Protecting and restoring river ecosystems to support biodiversity

Scoping paper on EU restoration targets for free-flowing rivers and freshwater ecosystems

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The overarching aim of the recently adopted EU Biodiversity Strategy is that 'By 2030, significant areas of degraded and carbon-rich ecosystems are restored; habitats and species show no deterioration in conservation trends and status; and at least 30% reach favourable conservation status or at least show a positive trend.' The alarming situation of the aquatic ecosystems shows that freshwater species have declined worldwide by a staggering 84% since 1970; with a 93% decline recorded for the migratory freshwater fish in Europe[1]. As much as 60% of European surface waters (rivers, lakes, transitional and coastal waters) are not meeting the standards of the EU Water Framework Directive (WFD), with rivers being in a relatively bad state.[2] Fragmentation of rivers is widely recognised as one of the main causes of biodiversity loss. Moreover, between 70% and 100% of floodplains have been lost over the past centuries[3] and two thirds of wetlands have been lost since the 1900s, being destroyed three times faster than forests. 85% of habitats related to wetlands have an unfavourable conservation status.

Unfortunately, European rivers and freshwater species continue to be under threat of further deterioration due to *inter alia* new infrastructure projects for hydropower, navigation and flood-protection, for example, nearly 9000 new hydropower plants are in a planning process or under construction, many of them in protected areas[4]. While in this paper we specifically focus on the restoration of the freshwater ecosystems, it is imperative to prevent the deterioration of these currently intact or functional ecosystems as a matter of priority.

If the EU is serious about achieving the goals set in the EU Biodiversity Strategy for 2030, then any legally binding restoration targets that the European Commission committed to propose in 2021 will need to drive the restoration of freshwater ecosystems and reverse the steep decline of freshwater biodiversity.

There is a **fundamental link between water, biodiversity and climate action**. Neither climate nor biodiversity ambitions can be achieved without large-scale action to protect and restore aquatic ecosystems (which also serve as natural carbon sinks) and achieve sustainable water management. Rivers that retain free flowing character, sediment transport and natural fluvial dynamics can host high biodiversity both in freshwater, adjacent land, bird communities and associated marine ecosystems. Restoring natural features and processes to the river, such as floodplains and wetlands, can reduce the risk of floods and mitigate droughts, help combat coastal erosion, favour nutrient cycling while reducing pollution, generate microclimates that help deal with heat waves, and create a healthier, more resilient and more attractive landscape with opportunities for nature, recreation and financial flows for local economies (fishing, water sports, tourism, etc.).

[1] The Living Planet Index for migratory freshwater fish (2020)
[2] EEA Report No 7/2018
[3] EEA Report No 24/2019
[4] WWF, Geota, RiverWatch, EuroNatur (Eds.), Ulrich Schwarz (2019), Hydropower Pressure on European Rivers. The Story in Numbers, https://wwfint.awsassets.panda.org/downloads/wwf_hydropower_report_2019_w.pdf

This paper builds and complements the position paper 'Restoring EU's Nature' released by a coalition of 20+ NGOs in October 2020. It presents elements to be considered as part of the new nature restoration law specifically related to the **protection and restoration of free-flowing rivers and freshwater ecosystems**. We consider these elements as **essential to meet the key needs of freshwater ecosystems to allow their natural processes to sustain biodiversity values and to provide key ecosystem services**. The legal requirements in the upcoming Nature Restoration Law need to be added to existing obligations, in particular under the Birds Directive (BD), the Habitats Directive (HD), the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD).

The baseline level for protecting and restoring river ecosystems, is to meet the objectives of the WFD. The WFD requires Member States to meet standards for ecology, quality and quantity of waters to achieve 'good status' by 2027, however, river basin management will continue well beyond 2027. Unfortunately, we continue to witness widespread and ongoing deterioration of rivers, which outpaces restoration efforts given the current enabling conditions. This is due to insufficient ambition of Member States in the implementation of the WFD, among other things.[5] **Some Member States are very remote from correctly implementing the WFD and fully benefiting from its opportunities, both in terms of preventing deterioration as well as implementing restoration measures in order to achieve the environmental objectives. Thus, any additional legislation for nature restoration agreed by the EU needs to be additional to the existing obligations under the WFD and combined with better implementation and enforcement of the existing legislation.**

Within the framework of "Restoring EU's Nature" we would like to make the following recommendations in relation to the freshwater ecosystems:

Our 10 key recommendations and asks are:

1. We recommend increasing the current target for free-flowing rivers of at least 25,000 km to 15% of all rivers to be restored to a free-flowing state by 2030 through *inter alia* barrier removal and floodplain restoration.
2. The upcoming Nature Restoration Law should have a specific focus on how the targets will address the hydromorphological elements of aquatic ecosystems and their functionality.
3. Restoration targets for freshwater ecosystems set in the upcoming Nature Restoration Law should focus on basin-scale restoration of river continuity to ensure better integration of the WFD and BHD implementation as well as targets to restore lateral connectivity through restoration of floodplains and wetlands.
4. We recommend the development of binding targets for restoration of wetlands and interconnected (small) waterbodies with high biodiversity or biodiversity potential, currently not addressed in the implementation of the WFD and HD. If added, they would build a more coherent, functional and lasting "green-blue infrastructure" network.
5. To increase investment in river restoration actions, we recommend earmarking funds to measures directed specifically to restoration needs of freshwater ecosystems. This should be done through:
    - Using opportunities in the existing financial structures (e.g. EU Common Agricultural Policy and related funds, European Structural and Investment Funds, Next Generation EU);
    - Adding new funding mechanisms (such as blended instruments or insurance industry funding) and the creation of a dedicated EU restoration fund (or facility within some other fund) in the MFF.

