Restoration of the Danube River Basin for ecosystems and people from mountains to coast

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Reconnect Rivers, Floodplains and Delta

Our waters - restoring the longitudinal connectivity of Romanian rivers – INTERNATIONAL SEMINAR

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AGENDA

PART ONE – Catalogue of actions

- Defining connectivity
- Legislation and Strategies summary
- Projects and databases
- Methods and tools overview

PART TWO – Longitudinal connectivity for fish in the DRB

- Technique used
- Challenges and Solutions
- Demonstration

DEFINING CONNECTIVITIES

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Free-flowing river

"The 25 000 km of free-flowing rivers is intuitively easy to understand: it suggests rivers (and lakes) in a natural state, undisturbed in their natural functions, unhindered by artificial barriers."

"However, there is no established consensus as to what criteria would define a free-flowing river that could count towards the EU target. Similarly, **a ready-to-use indicator to measure free-flowing rivers currently does not exist**."

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Connectivity dimensions

Connectivity - Type

- Longitudinal
- Lateral
- Vertical
- Temporal

Connectivity - Aspect

- Flow
- Sediment
- Biota
- Physicochemical
- Nutrient

Connectivity - Scale

- Local
- River
- River Reach
- River basin

AI-generated image

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LEGISLATION AND POLICIES

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Flood Directive

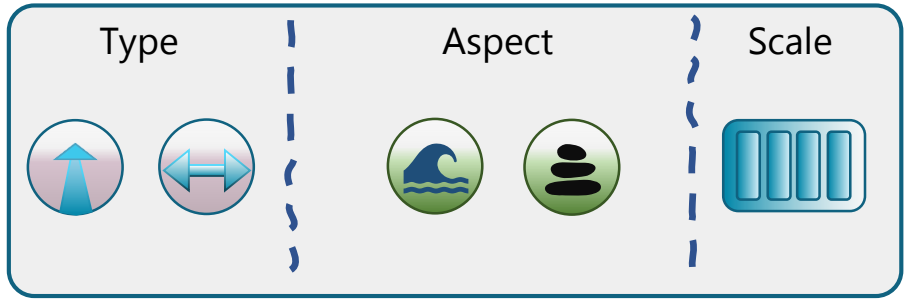
In legislation

EUR-Lex - 32007L0060 - EN - EUR-Lex (europa.eu)

Description

It promotes holistic and integrated approach for flood risk management, taking into account prevention, protection, preparedness and recovery measures.

Connectivity



Relevance for D4A

Suggests nature-based solutions and natural water retention measures.

Birds and Habitat Directive

In legislation

Natura 2000 - Environment - European Commission (europa.eu)

Description

Natura 2000 is the largest coordinated network of protected areas in the world. It offers a haven to Europe's most valuable and threatened species and habitats.

Connectivity

Relevance for D4A

Information is available on habitat sites, species, population size and conservation status.

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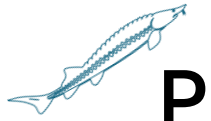
Summary on EU legislations

	Longitudinal	Lateral	Vertical	Temporal	Flow	Sediment	Biota	Physico-chemical	Nutrients
Water Framework Directive	X			X	X	X	X	X	X
Flood Directive	X	X			X	X			
Birds and Habitat Directive		X					X		
Integrated sediment management for WFD	X	X				X			
ICPDR Management Plan 2021 update	X	X			X	X	X	X	X
EU Strategy for Danube basin	X	X			X	X	X		
CEN standard for water quality	X	X			X	X	X	X	
Riparian Forest Corridor		X					X	X	
Dry Habitat strategy		X			X		X		
Biodiversity Strategy	X	X			X	X	X		
Nature Restoration Law	X	X			X	X	X		

PROJECTS AND DATABASES



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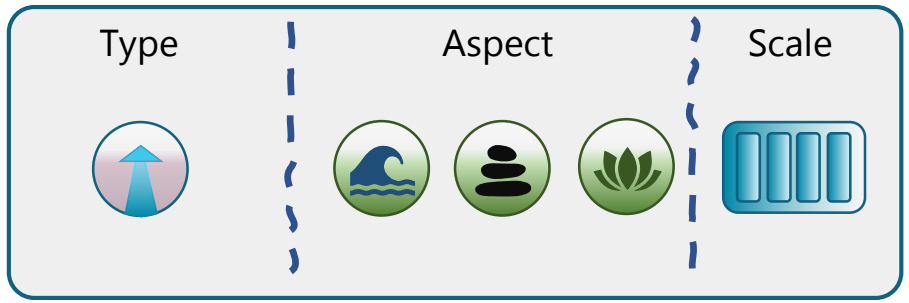
AMBER

