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Session C1: Assessing Longitudinal Connectivity Affected by Cross-Sectional Barriers in a Riverine Bidirectional Network

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Assessing longitudinal connectivity affected by cross-sectional barriers in a riverine bidirectional graph.

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The importance of longitudinal connectivity in rivers

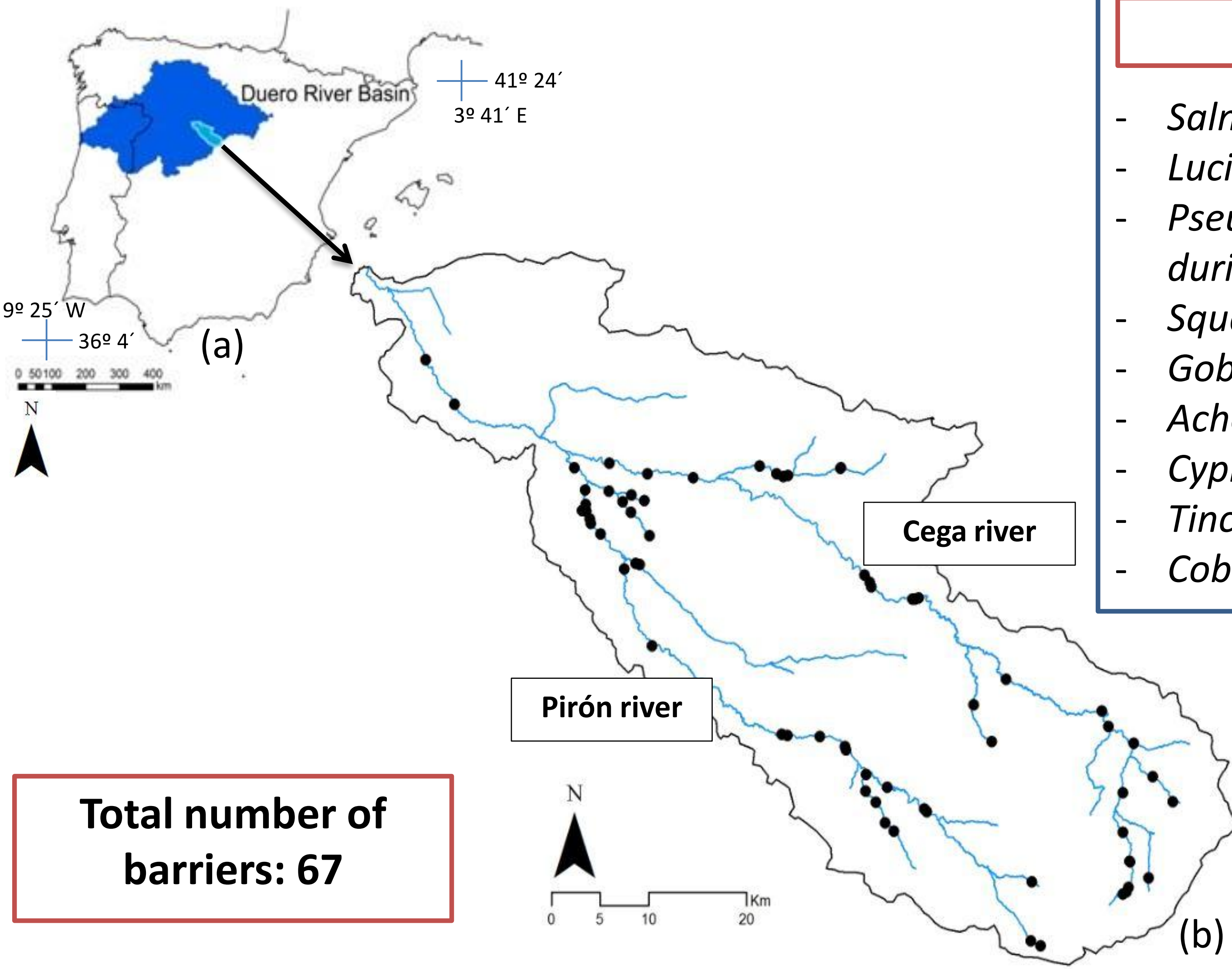
- **Alteration of longitudinal connectivity** in fluvial systems by the presence of **artificial barriers**.
- There is a **need to restore longitudinal connectivity** in riverscapes in order to meet the good ecological status.
- Challenge: **deal with short budgets** in restoration strategies trying to **reach the maximum cost-benefit ratio**.