[5] SWD(2019) 439 final COMMISSION STAFF WORKING DOCUMENT FITNESS CHECK of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive.

6. A “nature-based solution” requirement should be introduced to EU funds earmarked for investments in water, climate, disaster risk reduction, energy, agricultural and transport sectors, so that only interventions which both address societal challenges and preserve or improve biodiversity conservation can benefit from public funds. Under the upcoming Nature Restoration Law, river and wetland restoration measures and other nature-based solutions (NbS) which maintain and improve biodiversity whilst providing societal benefits should be given priority over single-objective solutions (such as grey infrastructure) to water-related problems.
7. Targets for river restoration should include effective management post-restoration to ensure the restored river systems maintain the environmental processes needed to meet the project goals, such as the occurrence of target species and habitats. This is especially relevant for anthropogenically modified rivers where periodic human intervention may be necessary for (re)creating optimal habitat characteristics.
8. The WFD and HD provide a good basis for monitoring. In addition to this, the upcoming Nature Restoration Law should require long-term monitoring programmes of the important freshwater key ecological attributes and biodiversity variables of holistic functioning riverine systems.
9. The upcoming Nature Restoration Law should include a requirement that restored and free-flowing rivers also will be protected and kept in their free-flowing status. They should be integrated (added) to the 30% of legally protected land area target proposed in the Biodiversity Strategy for 2030.
10. We recommend that the European Commission creates a “dashboard” system, in which the progress towards both no deterioration of current state as well as the target for free-flowing rivers can be monitored and publicly communicated.

River restoration

River restoration refers to ecological, hydromorphological, physical, spatial, and management measures and practices aimed at restoring a functioning river system in support of native biodiversity and key ecosystem services, such as flood and drought risk mitigation, aquifer recharge, nutrient retention, and recreation. River restoration needs to be an integral part of river basin management and directly supports the objectives of the WFD, BD, HD, Floods Directive. It also helps achieve the objectives of the EU Biodiversity Strategy for 2030 and the EU Strategy on Adaptation to Climate Change.

The current gap in reaching Good Ecological Status in rivers shows the imbalance between the large scale of the problem for rivers, failure to prevent further deterioration and the small scale of restoration efforts implemented by Member States so far. Interventions have worked at local scale, but generally not at water body or full river basin scale where more efforts are needed. To overcome this gap, we need:

- An intersectoral approach between water management and conservation authorities as well as other sectors which address spatial and land use planning.
- A large shift in funding to get restoration projects implemented. Funding should shift from single-purpose solutions – often working against nature - to multi-purpose and broader geographic solutions benefiting nature.
- More attention given to the catchment approach, because restoring a local site does not address systemic problems that often originate and accumulate from pressures from up or downstream in the river network.
- More guidance, including example plans and demonstrations of successful restoration projects, and training programs to build capacity and increase knowledge.

The goal should be to create and protect longer interconnected networks that are free-flowing and avoiding disjunct projects that don't accumulate ecologically-meaningful kilometres of habitat.

Setting legally binding targets to restore free flowing rivers

A very large share of Europe's large rivers are no longer free flowing (Figure 1).[6] Therefore, setting legally binding targets to restore rivers to free flowing state and add a layer of lasting protection is needed. This needs to be supported by integrated planning, guidance and funding to meet the goals of the EU Biodiversity Strategy to restore at least 25,000 km of free-flowing rivers by 2030 through the removal of primarily obsolete barriers and the restoration of floodplains and wetlands.