AMBER, Adaptive Management of Barriers in European River

Keywords

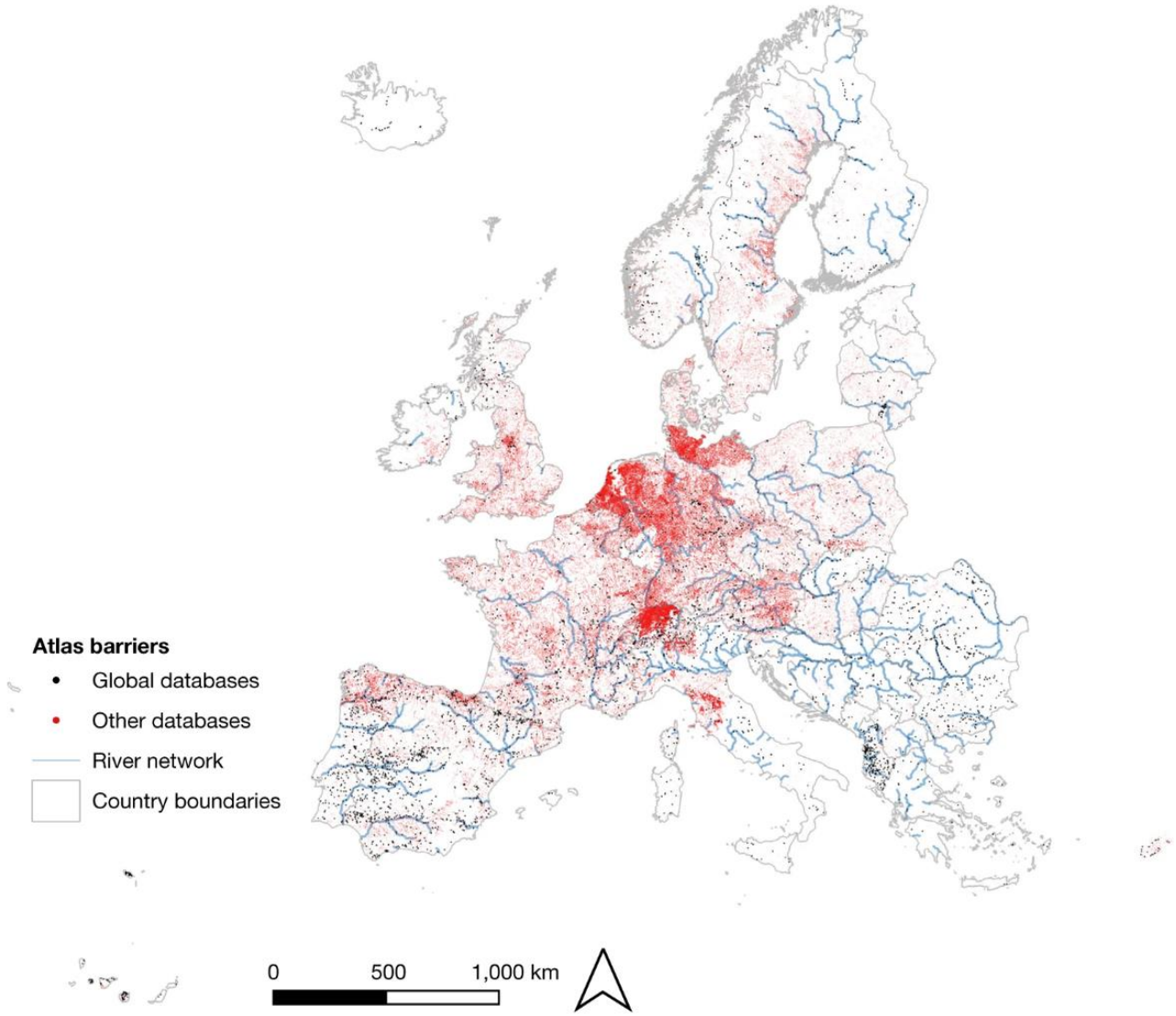
Holistic framework, hydropower, restoration guidance, citizen science, conservation, barrier management

Connectivity



Available data and information

EU wide barrier map for longitudinal fragmentation, decision support tools for managing and restoring river connectivity



The map shows the distribution of 629,955 unique barrier records compiled from 120 local, regional and national databases after duplicate exclusion. Red dots represent the new barrier records assembled in this study, whereas black dots represent large dams (>15 m in height) from existing global databases. The full georeferenced data can be downloaded from https://doi.org/10.6084/m9.figshare.12629051. Country and river networks were sourced from the European Environment Agency[35].

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Reported projects and data sources

AMBER

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Interreg
Danube Transnational Programme
DANUBEparksCONNECTED

Sediment Research & Management

Donaukommission – Commission du Danube – Дунайская Комиссия – Danube Commission
Austria Bulgaria Croatia Germany Hungary Moldova Romania Russia Serbia Slovakia Ukraine

Interreg
Danube Transnational Programme
coop MDD

NATURAVITA

DOORS
BLACK SEA

WePass

ICPDR IKSD
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

NWRM

Interreg
Danube Transnational Programme
MEASURES

Ljubljanica Connects

ENDANGERED LANDSCAPES PROGRAMME
Cambridge Conservation Initiative

Interreg
Danube Transnational Programme
DaRe to Connect

Mura-Drava-Danube
Austria, Slovenia, Croatia, Hungary, and Serbia

DANUBEPARKS
network of protected areas
WILD ISLANDS

DANUBE REGION strategy
Mobility | Waterways

WISE DRAVA

Interreg
Danube Transnational Programme
Sava TIES

ERTO
Copernicus Evolution – Research for harmonised and Transitional water Observation

DRAVALIFE
integrated river management

MERI
CHRISTIAN DOPPLER LABOR

Water - ForCE

Interreg
Danube Transnational Programme
lifelineMDD

Interreg
Danube Transnational Programme
Danube Floodplain

Interreg
Danube Transnational Programme
DanubeSediment

Interreg
Danube Transnational Programme
SIMONA

METHODS AND TOOLS

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Dendritic Connectivity Index (**DCI**)

Technique

Notes

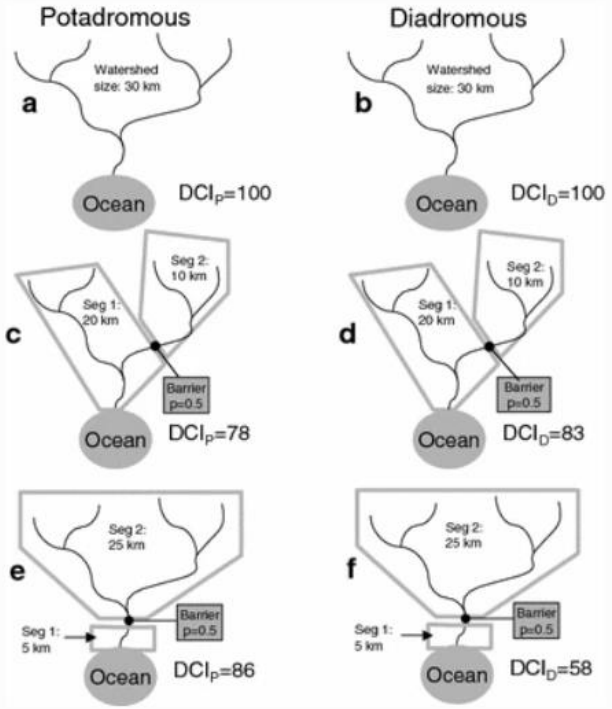
Assess connectivity based on expected probability of organism being able to move freely between two random points of the network. Flexible to use on various river structure and biological communities.

