Report on ECRR workshop "Free-flowing rivers and restoration of river connectivity: from theory to operational approaches"

4th July 2022, Lyon, France

Plenary introduction

On 4th July, river researchers and practitioners gathered in Lyon, France. For five days to come, I.S. Rivers 2022, an integrative science conference, was about to take place.

The conference began with three workshops, one of them the ECRR workshop titled "Free-flowing rivers and restoration of river connectivity: from theory to operational approaches", attended by 50 river professionals. It focused on EU Biodiversity Strategy 2030, and specifically on its objectives related to river restoration, in particular concerning free-flowing rivers. Technical questions were raised and discussed that could aid the Member states in efficiently implementing the Strategy, and the EC in improving its guidance.

Anders Iversen (ECRR) introduced the ECRR and the subject. When it came to the importance of the river health, he brought everyone's attention to the way our understanding of the issue was evolving globally. Looking at the existing goals and policy on freshwater ecosystem restoration, it appears that restoring river ecosystems by means of connectivity restoration is a practice gaining momentum. The goals that support this conclusion include the UN Sustainable development goals (6.6., Protect and restore water-related ecosystems and 15.1 Ensure <…> the restoration <...> of freshwater ecosystems), the EU Water Framework directive and its goal to achieve good ecological status in all EU waters, the EU Green deal, and EU Biodiversity strategy 2030, that aims at halting the biodiversity loss and restoring 25,000 km of free-flowing rivers.

Wouter van de Bund (EC) presented the EU policy context concerning free-flowing rivers. In 2021, the EC released a guidance document on Barrier Removal for River Restoration for achieving 25,000 km free flowing rivers by removing barriers and restoring related floodplains and wetlands. Additionally, a new EU Nature Restoration Regulation proposal had been passed just two weeks prior to the workshop. The goals to restore our freshwater ecosystems have entered our policy, and they call for greater river connectivity restoration efforts.

The EU Biodiversity strategy goal to restore 25,000 km of free-flowing rivers by 2030 ought to be achieved by increasing in particular the longitudinal and lateral connectivity of rivers. This is to be achieved primarily by removing obsolete dams and other longitudinal barriers, as well as removing or displacing lateral barriers, thus restoring floodplains and wetlands. Despite the undeniable inspirational ring to it, there are still several issues on a practical level that river managers may stumble across. **What is a free-flowing river; how do we define them?**

Barriers in the rivers of the EU number a truly overwhelming 1.2 million, recent research shows (AMBER project findings – Belletti et al 2020. Nature). Many of them are obsolete, which are those that are no longer needed for renewable energy generation, inland navigation, water supply, or other uses. As soon as one takes into account the number of barriers, the limits on available resources and the differences in ecological gains of barrier removals, a great need becomes evident for a strategic approach. **To effectively open our rivers, it is indispensable to prioritise the barriers for removals.**

The introductory session was framed by three other presentations, that grounded the need for an in-depth discussion on defining the "free-flowing river" metric and effective prioritisation. Joshua Royte (TNC, USA), the first speaker of the three, noted that thinking of rivers as "kilometres opened" was insufficient. Royte emphasised that it was necessary to define a minimal functioning river unit, and the metric should consider the needs of species and restoring functional habitats, so that restoration efforts actually benefit ecosystems.

The other two speakers, Sophia Vauclin (French Ministry of Ecology) and Arantza Unzurrunzaga Iturbe (Diputación Foral de Gipuzkoa, Spain) presented their national and regional strategies respectively for the restoration of longitudinal connectivity. In both countries, the strategies incorporated creating barrier databases and prioritising the barriers for removals. Both strategies, to a certain degree, were successful in helping restore rivers. However, both countries faced challenges, and as a result, many restoration targets were not met as planned. This had occurred because some criteria were overlooked, or some barrier removals were opposed by the public. All of this further invites for a deeper discussion on effective barrier prioritisation, and how it can address and improve planning.

The workshop took place in two parallel groups. The first group discussed possible metrics for the assessment of free-flowing rivers. The second group discussed approaches for the prioritisation of barriers removal.