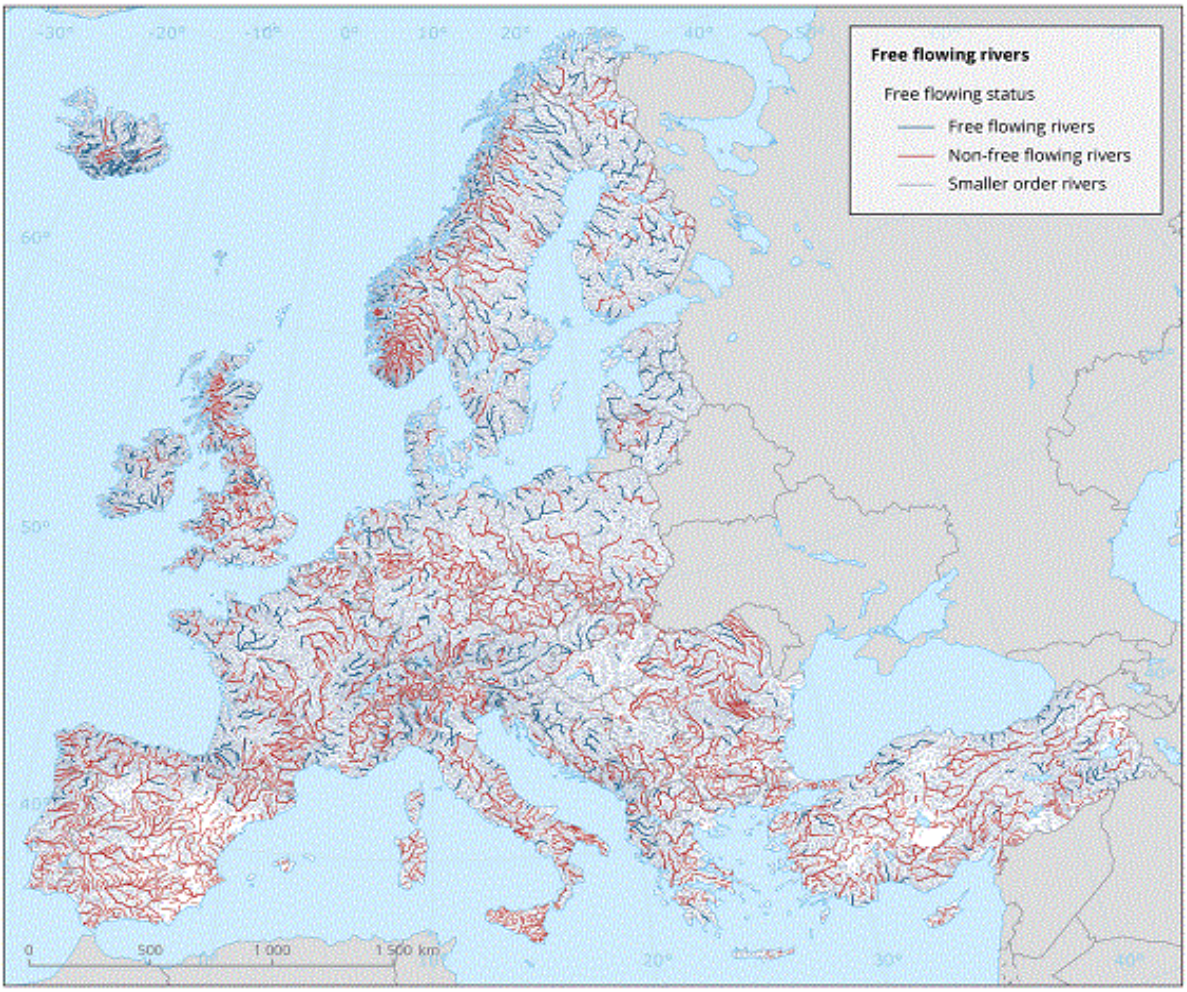

Figure 1: Free flowing and fragmented river networks in Europe, Source: EEA, 2020

In addition, several elements suggest that this target needs to be increased:

- The goal of 25,000 km of rivers returned to free flowing state would represent only around 2% of European rivers.[7] There is no overall assessment of the free flowing state of small rivers, but indications may be found at national level. For example, in the UK, less than 1% of catchments are

[6] EEA (2020). Floodplains: a natural system to preserve and restore. EEA Report No 24/2019

[7] According to the WISE database, river bodies (excluding UK and Norway) amount to 1,186,695 km. Source: https://tableau.discomap.eea.europa.eu/t/Wateronline/views/WISE_SOW_SurfaceWaterBody/SWB_NumberSize?:embed=y&:showShareOptions=true&:display_count=no&:showVizHome=no

free of artificial barriers.[8] In Spain and Portugal, estimations of existing obstacles in rivers are respectively 50,000 and 8,000.[9]

- The AMBER project concluded that more than 10% of the 1 million barriers recorded in Europe are abandoned or obsolete, which means that there may be over 100,000 obsolete barriers that could be removed to help reconnect Europe's rivers. By acting on only 2.5% of these, 25,000 km target could be reached[10], so that is indeed only the beginning of what's needed.
- The last State of Nature in the EU report shows that 10.5% of protected freshwater habitats (about 13 500 km^2) and 9% of Europe's wetlands (protected bogs, mires and fens habitats about 10 900 km^2) need restoration or improved management, and that 1700 km^2 of bogs, mires and fens need to be (re)created to add to the existing protected area in order to ensure the long-term viability of all habitat types.[11]
- Many rivers in Europe are heavily fragmented by dams, weirs, and road crossings, so they are transformed into chains of impoundments, leaving behind only small and short relicts of formerly dynamic rivers, not enough to conserve species, habitats, and most importantly the necessary processes that support them. To preserve and restore European river species and habitats the restoration of impounded river sections should refocus on restoration to increase free-flowing sections in larger rivers and key tributaries to restore the main axes of European river corridors and priority connected networks of a diversity of sizes, with the emphasis on large connected networks. There is a need for both better connections among headwaters and for migratory fish in larger river systems that connect to the sea.

Based on the above estimates, we recommend increasing this goal to achieve at least 15% of all rivers to be restored to a free-flowing state by 2030 through *inter alia* barrier removal and floodplain restoration.