Connectivity

Data requirements

Number, passability, and location of barriers, river network

Fig. 1



Components of the Dendritic Connectivity Index (DCI). In systems with no barriers, the system is fully connected and the DCI has a maximum value of 100 for both life histories considered: potadromous (**a**) and diadromous (**b**). The introduction of a single barrier creates two stream sections, and the DCI is based on both the sizes (total channel lengths) of the resulting sections, the permeability of the barrier in both upstream and downstream directions (in this case, the product of the two permeabilities = 0.5) and in the diadromous case, the location relative to the downstream end (represented by the ocean) of the system (**b**, **c**). Changing the barrier location to create a greater inequality in stream section sizes results in a more connected system (higher DCI) for the potadromous life history (**e**), and moving the barrier closer to the ocean significantly reduces connectivity (lower DCI) for the diadromous life history (**f**)

Cote, D., Kehler, D.G., Bourne, C. et al. A new measure of longitudinal connectivity for stream networks. Landscape Ecol 24, 101–113 (2009). https://doi.org/10.1007/s10980-008-9283-y

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Satellite survey for river assessment (**Earth Observations**)

Technique

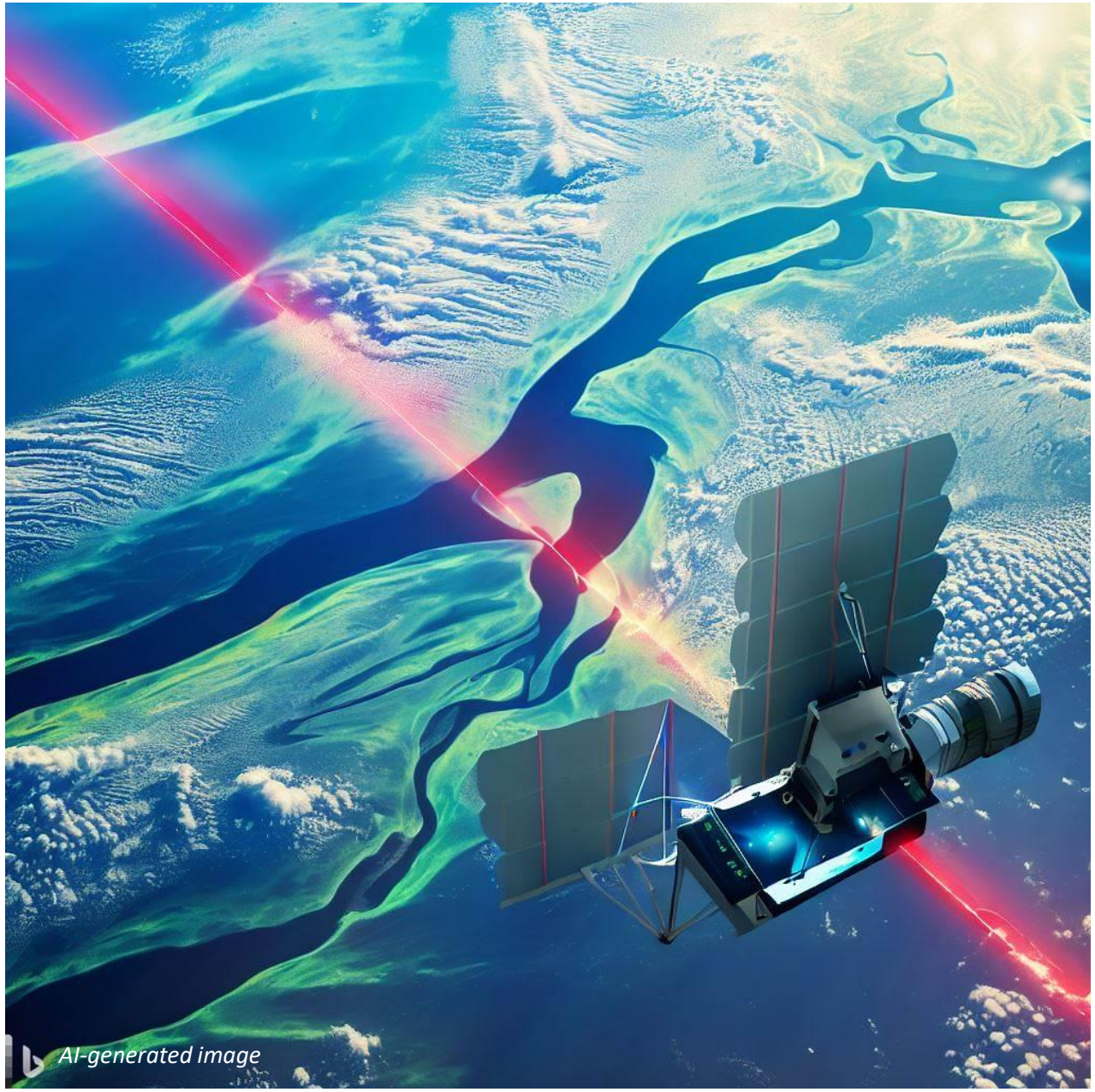
Notes

Promising technique to be used for connectivity analysis; developed workflow

Connectivity

Data requirements

Satellite data, field measurements for validation



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Connectivity Status Index (**CSI**)