Discussion group 1: Metrics for "free-flowing rivers"

In the EC guidance for barrier removal the EC proposes to primarily focus efforts on barriers to longitudinal and lateral connectivity and mainly interprets 'free-flowing' rivers as surface water bodies that are not impaired by artificial barriers and not disconnected from their floodplains. The EC guidance preliminarily introduces general principles and concepts, such as 'river functional units', to guide Member States in the development of projects and programmes for the restoration of connectivity. But the development of concrete methods and tools to make the 'free-flowing river' concept operational is still an open task and several questions require technical discussion.

A. Goltara: Introduction of discussion point 1: Why a metric for free-flowing rivers? What changes should it foster? Therefore, how should it be designed?

General agreement the main need is not a precise measure of connectivity, but rather a tool to foster dam removal in a short time frame and to promote conservation of currently connected river reaches. Therefore, the metrics should be scientifically sound and take into account all the main river functions affected by connectivity, but at the same time sufficiently simple (e.g., proposal to have binary "Y/N" indicators, as much as possible) and easy to communicate.

A. Goltara: Introduction of the following discussion points: a) Which components of connectivity should be included in the FFR metrics? b) At what scale should FFRs be assessed? How the River Functional Unit concept can be applied to the different components of connectivity?

a) General agreement that, coherently with the EC guidance, the metrics should include **at least** the following components:

- longitudinal connectivity for fish (upstream/downstream) at least; if additional taxa/ processes are included, operational methods to assess the corresponding connectivity are needed,
- longitudinal connectivity for sediments,
- lateral connectivity in relation to ordinary (2 to 10 years) flooding processes,
- lateral connectivity in relation to riverbed mobility/lateral erosion.

It seems reasonable to avoid the inclusion in the metrics, for the time being, of vertical and temporal connectivity, and to tackle separately ecological flows.

There is a general agreement that:

- for longitudinal connectivity the metric should be based on the presence/absence of specific category of barriers (possibly, preliminarily identifying those categories that do not constitute a significant hindrance to connectivity),
- for lateral connectivity the approach should, ideally, be the same, but as the total absence of lateral obstacles is in many cases not foreseeable, instead, river type/size-specific thresholds could be defined in terms of minimum lateral space available for the relevant processes (flooding/erosion) for a river (reach) to be defined as free-flowing.

Prof. Carlos Garcia de Leaniz: Functional River Units: why do we need them? and how can they be defined?

Prof. Carlos Garcia de Leaniz (Swansea University, UK) started his presentation on Functional River Units with some notes.

- Is ‘free-flowing’ free of barriers or free of barrier effects?
- Just longitudinal barrier effects or barriers in all dimensions?
- If one continuity dimension fails, do all fail? What about river quality?
- Targets should be realistic enough to get a significant number of free-flowing rivers.
- A certain pragmatism is needed.
- Should our thinking change from passability (species) to discontinuity (processes)?
- What is the definition of a free-flowing river?

For the reconnecting of rivers, he suggested the Functional River Unit (FRU) concept could be used as an operational unit to reconnect rivers. The FRU can be defined as the minimum viable functional unit of a waterbody i.e., the minimum size that captures the diversity of the waterbody and that is required for the waterbody to function properly. The FRU is based on the concepts of redundancy, distinctiveness and complementary used in conservation planning, i.e., the aim is to delineate the essential features of a waterbody. Its size can be based, in part, on the river continuum concept and the physical characteristics of the river, as these determine to some extent the regulating,

provisioning and recreational ES provided by rivers.

Moreover, the **quality** of these connected river reaches (i.e., of FRU) should be considered when assessing FFR (reaches). Typically, the process involves two steps (i) identifying the list of important basin features; (ii) determining how much of each of these features should be conserved or restored for the river to function properly.

The concept was illustrated with the following figures with the assumption that all 'green stretches' are open to all, longitudinal and lateral processes.