For this paper we use the following **definition of free-flowing rivers**: "Free-flowing rivers are rivers where ecosystem functions and services are largely unaffected by changes to the fluvial connectivity, allowing unobstructed movement and exchange of water, energy, material and species within the river system and with surrounding landscapes. Fluvial connectivity encompasses longitudinal (river channel), lateral (floodplains), vertical (groundwater) and temporal components. It can be compromised by (i) physical infrastructure in the river channel, along riparian zones or in adjacent floodplains; and (ii) hydrological alterations of river flow due to water abstractions or regulation".[12,13]

Additional guidance is needed to prioritize those kilometres to places with existing, or with the potential for restoring at a large-enough scale, outstanding biodiversity and climate mitigation and adaptation potential. We recommend for the European Commission to use the above-mentioned definition of free-flowing rivers, which suggests that not only obstacles to longitudinal connectivity should be removed, but also the lateral connectivity should be restored. The prioritisation should consider the reconnection potential, i.e. the potential for a barrier removal to reconnect not only two

[8] EEA Report No 24/2019

[9] Centro Ibérico de Restauración Fluvial (CIREF). 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. Technical report developed by D. Miguélez Carbajo, León, Spain. https://europe.wetlands.org/download/3016/

[10] https://amber.international/european-barrier-atlas/

[11] REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL AND THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE. The state of nature in the European Union Report on the status and trends in 2013 - 2018 of species and habitat types protected by the Birds and Habitats Directives https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0635&from=EN page 16.

[12] In addition, longitudinal continuity for fauna can be affected by changes to water quality that lead to ecological barrier effects caused by pollution or alterations in water temperature.

[13] Grill, G., Lehner, B., Thieme, M. et al. Mapping the world's free-flowing rivers. Nature 569, 215–221 (2019). https://doi.org/10.1038/s41586-019-1111-9

sections of the river channel, but also the river with its surrounding floodplains, riparian zones or wetlands. In this regard, the ecological quality of the reconnection should also be considered, including the length of reconnected river, the natural habitats which can be reconnected, the potential for reconnecting the riparian zone, the protection status of the reconnected river stretch as well as the position of the barrier inside protected areas.[14]

Care in prioritisations of basins or stream networks for restoration is critical, not only to focus restoration to the most valuable habitats, but also to avoid potential situations where the WFD and HD objectives are at cross-purposes. For example, this might happen when restoring water bodies to achieve Good Ecological Condition under the WFD causes the loss of Natura 2000 habitats or species which have developed in an artificially modified or managed environment (e.g. reconnection of oxbows lakes).

Focus on hydromorphological restoration

The upcoming Nature Restoration Law should have a specific focus on how the targets will address the hydromorphological elements of aquatic ecosystems and their functionality. Hydrological connectivity is essential for maintaining freshwater biodiversity.[15] Hydromorphological processes drive longitudinal, lateral and vertical connectivity within river networks and surrounding corridors, the assemblage and turnover of habitats, the movement of sediment and structures, and the ecosystems associated with the diverse mosaic of continuously changing habitats. All of these processes and structures are relevant to ensuring that robust, enduring habitats can support the entire life cycle of organisms including refugia, feeding and spawning.[16]

Despite the fact that natural hydromorphological dynamics are fundamental in supporting ecosystem function and quality, hydromorphological elements are generally not fully considered in the application of the WFD classification system of water bodies. This can potentially lead to further modifications and deterioration.[17] For instance, conditions for the three hydromorphological quality elements (hydrological regime, river continuity and morphological conditions) are only specified for High status, but not for Good and Moderate Status. **A wider consideration of the needed functioning of hydromorphological elements under the future Nature Restoration Law would enhance the ability of Member States to conserve and restore water bodies.**

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[14] WWF is working on a study using those parameters, expected in Q2 2021.
Other prioritisation tools include:

- TNC: an interactive, GIS based decision support tool using a large set of data (morphology, infrastructure, biotic, etc.) which can be queried for various outcomes (cost effectiveness, biodiversity impact, interventions for target species improvement). While it has been used in the USA for many years, it is currently being field tested in two watersheds in Slovenia to illustrate how the tool can be applied in Europe. It will be ready for demonstration in Q2 2021.
- BOKU University (Vienna): a prioritization tool/multicriteria analysis (FEM- Floodplain Evaluation Matrix) using different type of hydrological, hydraulic, socio-economic and biodiversity parameters.

[15] Van Rees, C.B. e.a. (2020). Safeguarding Freshwater Life Beyond 2020: Recommendations for the New Global Biodiversity Framework from the European Experience. Preprints 2020, 2020010212 (doi: 10.20944/preprints202001.0212.v1).

[16] A.M. Gurnell, e.a. (2014) A hierarchical multi-scale framework and indicators of hydromorphological processes and forms. Deliverable 2.1, a report in four parts of REFORM (REstoring rivers FOR effective catchment Management), a Collaborative project (large-scale integrating project) funded by the European Commission within the 7th Framework Programme under Grant Agreement 282656.
https://www.reformrivers.eu/system/files/D2.1%20Part%201%20Main%20Report%20FINAL.pdf

[17] Nones, Michael (2015). Sediment management of rivers and water framework directive: the case of the spree river. E-proceedings of the 36th IAHR World Congress, 28 June – 3 July, 2015, The Hague, the Netherlands.
https://www.researchgate.net/publication/280306278_Sediment_management_of_rivers_and_Water_Framework_Directive_the_case_of_the_Spree_River

Large-scale restoration of longitudinal and lateral continuity for hydrologic and sediment transport and mitigation of hydrological alteration can help improve the link between the (local) conservation of Natura 2000 freshwater sites and catchment scale processes (e.g. hydropeaking, sediment deficit, lack of morphologically active floods). The hydromorphological character of river reaches depends not only on interventions and processes within the reach but also within the upstream and sometimes the downstream catchment (which may cross the national boundaries).[18] However, pressures from upstream are often outside the sphere of control of the management authority and may happen within water bodies that are in Good Ecological Status, meaning that strictly speaking, the relevant authorities do not have to intervene or may find it challenging to justify the investment. Proper river basin management planning should address such situations, but in practice the preservation of whole connected systems of habitats and species under the HD is hampered.