Technique

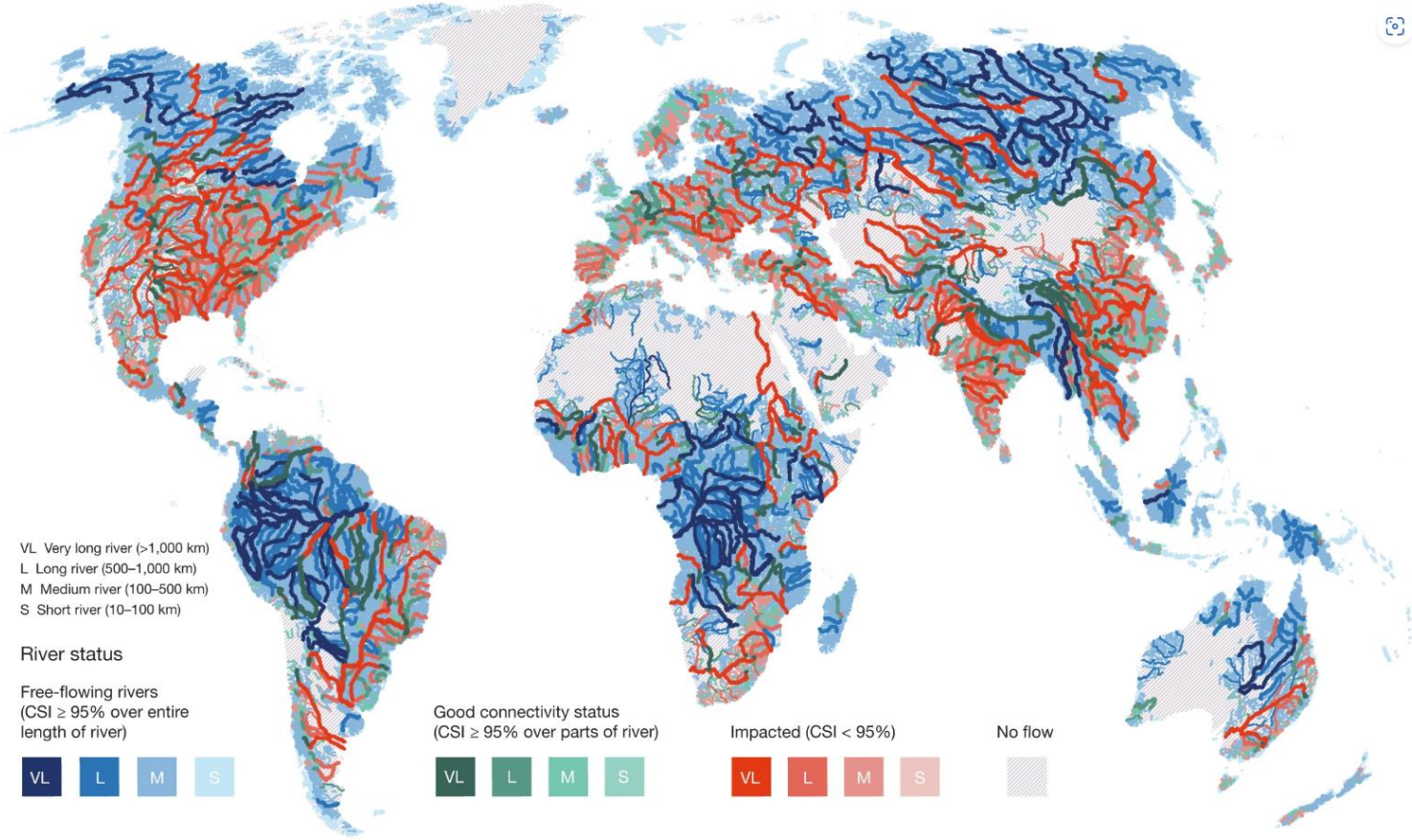
Notes

Takes into account several different factors;
Conceptualizes free-flowing river approach:
FFR where CSI for the river is 95% or above

Connectivity

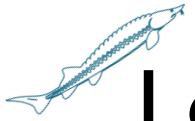
Data requirements

Rely on global datasets of hydrography and pressure indicators

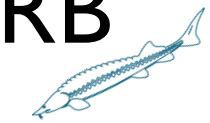


This map shows the global distribution of FFRs, contiguous river stretches with good connectivity status and impacted rivers with reduced connectivity. Rivers that are not free-flowing over their entire length (that is, partially below the CSI threshold) are divided into stretches with good connectivity status (that is, the connectivity status remains above the threshold throughout the stretch; green colours) and stretches where the connectivity status is below the CSI threshold (red colours). A list of FFRs longer than 500 km is given in Supplementary Table 1.

G. Grill et al., Mapping the world's free-flowing rivers. Nature 569, 215–221 (2019). doi: 10.1038/s41586-019-1111-9; pmid: 31068722



Longitudinal connectivity for fish in the DRB



TECHNIQUE USED

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Riverconn R package

Notes

Tool that calculates longitudinal connectivity indices following several methods;

https://damianobaldan.github.io/riverconn_tutorial/

Connectivity

Data requirements

River network, habitat suitability, location and passability of the barriers

Index name	Reference	Index type	Weight	c_{ij}	B_{ij}
Dendritic Connectivity Index (DCI)	Cote et al. (2009)	CCI	Reach length	Symmetric passabilities	No
Population Connectivity Index (PCI)	Rodeles et al. (2021)	CCI	Reach length	Symmetric passabilities	Exponential symmetric dispersal kernel
Probability of Connectivity (PC)	Pascual-Hortal and Saura (2006)	CCI	Reach/Habitat Area	No	Exponential symmetric dispersal kernel
Integral Index of Connectivity (IIC)	Pascual-Hortal and Saura (2006)	CCI	Reach/Habitat area	No	Binary symmetric dispersal probabilities
Volume-based River Connectivity Index (RCI_{VOL})	Grill et al. (2014)	CCI	Reach volume	Symmetric passabilities	No
River Class Connectivity Index (RCI_{CLASS})	Grill et al. (2014)	CCI	Reach volume, unique reach classes	Symmetric passabilities	No
River Migration Connectivity Index (RCI_{RANGE})	Grill et al. (2014)	CCI	Potential number of migratory fish species	Symmetric passabilities	No
Stream Continuity Index (SCI)	Shao et al. (2020)	CCI	Stream order, reach length	Symmetric passabilities	No
Dendritic Connectivity Index for diadromous fish (DCId)	Cote et al. (2009)	RFI	Reach length	Symmetric passabilities	No
Breeding Area Connectivity Index (BACI)	Rodeles et al. (2019)	CCI	Habitat area	Binary passabilities	No
Residual Core Length (RCL)	Fuller et al. (2015)	CCI	Reach length	Binary passabilities	No
Catchment Area Fragmentation Index (CAFI)	Jumani et al. (2022)	BFI	Barrier upstream area	Symmetric passabilities	No
Catchment Area Rainfall Fragmentation Index (CARFI)	Jumani et al. (2022)	BFI	Barrier upstream precipitation	Symmetric passabilities	No

Table 1. Examples of connectivity indices that can be calculated with 'riverconn'. Index type refers to the typologies introduced in this paper. CCI: Catchment Fragmentation Index, RFI: Reach Fragmentation Index, BFI: Barrier Fragmentation Index.