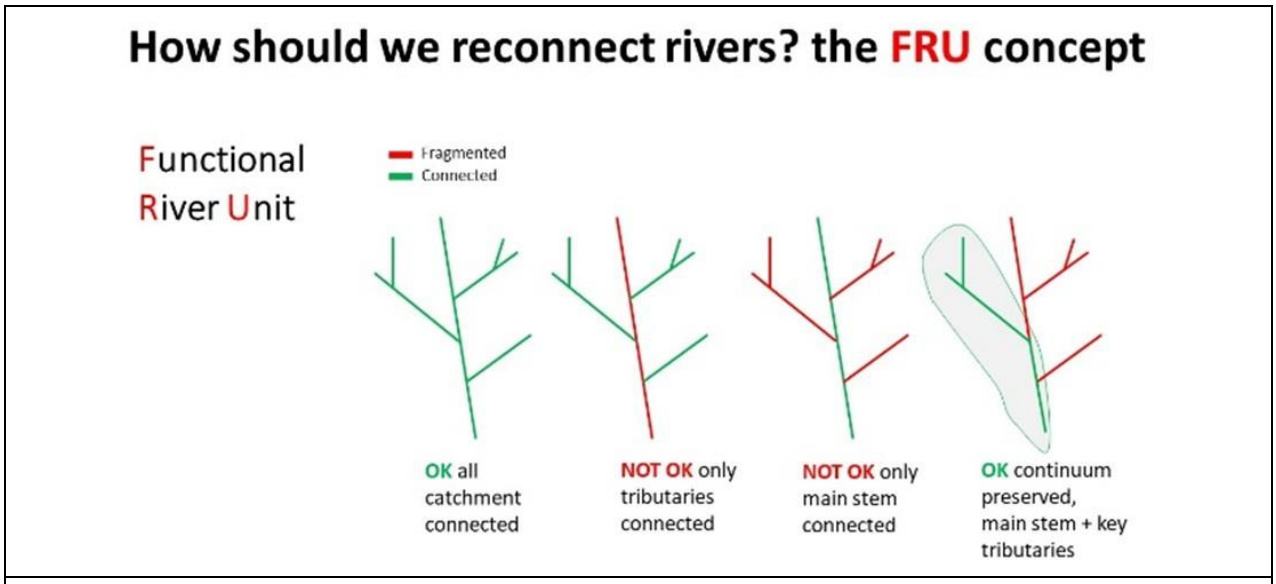

Figure 1. *The FRU (Functional River Unit concept) requires restoring connectivity either of the main stem and tributaries, or of the entire catchment; Carlos Garcia de Leaniz, Swansea University.*

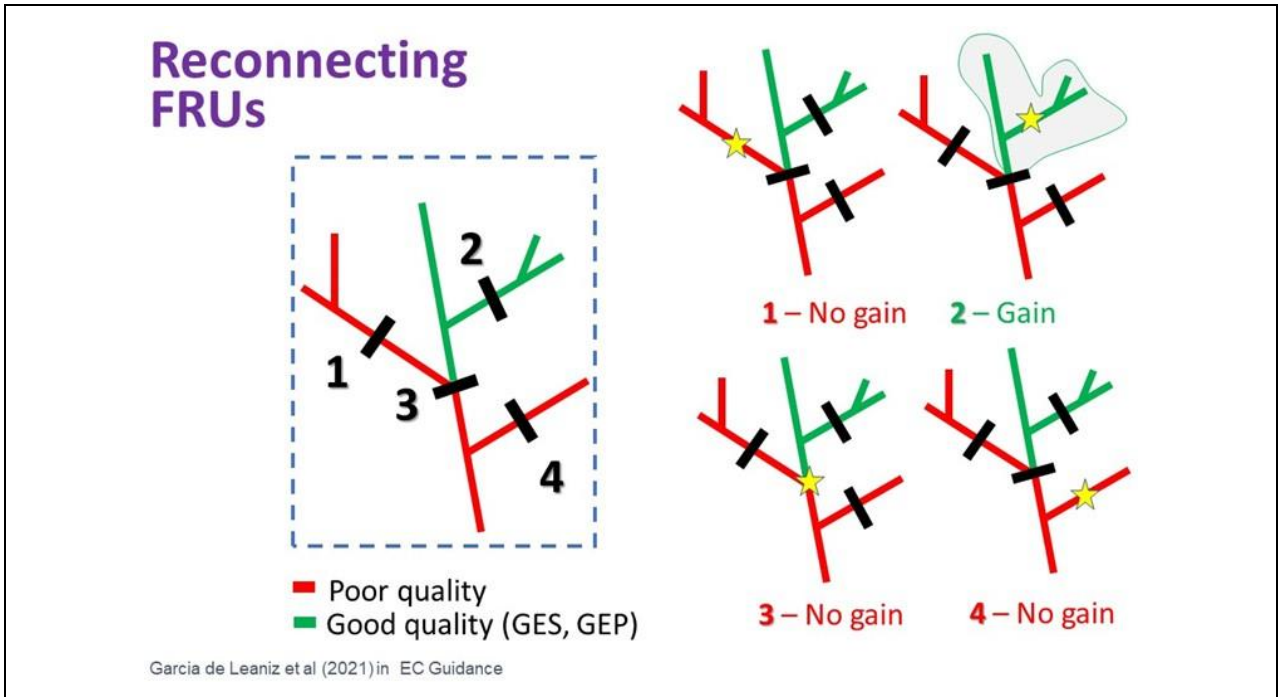

Figure 2. *The concept of restoring river to a "free-flowing state" should focus on restoring functional river units; Carlos Garcia de Leaniz, Swansea University.*