Objectives

1. Quantifying the **loss of global connectivity** in a basin network due to the presence of barriers.

2. Prioritizing the **target river segments to be preserved** and the **obstacles to be removed** for connectivity conservation and restoration purposes.

Study area and fish species



Fish species

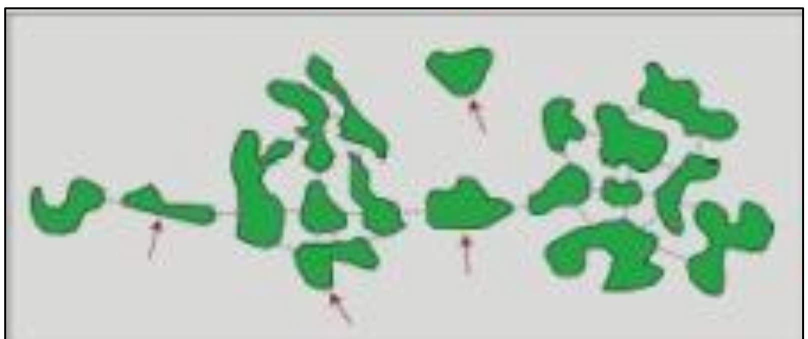
- *Salmo trutta*
- *Luciobarbus bocagei*
- *Pseudochondrostoma duriense*
- *Squalius carolitertii*
- *Gobio lozanoi*
- *Achondrostoma arcasii*
- *Cyprinus carpio*
- *Tinca tinca*
- *Cobitis calderoni*

Total number of barriers: 67

Connectivity tools

- Developed by Saura and Torné in 2009

Software package that **allows quantifying** the **importance** of **habitat areas** and **links** for the maintenance or improvement of **landscape connectivity**



Inputs:

- Graph representation of the fluvial network
- Passability value of each obstacle

Can we apply this idea to fluvial connectivity?