Growing scientific knowledge indicates that the natural hydromorphological systems are generally more resilient to sudden events and have faster recovery so approximation of natural conditions through restoration is a win-win situation i.e. for flood protection and biodiversity.

Restoration targets for freshwater ecosystems set in the upcoming Nature Restoration Law should focus on basin-scale restoration of river continuity to ensure better integration of the WFD and HD implementation as well as targets to restore lateral connectivity through restoration of floodplains and wetlands.

Restoration of water bodies not addressed in the implementation of the WFD and HD

Although the WFD aims to protect, enhance and restore all bodies of surface water, its implementation is focused on the designation of water bodies *i.a.* based on the size of the catchment area, only considering the largest rivers (catchment >10km^2) and lakes (>0.5 km^2 surface area).[19] Other water bodies, especially small lakes, ponds, headwater streams, temporal or ephemeral rivers, floodplains, and ditch systems are largely excluded despite the fact that they provide some of the most important, abundant and diverse aquatic habitats.

In its *Resolution 2020/2613(RSP) on the Implementation of the Water Legislation*, the European Parliament "[c]all[ed] on the Commission and the Member States to enhance the synergies between water and biodiversity policies by introducing appropriate measures to better protect small water bodies and groundwater [dependent] ecosystems in the context of river basin management, including reporting requirements, guidance and projects".[20]

The HD protects small standing and running waters but relies on other mechanisms for dealing with major catchment pressures (e.g., diffuse pollution)[21] while the provisions of its Article 10 are poorly implemented and enforced. Moreover, small water bodies are insufficiently represented in the Natura 2000 network.[22]

For example, the presence of standing waters in floodplains (backwaters and ponds) significantly enhances biodiversity in the system but is overlooked in existing legislation and/or its implementation. To improve bioindicators outside the channel, the entire functional river–floodplain ecosystem needs

[18] A.M. Gurnell, e.a. (2014) – see footnote 7.
[19] Water Framework Directive, annex II.
[20] Paragraph 39, https://www.europarl.europa.eu/doceo/document/TA-9-2020-0377_EN.html
[21] Sayer, C.D. (2014). Conservation of aquatic landscapes: ponds, lakes, and rivers as integrated systems. WIREs Water 2014, 1:573–585. doi: 10.1002/wat2.1045
[22] Paragraph 5.3, EEA (2020). State of nature in the EU, Results from reporting under the nature directives 2013-2018. EEA report | No 10/2020.

to be considered. Restoration activities need to cover not just the stream itself but also adjacent wetlands, headwaters and riparian habitats. Moreover, protection, restoration, and appropriate management of headwater areas with networks of (farmland) ponds, ditches, and small streams should increase connectivity for native aquatic species, while providing benefits downstream in terms of flood attenuation and water quality improvement.[23]

Groundwater is interacting with rivers, streams, wetlands and springs, and is an important element of the water and river ecosystem network in the landscape. The exchange of water between rivers, streams, floodplains, and groundwater bodies is essential in the river corridors, connecting aquatic and terrestrial habitats. However, the groundwater bodies under the WFD are often too big to prevent deterioration of groundwater-dependant species and habitats.

Disconnection from riverine landscapes, straightening, damming, hydro-peaking from dam operations, and gravel extraction accompanied by agricultural and sewage nutrients, pesticides, and invasive species further exacerbate river degradation in many European regions. Each impact causes problems for river ecology and biodiversity, and our human benefits; all together it means our rivers need enormous ambition and resources to be restored and then protected.

Restoration activities need to focus on all of the freshwater habitats in the landscape, including groundwater bodies and on the linkages between them and surface waters, following an integrated approach. Therefore, **we recommend the development of binding targets for restoration of wetlands and interconnected (small) water bodies with high biodiversity or biodiversity potential, currently outside the implementation of the WFD and HD. If added, they would build a more coherent, functional and lasting "green-blue infrastructure" network.**

Integrated and nature-based solutions and green-blue infrastructure along rivers

Current investments in water solutions are strongly related with grey infrastructure such as dikes and dams as part of infrastructure projects serving only one sectoral objective. They often have significant negative impacts on freshwater ecosystems, including accumulated impact from several hydropower plants or other infrastructure in the same catchment. To increase coherence between the WFD, the Floods Directive, Biodiversity Strategy and other sectoral policies such as climate change adaptation, agriculture and spatial planning, Member States should apply integrated river restoration measures which can both improve the ecological functioning and biodiversity status of water bodies and address the objectives of multiple policies. These measures and other types of NbS can play a central role in mainstreaming biodiversity across sectoral policies, as they benefit and are based on biodiversity, while also delivering multiple wider societal, environmental and economic benefits. Therefore, their full potential should be tapped to contribute to the EU Biodiversity Strategy to 2030.[24] Examples and guidelines of NbS in river restoration have been developed and are ready for practical use in many European rivers and streams.[25] Unfortunately, in the majority of Member States there is a deficiency in the adoption of NbS.[26]