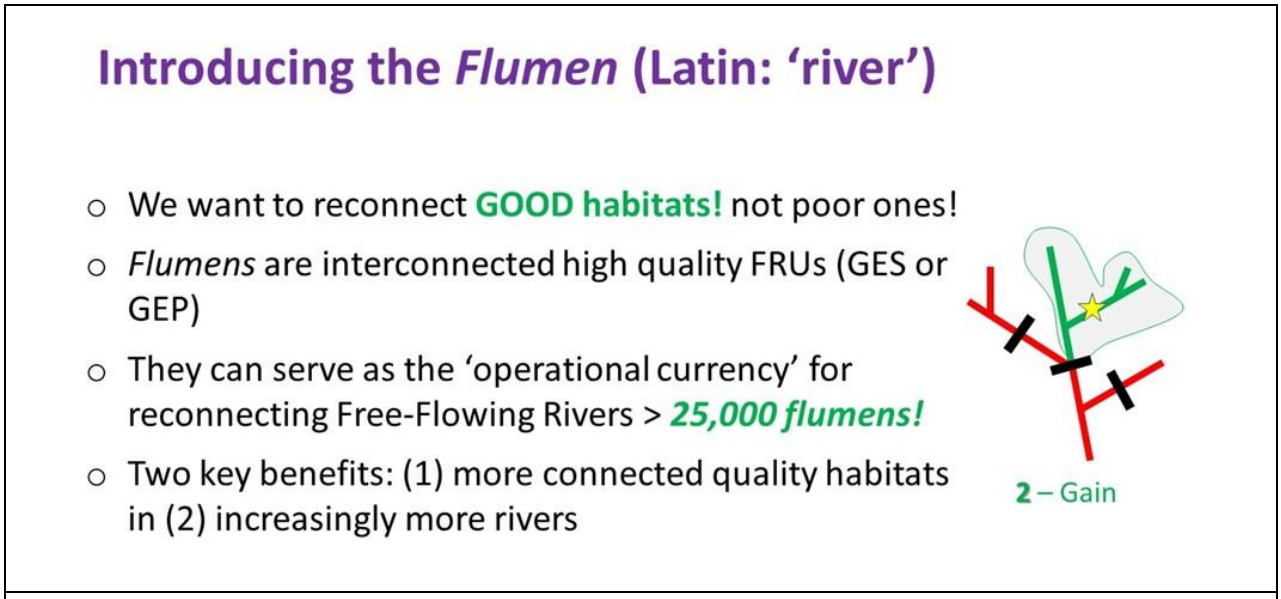

Figure 3. *Connected rivers with Good Ecological Status / Potential; Carlos Garcia de Leaniz, Swansea University.*

Concerning the size of a Functional River Unit there are some facts that could be taken into account:

- European water bodies (WFD/RBMP) have an average length of about 80 km
- In Spain 135 Fluvial Reserves (GES) have an average length of about 20 km
- Studies show a (fish) patch size of 24 km length and a surface of 40 km^2
- Potential size of FRU's 10 – 30 km and 40 – 100 km^2 ?

Prof. Carlos Garcia de Leaniz concludes that, seen in a broader context, we are just at the start of a growing process, where we are now often taking away the barrier effect by fish (by)passes. For the future this could be extended with other measures up to dam removal.