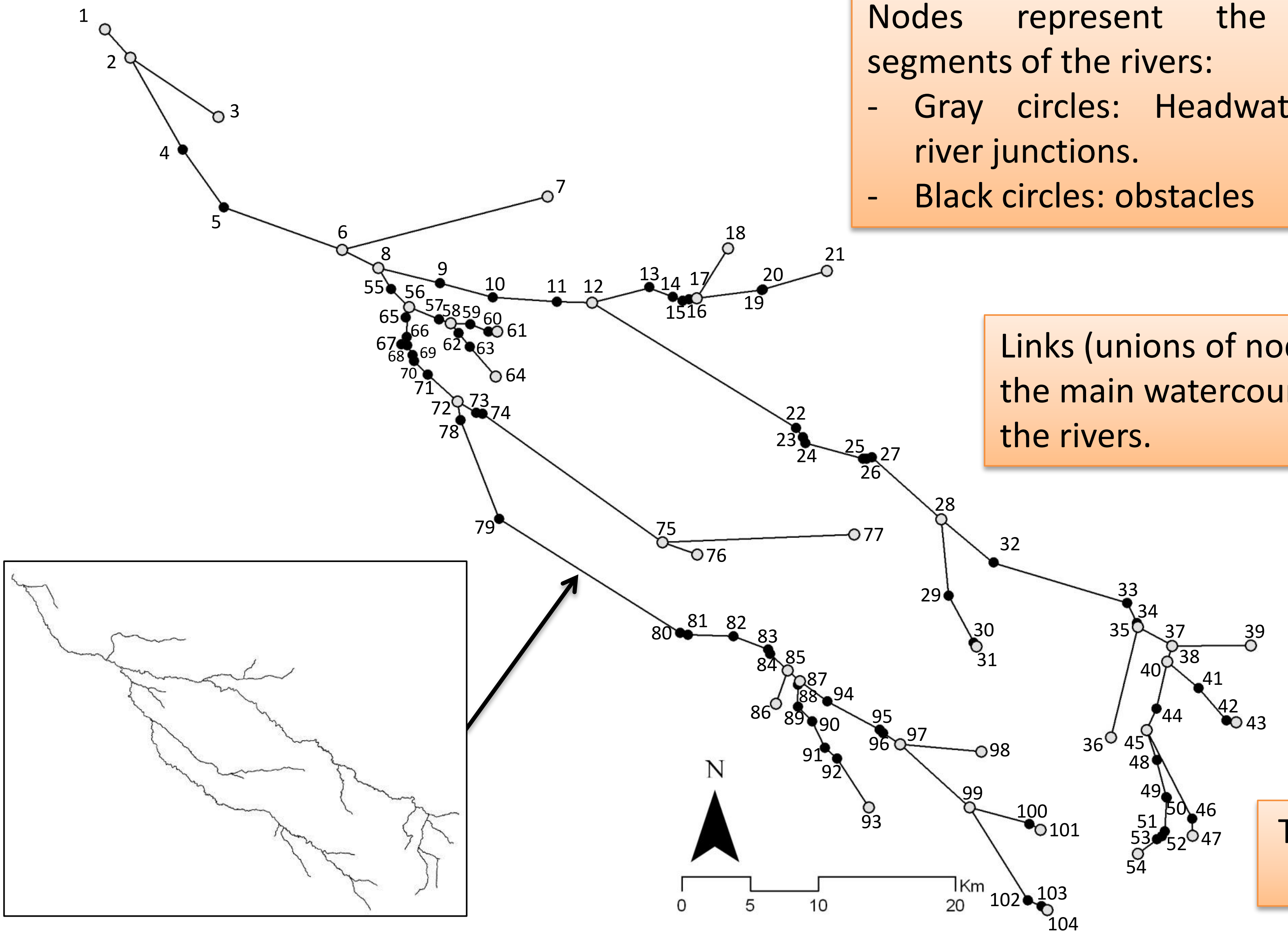
Free download at
www.conefor.org

From a fluvial network to a graph

Nodes represent the stream segments of the rivers:

- Gray circles: Headwaters and river junctions.
- Black circles: obstacles

Links (unions of nodes) are the main watercourse of the rivers.



Total: 104 nodes

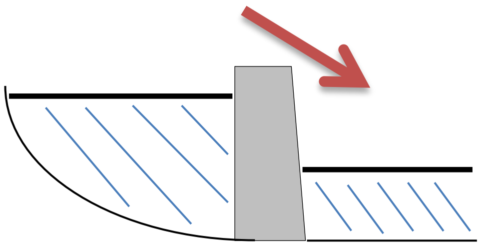
Passability value of each obstacle

- **Passability Index (PI)***

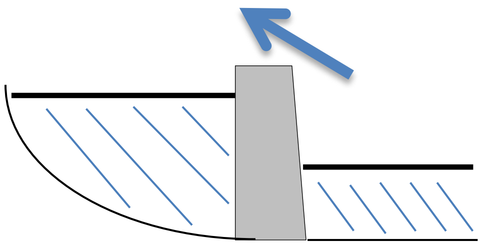
PI= P upstream + P downstream (for each fish species)

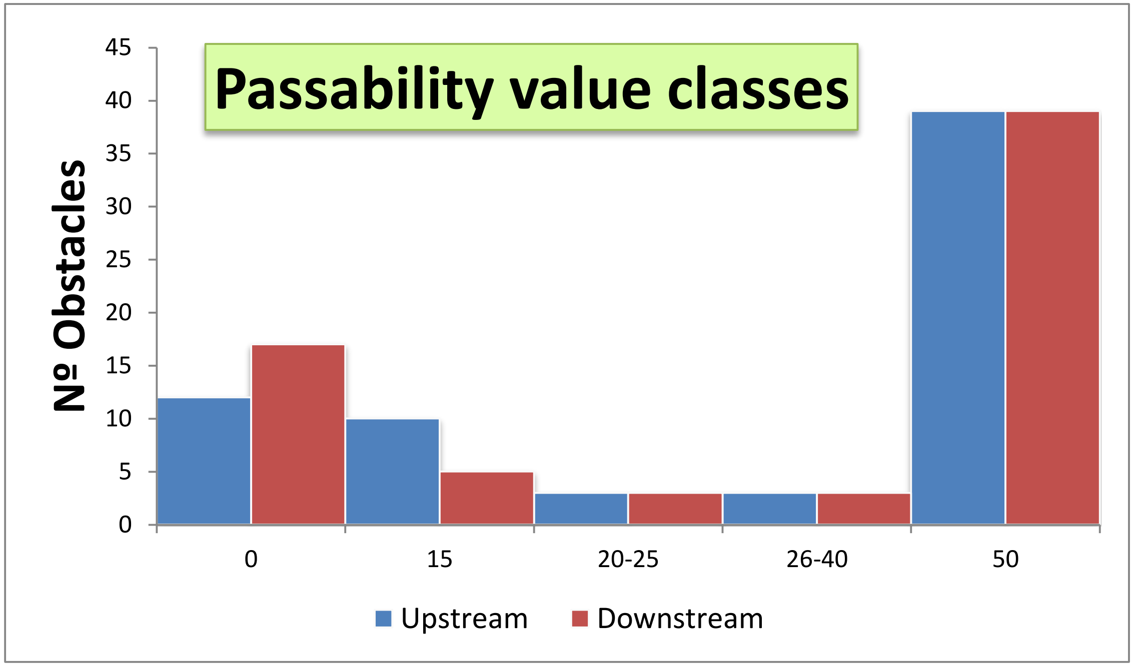
PI = 100 → Insurmountable.
PI = 0 → Totally surmountable.
Intermediate values of PI → crossing depends of flow conditions and the characteristics of the fish species.