[23] Sayer, C.D. (2014). Conservation of aquatic landscapes: ponds, lakes, and rivers as integrated systems. WIREs Water 2014, 1:573–585. doi: 10.1002/wat2.1045

[24] Sandra Naumann and McKenna Davis (2020). Biodiversity and Nature-based Solutions, Analysis of EU-funded projects. European Commission, Directorate-General for Research and Innovation. https://www.ecologic.eu/sites/files/publication/2020/naumann-20-biodiversity-and-nature-based-solutions.pdf

[25] See e.g. IUCN National Committee United Kingdom, Stephen Ally et al., River Restoration and Biodiversity. Nature-Based Solutions for Restoring the Rivers of the UK and the Republic of Ireland; Georg Hermannsdorfer (2020), Renaturierung von Fließgewässern: Praxishandbuch für naturnahe Bauweisen; Heinz Patt (2018), Naturnaher Wasserbau: Enwickeln und Gestalten von Fließgewässern

[26] Wetlands International (2020), Time for a new recipe for flood risk management in Europe. https://europe.wetlands.org/download/4684/

Rivers in Europe are most important corridors for biodiversity and for many migratory species. Large free-flowing rivers should be the backbones of green-blue infrastructure in Europe. With the river as a dynamic connecting lifeline in the centre, ecological river corridors are able to not only connect landscapes as a linear element from source to sea but should be broad enough and contain diverse terrestrial ecosystems at its margins to be functional and flexible, while also protecting people and some habitats from floods whilst enabling habitat connectivity in and around settlements and cities where communities have some of their most important connections to nature.

Restoring connectivity and habitats in mainstream and tributary rivers should be a priority for restoration of key long-distance and most endangered fish species. The measures to conserve the European eel and the Pan-European Action Plan for Sturgeons[27] are important elements to save migratory fish species and should be fully implemented to support the achievement of the targets in the European Biodiversity Strategy for 2030.

Several projects provide good examples that should be replicated for migratory fish species restoration and protection. One is the Danube MEASURES project (Managing and restoring aquatic ecological corridors for migratory fish species in the Danube river basin). However, yet until 2030 connectivity and habitat restoration should also be implemented in the upper sections of rivers as set in the Pan-European Action Plan for Sturgeons and more broadly in the objectives for Salmon and European Eel conservation.

Under the upcoming Nature Restoration Law, river and wetland restoration measures and other NbS which maintain and improve biodiversity whilst providing societal benefits should be given priority over single-objective solutions (such as grey infrastructure) to water-related problems. **A "nature-based" requirement should be introduced to EU funds earmarked for investments in water, climate, disaster risk reduction, energy, agricultural and transport sectors, so that only interventions which both address societal challenges and preserve or improve biodiversity conservation can benefit from public funds.** This could be supported by UN guidelines, EU-supported research and guidance documents, and the IUCN global standard for nature-based solutions with associated NbS self-assessment tool.

Management of rivers post-restoration

Restoration measures should result in restored functionality and hydromorphological processes which are more resilient, deliver high quality nature and as often as possible require minimal if any "maintenance". It should be noted that approaches that bring the whole hydrological system of watershed closer to its natural state have greater chances of achieving stability in the new restored conditions through changing climate conditions. Ideally, the free-flowing state and habitat restoration would be secured through lasting river and/or watershed protection measures. Nevertheless, some effects of river restoration projects may vanish over time, causing restored areas to lose their ecological functions and services.

This could be especially true in rivers which support many important socio-economic services such as navigation, irrigation, recreation, and flood protection (e.g. large lowland rivers), where restoration to an undisturbed condition is not feasible. Restoration measures are often restricted within the

[27]Convention on the Conservation of European Wildlife and Natural Habitats (2018), Pan-European Action Plan for Sturgeons. https://ec.europa.eu/environment/nature/conservation/species/action_plans/pdf/Sturgeon action plan.pdf

boundaries of modified dynamic forces of regulated rivers [28], but could more often include adjacent protected, natural or other landscapes that could be flooded or provide a large-enough segment of riparian habitat to provide added benefits (e.g. flood mitigation, riparian habitat, riverine benefits). The effectiveness of restoration depends on both the extent to which the project is self-sustaining (sufficiently supporting natural processes) and the required maintenance frequency (based on the life span of the restoration project), to ensure continued ecological functioning. For example, flow conditions of reconnected floodplain channels in regulated lowland rivers – important fish nursery habitat – may decrease over time due to channel aggradation or incision due to lack of system-appropriate flood timing and intensity, sediment starvation from upstream dams, or evolution of new side channels.[29]

Targets for river restoration should include effective management post-restoration to ensure the restored river systems maintain the environmental processes needed to meet the project goals, such as the occurrence of target species, habitats, and processes. This is especially relevant for anthropogenically modified rivers where periodic human intervention may be necessary for (re)creating optimal habitat characteristics (e.g. adaptive management to sustain ecological flow regimes at the right timing and frequency needed for biotic cues and both short and long-term channel migration).