Discussion

Most participants seem to agree that the water body is not the right scale for the assessment of FFR (too wide and insufficiently homogenous) and that it is reasonable to take into account the quality of the reconnected reaches. However:

- A clearer methodology for the identification of FFR in relation to connectivity should be defined (e.g., how to identify the minimum level of "functionality"?)
- Operational methods are needed to extend the approach to all relevant processes, i.e., longitudinal connectivity for sediments.
- For example, in Figure 1, the sketch on the right describing "*OK, continuum preserved, main stem and key tributary*" refers to the FRU, not to the entire river. Sediment supply and sediment transport are key processes of the main stem but according to the FRU concept it would not be necessary for the entire river to be free of barriers.
- Some have commented, that if sediment transport in one point of the main stem is impeded by a barrier and the reconnected tributary does not play any role in the sediment supply of the main stem (sediment processes of the main stem rely on the sediment supply of the u/s), then the downstream part of the main stem should not be classed as a functional river unit as shown in the figure.

- There seems no consensus among participants on the proposed use of the WFD status of water bodies to evaluate the “quality” of the reaches, and correspondingly, of the “good” status as threshold for the applicability of the FFR status to a connected reach/FRU.
- It is not fully clear how the proposed FRU approach can tackle those cases when relevant barriers hindering one or more processes (e.g., fish upstream migration or sediment transport downstream from the main sources) are present upstream or downstream the assessed reach.
- Some participants suggested to use instead of FRUs homogeneous units defined according to physical and biotic descriptors (confinement, confluences, hydromorphological river types, reference fish communities, etc.).

Furthermore, questions were raised as to whether there should be different metrics for different purposes: for practitioners (with a focus on easy application), communication and marketing (scenario-based), numbers (for politics and funding), but there was a general agreement amongst the participants that there is no need for, they could even be contra-productive.

More information on barriers is needed: not only on the (total) number of barriers, but also on the type, the situation, the height, the habitat effects and related points at issue.

How to merge the different aspects (and corresponding indicators) of connectivity in a single FFR metrics was not discussed due to lack of time.

Discussion on some principles showed a strong disagreement among the participants and for others the discussion did not come to a real conclusion. More discussions and/or scientific studies will be needed to come to conclusions.

Discussion group 2: Prioritisation of barriers and rivers for restoration measures

J. Royte: Prioritisation methods and needs

The second session was based on two presentations on prioritisation methods. The first speaker was Joshua Royte (TNC, USA); he presented some prioritisation methods that exist to date, as well as some key lessons and needs in relation to them.

The methods ranged in their scale. Continental-scale methods included the DAMROS method by Prof. Carlos Garcia de Leaniz (Swansea University, UK) for prioritising regions of Europe for restoration. On a national scale, we find, among others, TNC and Revivo’s barrier prioritisation method for Slovenia. Finally, some methods had been applied on a regional level; take, for instance, TNC’s West Atlantic prioritisation models of small dams and culverts in the state of Maine, US.

The methods share some similarities regarding metrics, criteria, and data. Virtually all methods focus mainly on longitudinal connectivity for fish and in a certain way consider priority species, the number of barriers either upstream, downstream, or to the sea, the potential for kilometres of rivers (and hectares of habitat) opened if a barrier is removed, and the financial efficiency of the project (km/€).

However, it is also important to highlight some key features that are unique to individual methods. For instance, West Atlantic models prioritise dams and culverts, in contrast to many other methods for barrier prioritisation, that only look at dams. These models also take into the account the need for reconnecting important habitats for different local fish species. It also looks at the ecological

outcomes of barriers that are cheap vs. expensive to remove, the risks associated with barriers in relation to their condition, and whether the barriers would handle floods.

Another unique method was the Finnish method developed by Syke, which considers costs of biodiversity vs. hydropower based on their predicted future net value. They also take into account the water framework status. These criteria are usually overlooked in most methods.

The unique feature of the Pacific North-West methods was that for the evaluation of the feasibility of barrier removal, they separately ran the analyses of ecological benefits and social costs in parallel, rather than blending them all together in one score.

Another important distinction emerged among the methods. Some of them aim to prioritise barriers for removal (which means, that projects with greatest ecological outcomes are the top priority, and projects with the lowest ecological outcomes are the lowest priority); while the others optimise the choice of specific barriers for highest ecological gains with given resources. Referring to Eric Martin's paper "Assessing and Prioritizing Barriers to Aquatic Connectivity in the Eastern United States", published in the Journal of the American Water Resources Association in 2019, the limit of prioritisation is that the priorities may not be implemented due to limiting factors, such as lack of opportunities, finances, or political issues. Optimisation, on the other hand, is focused on priorities that can realistically be implemented on a given budget and time frame, but the ecological gains may be lower.