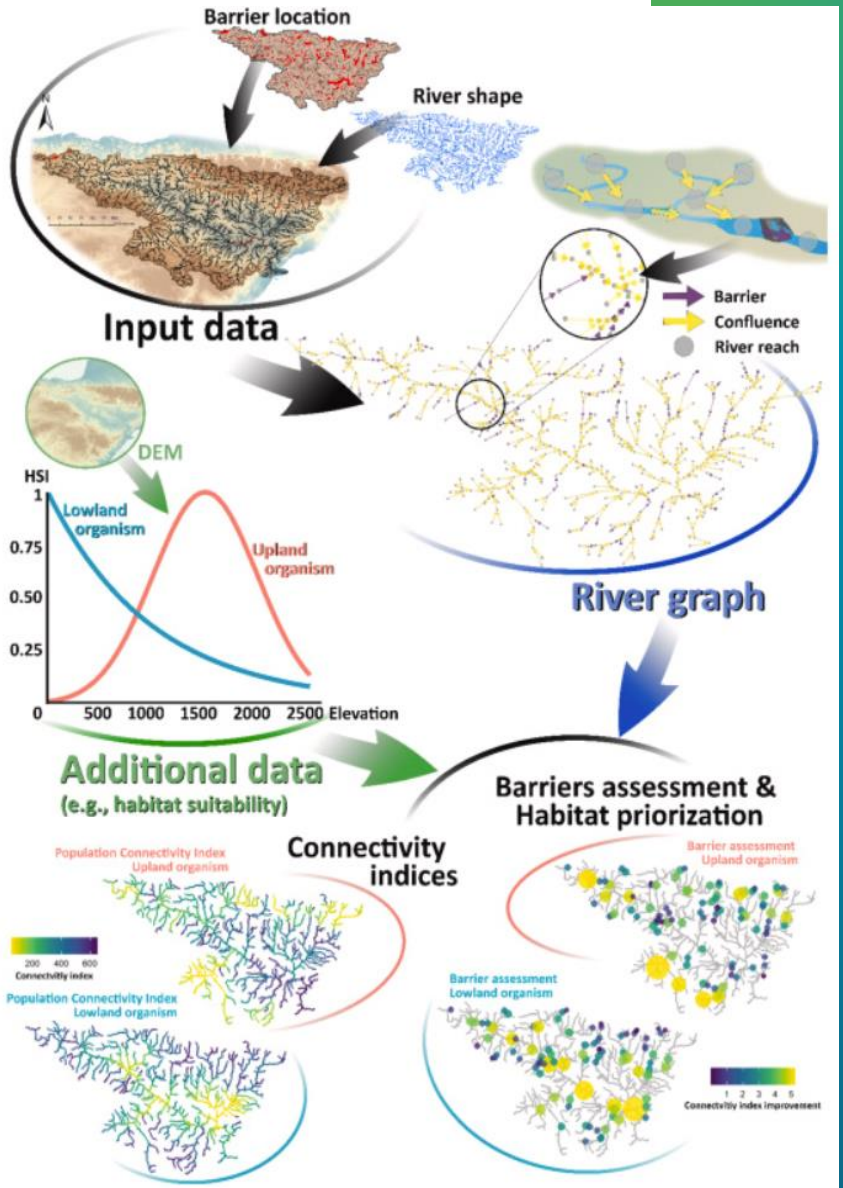
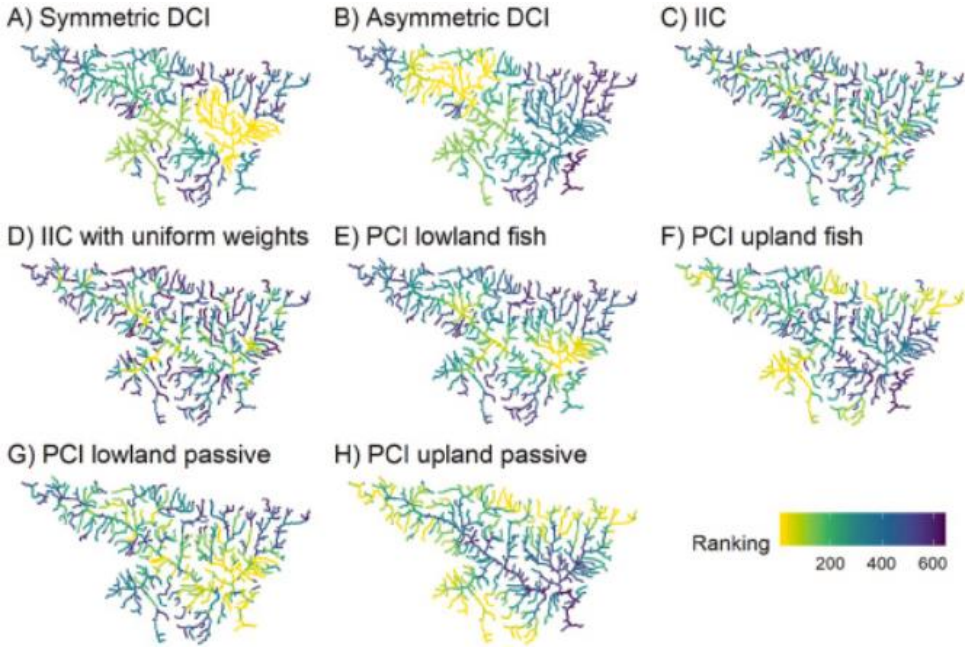


Fig. 1. Package workflow. DEM: Digital Elevation Model; HSI: Habitat Suitability Index.

Baldan, D., Cunillera-Montcusí, D., Funk, A., & Hein, T. (2022). Introducing 'riverconn': an R package to assess river connectivity indices. Environmental Modelling & Software, 156, 105470. https://doi.org/10.1016/j.envsoft.2022.105470

Riverconn usability



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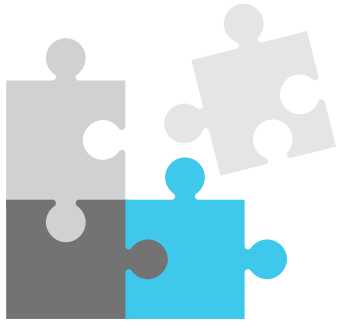

