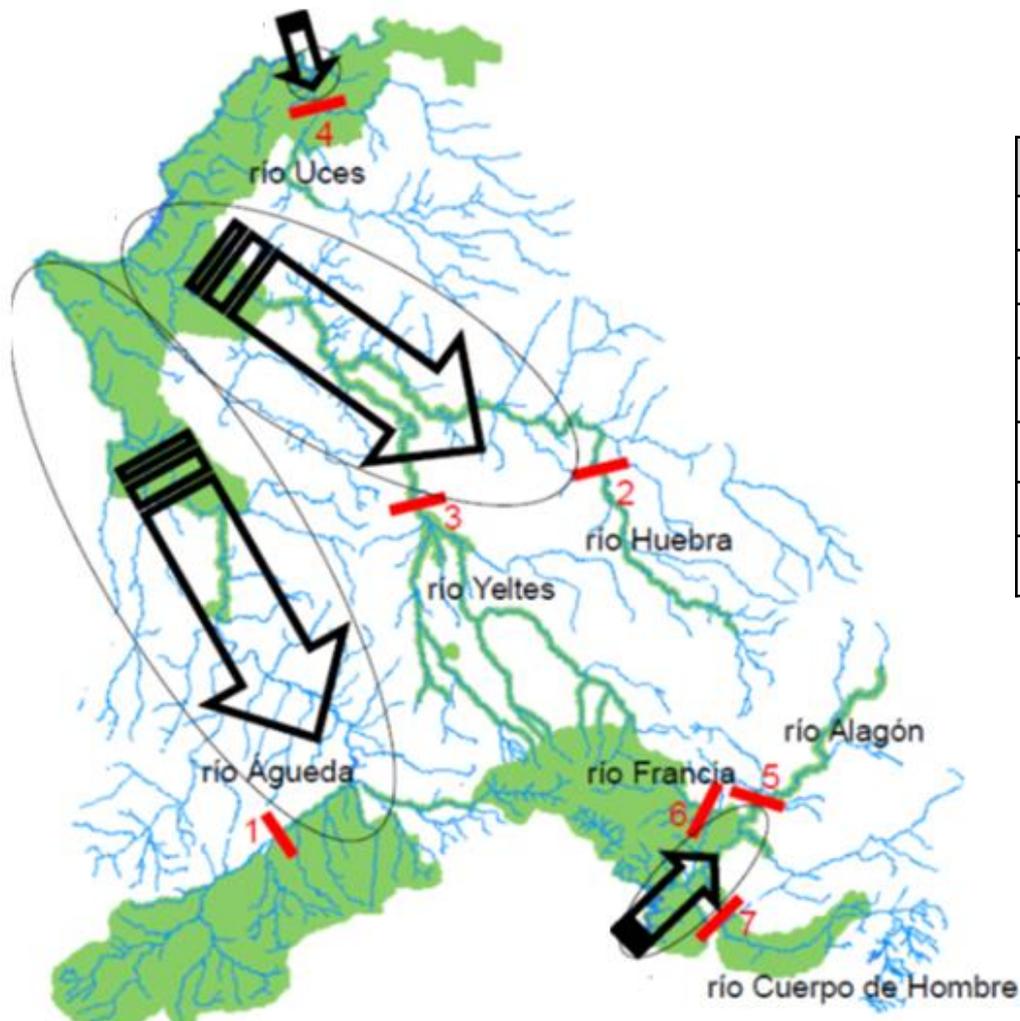
Lepomis gibbosus



Alburnus alburnus



Gambusia holbrooki



River	Name	
Águeda	Embalse de Irueña	1
Huebra	Jumillano	2
Yeltes	Balneario de Retortillo	3
Uces	Pozo de los Humos	4
Alagón	El Pipero	5
Francia	La Regajera	6
Cuerpo de Hombre	Central de Valdelageve	7

Selected barriers to avoid the spread of invasive species upstream, where target species populations are still in good conditions

	Remove the dam	Keep the dam	
What is the degree of concern of the native species ?	✓ Natives little threatened upstream or very threatened downstream	Natives very 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	High competition for food resources, space and/or refuge between native and invasive	✓
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	
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 reservoiri neither Invaders transport bioaccumulated toxic substances	Toxic substances in the reservoiri or Invaders transport bioaccumulated toxic substances	
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 remove 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 improve conectivity and to safeguard a necessary isolation	
Are other invasive species, not fish, present?	✓ No risk of expansion of other invasive, not fish, species.	Risk of expansion of other invasive species.	
Are other threatened species, not fish, affected?	✓ It favors other highly threatened aquatic native species	It harms other highly threatened aquatic native 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	✓

SOCIAL RESTRICTIONS





GAPS OF KNOWLEDGE & FUTURE CHALLENGES

- Learning more about the interactions between IAS and threatened species
- Identifying approaches for maintaining incompatible taxa, such as sport fishes and small nongame species
- Maintaining hydrologic connectivity while blocking biological connectivity
- Learning about Invasive Alien Species' ability to overcome obstacles
- Developing selective barriers and fish ladders
- Long term monitoring dam and weirs removals

THANK YOU !

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