Downstream passability



Upstream passability





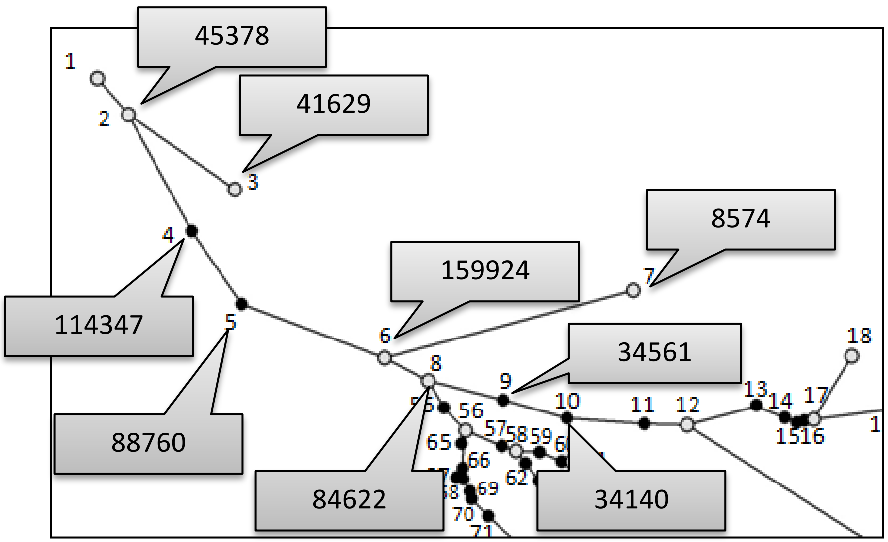
*** (González Fernández *et al.* 2010)**

Attribute values for nodes and links

Habitat attribute value: **river segment lenght x mean width (*Erös 2011, Segurado 2013*)**

Link value between nodes:

- PI = 100 → passability probability = 0
- PI = 0 → passability probability = 1



Ascent

From node	To node	
1	2	**1**
2	3	**1**
2	4	**0**
4	5	**0.2**
5	6	**1**
6	7	**1**
6	8	**1**
8	9	**0**
9	10	**0**
10	11	**0**
11	12	**1**
12	13	**1**
13	14	**1**
14	15	**1**
15	16	**0**
16	17	**1**
17	18	**1**
17	19	**1**
19	20	**1**
20	21	**1**
12	22	**0**
22	23	**0**
23	24	**0**
24	25	**0**
25	26	**0**

Descent

From node	To node	
2	1	**1**
3	2	**1**
4	2	**0**
5	4	**0.4**
6	5	**1**
7	6	**1**
8	6	**1**
9	8	**0**
10	9	**0**
11	10	**0**
12	11	**1**
13	12	**1**
14	13	**1**
15	14	**1**
16	15	**0**
17	16	**1**
18	17	**1**
19	17	**1**
20	19	**1**
21	20	**1**
22	12	**0**
23	22	**0**
24	23	**0**
25	24	**0**
26	25	**0**