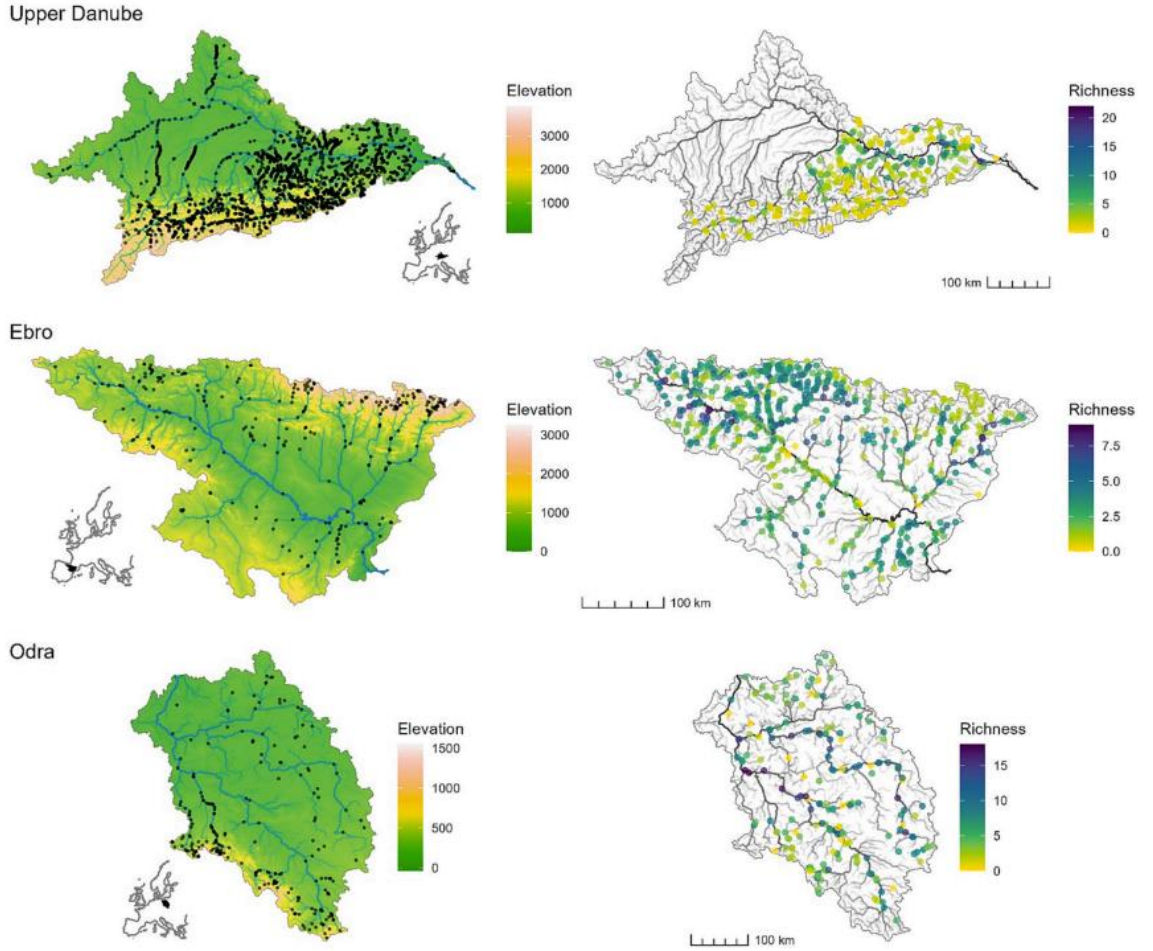

Fig. 1. Maps of the studied catchments. The left column shows the spatial distribution of the dams considered in this study. The right column shows the position of the fish sampling points used. Only streams with stream order greater than two are displayed.

Baldan, D., Cunillera-Montcusí, D., Funk, A., Piniewski, M., Cañedo-Argüelles, M., & Hein, T. (2023). The effects of longitudinal fragmentation on riverine beta diversity are modulated by fragmentation intensity. Science of the Total Environment, 903, 166703. https://doi.org/10.1016/j.scitotenv.2023.166703

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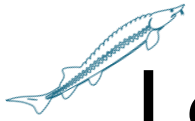

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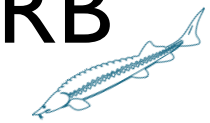

CHALLENGES AND SOLUTIONS

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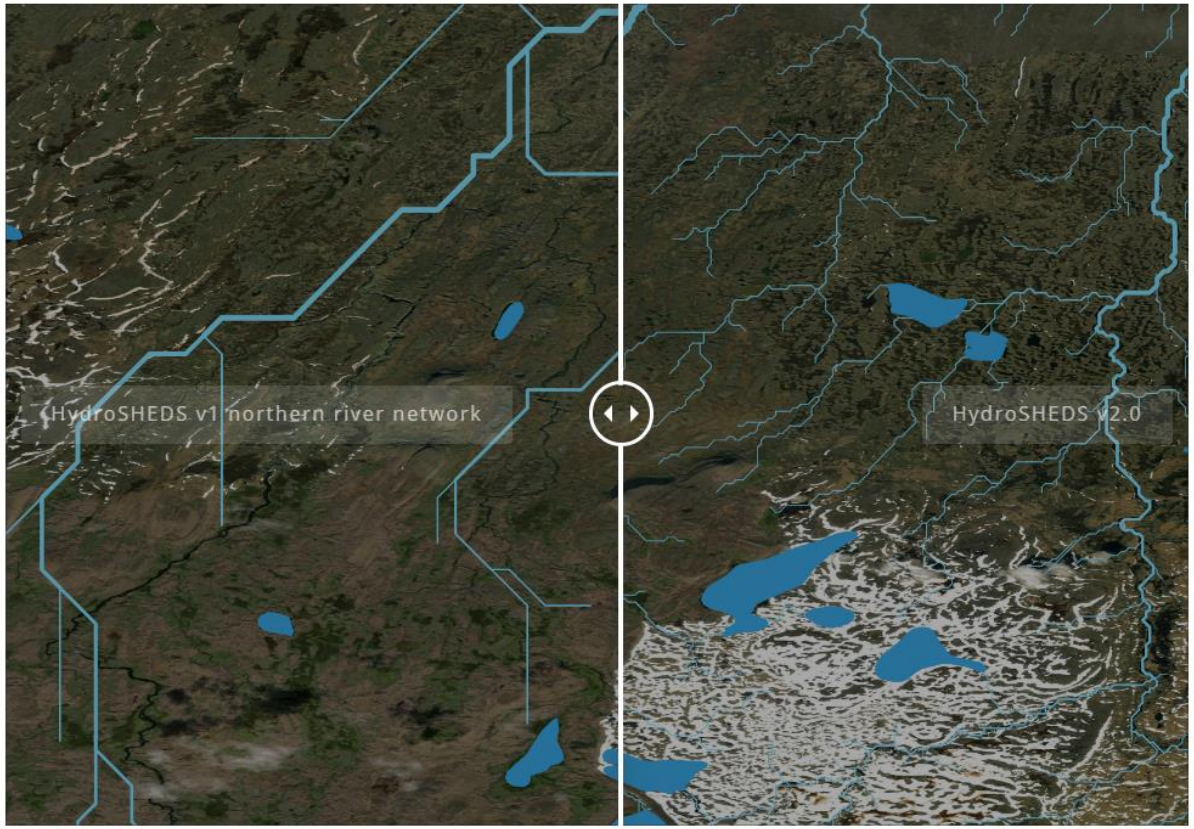
Challenges and solutions

RIVER NETWORK: HYDROSHED

Concerns and Solutions

- Inconsistent datasets (National, International & EU databases)

- Simplified (but consistent) dataset
  - Unrealistic layout on microscale
  - No islands, or branches, side arms included
- ICPDR evaluation criteria has been followed for tributary selection (>4000 km^2)



The left image depicts the HydroSHEDS v1 river network (produced in northern regions from coarser HYDRO1k elevation data) and the right image depicts the HydroSHEDS v2 preliminary river network (produced at 90 m resolution). Slide to compare the two river networks.