Monitoring of ecological status of rivers

Under the WFD, monitoring efforts have increased significantly but results often remain, to a significant extent, ambiguous.[30] The assessment of Biological Quality Elements (BQEs) - considered good indicators of water quality - defines the ecological status of rivers. Recent studies showed that these BQE-based metrics and indices are sensitive to water quality alteration and general habitat degradation, but their response to hydromorphological degradation is generally weak or absent and restoration actions show contrasting results for the BQEs' richness and abundance.[31, 32]

Moreover, the standard application of WFD-compliant biotic indices is limited to flowing channels. Sampling sites are generally located along the main channel, whereas side channels and lentic sites within the river corridor are generally not sampled. If river restoration projects involve adjacent wetlands and habitats, as recommended above, the monitoring programmes will need to include the active river area (including backwaters, meander belts, and riparian buffer) to allow a more appropriate and detailed evaluation of the ecological conditions of the whole river corridor.[33]

Relying exclusively on the BQE-based indices and metrics does not allow a comprehensive assessment of the ecological conditions of the whole river corridor, in particular in large multiple-thread river

[28] T. Stoffers, F.P.L. Collas, A.D. Buijse, et al. (2021). 30 years of large river restoration: How long do restored floodplain channels remain suitable for targeted rheophilic fishes in the lower river Rhine? Science of the Total Environment, Volume 755, Part 1, 10 February 2021, 142931 https://doi.org/10.1016/j.scitotenv.2020.142931

[29] Idem.

[30] Critical gaps in the approaches include insufficient spatial and temporal scales of monitoring (resulting for example in discrepancies between the length of the monitoring programme and the time needed for the restoration measure to reach its ecological potential), lack of reference conditions, and insufficient consideration of all the cause-effects relationships involved. Source: CIRF and Wetlands International (2017). Benefits of European river restoration schemes, An analysis of 13 case studies aiming to integrate improvement of ecological conditions and flood risk mitigation. https://europe.wetlands.org/download/2535/

[31] CIRF and Wetlands International (2019). Successes of EU Water Framework Directive implementation, Evidence of river restoration measures improving ecological conditions. https://europe.wetlands.org/download/3279/

[32] Van Rees, C.B. e.a. (2020).

[33] See for example: Wetlands International Europe, Case study: River Restoration – River Glaven, https://europe.wetlands.org/casestudy/case-study-river-restoration-river-glaven/

systems, but also in smaller systems.[34] An incomplete evaluation could lead to incorrect planning in river management and restoration actions. The application of promising biotic evaluation tools based on functional traits or indicators of ecosystem functioning might provide deeper insights into the assessment of river conditions, particularly in the context of multiple pressures.[35] Additional metrics which should be considered include the appropriate connectivity for long-distance migratory fish (supporting the presence of native species) and hydrogeomorphologic health (the free flow of nutrients, sediment, and in-stream structure through the system). Furthermore, specific monitoring activities are needed to track habitat/species "migration" outside currently protected areas which are likely to be even more important with climate change.[36]

The WFD and HD provide a good basis for monitoring. On top of this, the upcoming Nature Restoration Law should require **long-term monitoring programmes of important freshwater biodiversity variables (e.g. relative population size, species diversity, habitat quality indices including those not threatened) and other indices of holistic functioning riverine systems**. **These programmes should deliver an appropriate assessment of the entire fluvial corridor, also considering the lateral dimension of the river system.** They would help identify better the pressure factors to be tackled related to the hydromorphological character of rivers (see above).

River protection

The EU Biodiversity Strategy provides new prospects for a more holistic vision of a European network of strictly-protected, healthy, dynamic and free-flowing rivers. This policy aims to both protect and restore the key properties of rivers: the free flow of water, sediment dynamics, and connectivity in all dimensions. Protecting the pathways rivers create and allowing the river to continuously renew itself and adapt–is what river conservation requires.

There is a paucity of protected freshwater systems around the world and Europe is no exception. Riverine ecosystems in particular have not been a priority in the planning, design, management, and evaluation of protected area schemes to date. Freshwater fish are the taxonomic group with both the largest number of threatened species and the lowest proportion of these covered by the Nature Directives' annexes (13%).[37] To stem the rapid decline in freshwater ecosystems, more and more effective protective measures need to be designed and implemented in ways that meet biodiversity needs.

Measures are beneficial when they simultaneously support multiple local social and cultural values, economic livelihoods, and have the political and legal frameworks required to sustain protections over time given changing natural and social conditions. The core characteristics of good protection include: adequate planning, designation instruments, stakeholder engagement, management planning, enforceability, institutional arrangements (e.g. river basin commissions), supportive political climate (local and regional), funding, and a system for evaluation and adaptive management.[38] Protective mechanisms include legal designation of protected surrounding riparian and watershed areas, protected ecological flow regimes, and protective management zoning.

[34] See for example the aforementioned case study of the River Glaven.
[35] CIRF and Wetlands International (2019). Successes of EU Water Framework Directive implementation, Evidence of river restoration measures improving ecological conditions. https://europe.wetlands.org/download/3279/
[36] Brink et al. 2018. From Sea to Source 2.0 Protection and restoration of fish migrations in rivers worldwide. World Fish Migration Foundation Publisher April 2018.
[37] Hermoso, V., Morán-Ordóñez, A., Canessa, S. et al. Realising the potential of Natura 2000 to achieve EU conservation goals as 2020 approaches. Sci Rep 9, 16087 (2019). https://doi.org/10.1038/s41598-019-52625-4
[38] The Nature Conservancy 2020 (in print). Durable River Protection: A special report by The Nature Conservancy.