An interesting example illustrating this case was a model developed by the WWF that was looking at potential kilometres to reconnect Europe-wide. WWF found that by implementing projects and removing barriers that rank as "good" rather than "high" priority, there is more potential to open rivers, implementing a reasonable number of projects.

Royte made several concluding points that it was important to put river restoration into the context of climate change, highlighting the need to incorporate into restoration the effects and stresses brought about on rivers by climate change. He also proposed to include protected areas as a criterion for restoration priorities. He also noted that whereas cheap barrier removals may be very cost-effective, some expensive-to-remove barriers on the main stems of rivers need to be prioritised and removed too, as the main stems are critical to certain species. Finally, he noted that in real life, the removal of lower-priority barriers should be considered for the sake of constructing a narrative of success, that could pave the way for more removals. At the same time, as the French experience illustrated by Sophia Vauclin show, removing a large amount of barriers with insufficient evidence of ecological benefits may reduce the social and political acceptability of this kind of measures.

F. Magdaleno: prioritisation approaches in Spain

The second speaker was Fernando Magdaleno (Ministry of Ecological Transition and the Demographic Challenge, Spain). He presented the Spanish strategy for river restoration. From 1989 to 2020, Spain removed over 300 barriers, mostly weirs, but also 7 large dams, and installed 240 fish passes. In the near future, 108 barriers are planned to be removed. To a great extent, such success could be attributed to the effective strategy.

Spain prioritised:

- water bodies (WBs) with those barriers that were priority for removal or permeabilisation as part of the Programme of Measures (as parts of the River Basin Management Plans),
- WBs that were in protected areas (e.g., Natura2000),

- WBs with barriers whose removal or permeabilisation would maximise unfragmented river length,
- WBs with significant fish populations that are threatened with invasive species, and
- WBs particularly sensitive to climate change.

Each of these criteria were represented on maps (GIS layers) and were given certain weights. Once the maps were superimposed on each other, each barrier came out with its own prioritisation score.

Magdaleno shared that their approach had led to a successful implementation of barrier removal projects. However, some limiting factors had also occurred, and not all high-priority barriers could be removed. Among these factors, one finds socio-economic ones, as well as some unforeseen circumstances such as the risk of spreading of invasive species after removing the barrier. Any of such factors could be overlooked in the prioritisation process. Magdaleno stressed that eventually, decisions for each barrier have to be taken individually.

Discussion

For the discussion part, Piotr Parasiewicz (Sakowicz Inland Fisheries Institute, Poland) referred to his recent research on the effects of barriers on microhabitats and fish communities. Further restoration work could also be guided by taking into account the vulnerability of fish communities to barriers. Consequently, he suggested that this aspect could be included in prioritisation studies.

The developer of the Slovenian prioritisation tool, Polona Pengal (REVIVO, Slovenia), shared that the major challenge was the insufficiency and scatteredness of data. Some technical solutions had been adopted, but she noted that eventually, it is essential to develop a better database of barriers. Royte had also noted the importance of filling in data gaps on barriers, habitats, social acceptance, communities' positions on barriers, and information about surrounding infrastructure, all of which could have an impact on removals.

There were also several suggestions to include metrics on sediment connectivity into the prioritisation tools, given that sediment discontinuity is a key issue.

The focus of the remaining discussion revolved mainly around social issues and the negative community perception of barrier removals. Multiple persons from the audience shared their experience that the opposition from communities is the greatest hindrance to successful barrier removals, and that this is often overlooked during prioritisation. It became clear that in order to seek consensus between the data and the stakeholders, it is important to involve the stakeholders in the prioritisation.

Royte made an important point that one of the main needs for the prioritisation systems was making the tools tailored to multiple users and their needs, so that the users see value in them. That of course leads to the need of multiple prioritisation methods, and that consider different parameters reflecting the different needs of stakeholders, such as cost and social values. Pengal also added that it was critical to include communities at the early stages of prioritisation and related projects.

Another point brought up by Royte was that prioritisation alone will not be sufficient to achieve the desired ecological goals. There is a need for better communication and community engagement to enable socio-political conditions, to train more experts, and to make use of businesses and recreational opportunities – as well as to monitor success and replicate it.

It seems that in the future, our greatest challenges to implementing the EU's river restoration goals will include not only the need for technical advances, but also gaining support from communities and finding a common ground with stakeholders.

Reporters

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