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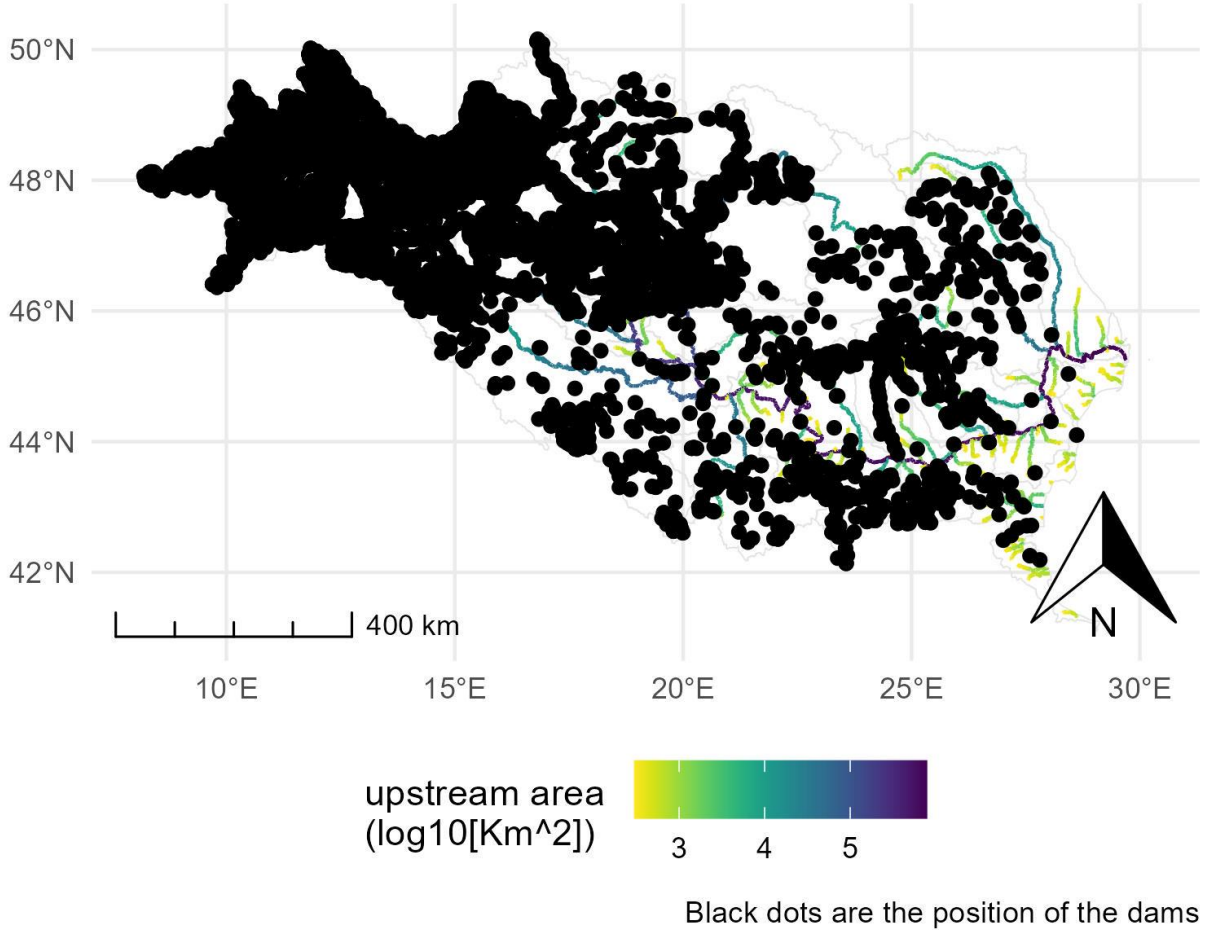
Challenges and solutions

BARRIER DATABASE:

Concerns and Solutions

- Incomplete datasets (e.g.: AMBER)
- Not only dams, but weirs, groynes, sills also found in some databases
- Passability assessment are mostly unknown
  - When any info is available, experts' judgement further is needed
- ICPDR dataset provide a good basis