With the millions of euros spent on both river restoration and adaptive management of flows, extractions, and transportation needs and the associated scientific, engineering, political and social buy-in, there is a strong argument for establishing durable freshwater protection measures to prevent hard-won successes from back-sliding.

Most importantly, once restored the rivers' free-flowing character needs permanent and strict protection inter alia against new damaging installations. This should be combined with protections for remaining and much rarer free-flowing rivers. In such way, a European network of protected free-flowing rivers can take shape.

The EU needs a framework for evaluating, prioritising, funding and creating legal mechanisms to implement durable freshwater protection on its own and as an overlay when restoration practices have been implemented. These protection measures need to be embedded in an adaptive framework for a river basin management plan that allows updating the plan and protection measures (rules, management zones, legal designations) to address reoccurring and new threats to aquatic biodiversity and the processes that support it.

The EU has committed itself to legally protect a minimum of 30% of the EU's land area and 30% of the EU's sea area and integrate ecological corridors, as part of a true Trans-European Nature Network, and strictly protect at least a third (10% of the EU's land and sea area) of the EU's protected areas. Knowing how fragile freshwater habitats are, restored, and existing free-flowing rivers should receive additional and more intentional legal protection. A good example is the US Wild and Scenic Rivers Act in force "to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations."[39] These measures ensure durability and are needed to support a European blue infrastructure network. It would help avoid further alteration of river morphology and function from a "free-flowing status" and create conditions that supports more resilient biodiversity.

We recommend the upcoming Nature Restoration Law requires restored and free-flowing rivers to be kept in their free-flowing status. They should be integrated (added) to the 30% of legally protected land area target proposed in the Biodiversity Strategy.

Funding

There is a need for increased investment in measures addressing river ecosystem restoration needs.[40,41] Many Member States failed to provide funding to implement the proposed measures in the first and second RBMPs. EU funding for WFD and Nature Directives implementation is integrated into the budget of the LIFE financing instrument and is highly dependent on (much larger) financial instruments in other sectoral policies (CAP, Regional Funds, Next Generation EU).[42] If the EU is to deliver on its objectives under the Biodiversity Strategy, it must tackle the finance gap for nature protection and restoration and reduce the impact of much larger sectoral policy frameworks. For example, funds for flood protection should recognise importance of NbS (i.e. floodplains as natural flood retentions) and promote and fund such projects.

[39] Available at https://www.nps.gov/orgs/1912/faqs.htm

[40] REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC). COM(2019) 95 final.

[41] Bernhardt, E. S. et al. 2005. Synthesizing US River Restoration Efforts. Science 29 April 2005. Vol. 308, Issue 5722, pp. 636-637.

[42] Carvalho, L. e.a. (2019). Protecting and restoring Europe's waters: An analysis of the future development needs of the Water Framework Directive. Science of The Total Environment, Volume 658, 25 March 2019, Pages 1228-1238.

Incentives are needed for positive impacts on biodiversity and environmentally harmful subsidies should be phased out. The increase in investment should come first from a shift in funding provided by existing financing mechanisms[43] to minimize public funding for projects conflicting with biodiversity objectives. On top of that, funding mechanisms could include blended instruments (loans and public funding), philanthropy, "revolving funds", corporate investments (especially corporates with a large impact on freshwater ecosystems) and insurance industry funding for natural flood management measures to decrease costs of flooding.

To increase investment in river restoration actions, we recommend earmarking funds to measures dedicated to key restoration needs of freshwater ecosystems including improvement of river continuity and ecological flows, natural water retention measures, floodplain and habitat restoration and specific restoration of sediment dynamics and modified bed and bank structures. This should be done through:

- **Maximising opportunities in the existing financial structures (EU Agricultural Funds, European Structural and Investment Funds, Next Generation EU);**
- **Adding new funding mechanisms (such as blended instruments or insurance industry funding) and the creation of a dedicated EU restoration fund (or facility within some other fund) in the MFF.**

Communication, Monitoring Progress, and Education

We suggest that the Commission creates a "dashboard" system, in which the progress towards the no deterioration of rivers and freshwater ecosystems as well as progress on target to restore rivers into the free-flowing state can be monitored and publicly communicated. It must clearly reflect both positive or negative trends by biogeographic region and by broadly interconnected networks.

Living Rivers Europe is a coalition of six environmental and angling organisations: **WWF's European network**, the **European Anglers Alliance**, **European Environmental Bureau**, **European Rivers Network**, **Wetlands International Europe** and **The Nature Conservancy**. Living Rivers Europe puts forward a strong vision of healthy river ecosystems flourishing with wildlife to the benefit of society at large, the economy and sustainable development in Europe. To make this vision a reality and give our water ecosystems a real future we stress the importance of an ambitious implementation of the EU Water Framework Directive and related policies. Together with our members and supporters, representing a dedicated movement of over 40 million people across Europe, we aim to ensure that the loss of aquatic wildlife is halted and reversed and that European waters are managed more sustainably.

[43] For example, under the CAP, substantial share of funds should be allocated to eco-schemes (e.g. natural water retention on agricultural land) or other solutions to effectively incentivise the agriculture sector for land use change in restored areas, and ensured these incentives do not end up as a low-ambition flat-rate payment for all farmers.