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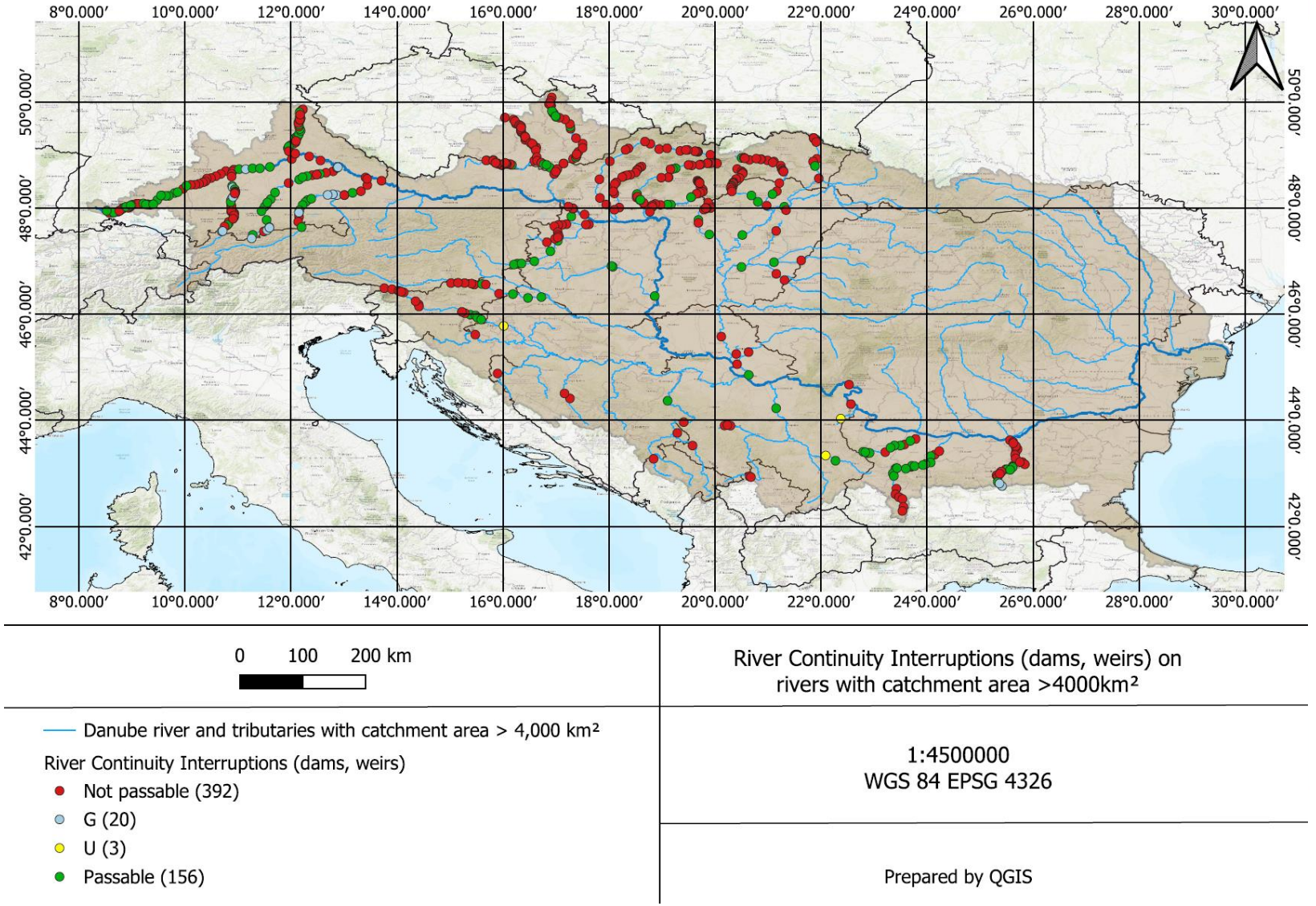
Challenges and solutions

BARRIER DATABASE:

ICPDR database:

- Access to the reported barriers and their binary passability from the most countries
- Austrian and Romanian barriers are upon request (?)



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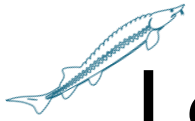

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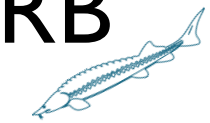

DEMONSTRATION

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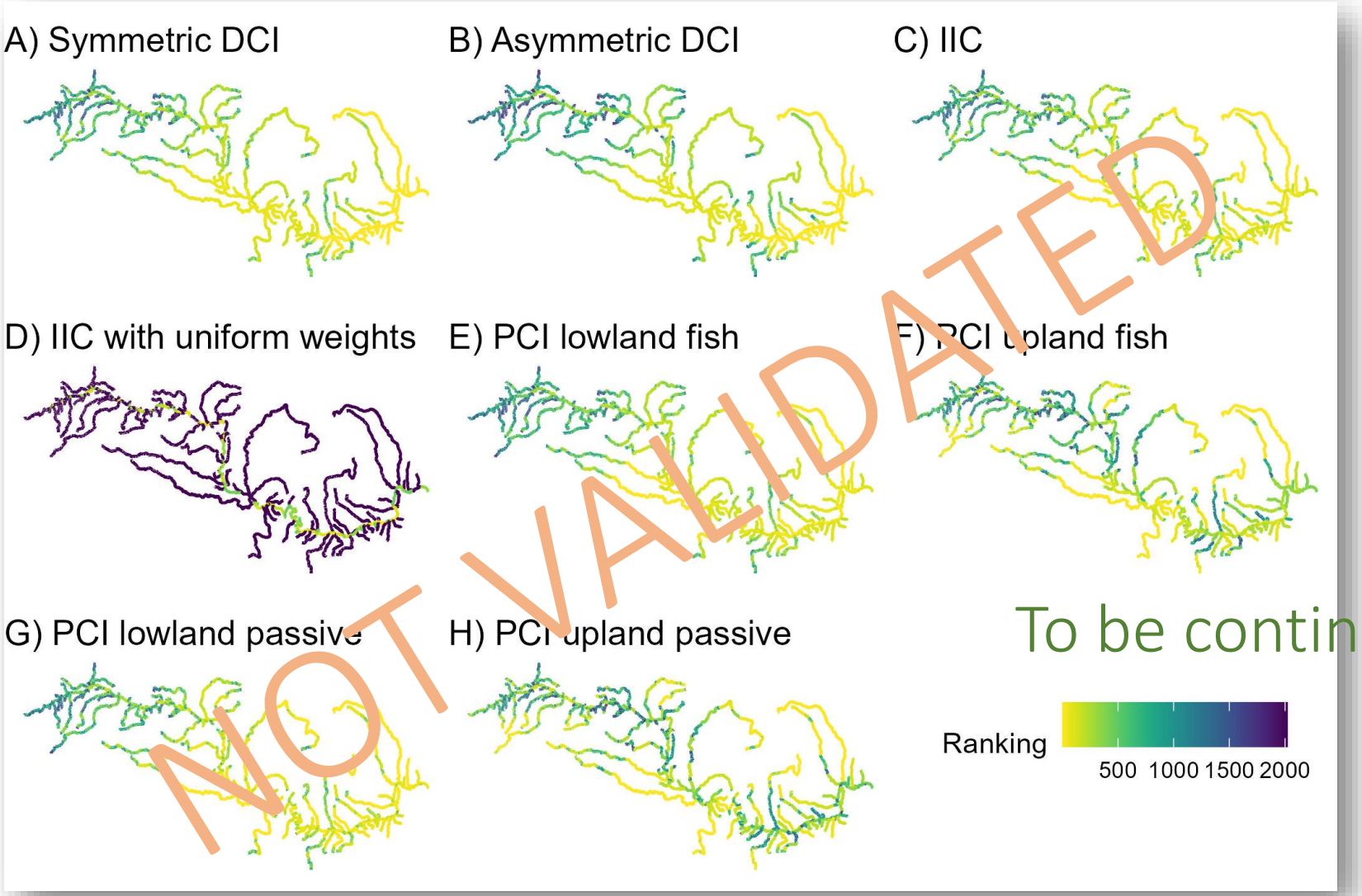
First riverconn models on the DRB



To be continued…

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Thank you!

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