Connectivity index: PC

- *Probability of Connectivity Index* *(PC*)*: probabilistic and asymmetric model.

dPC = dPCintra + dPCflux + dPCconnector

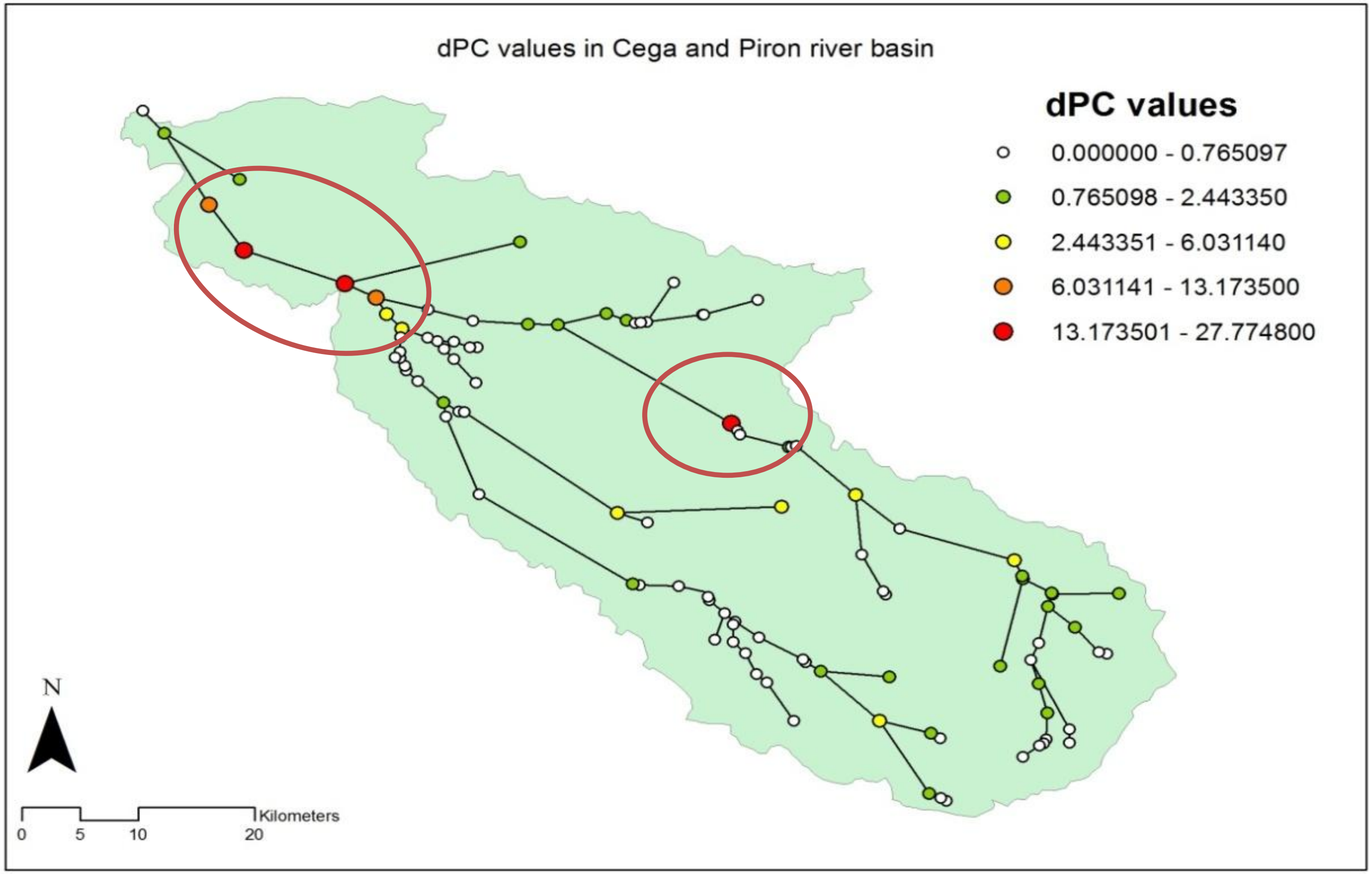
Measures the variations of contribution of each fragment to total connectivity and habitat availability.

dPCconnector indicates the patch contribution to general connectivity as a connecting element or “stepping stone” between other habitat patches.

*Saura and Pascual-Hortal 2007

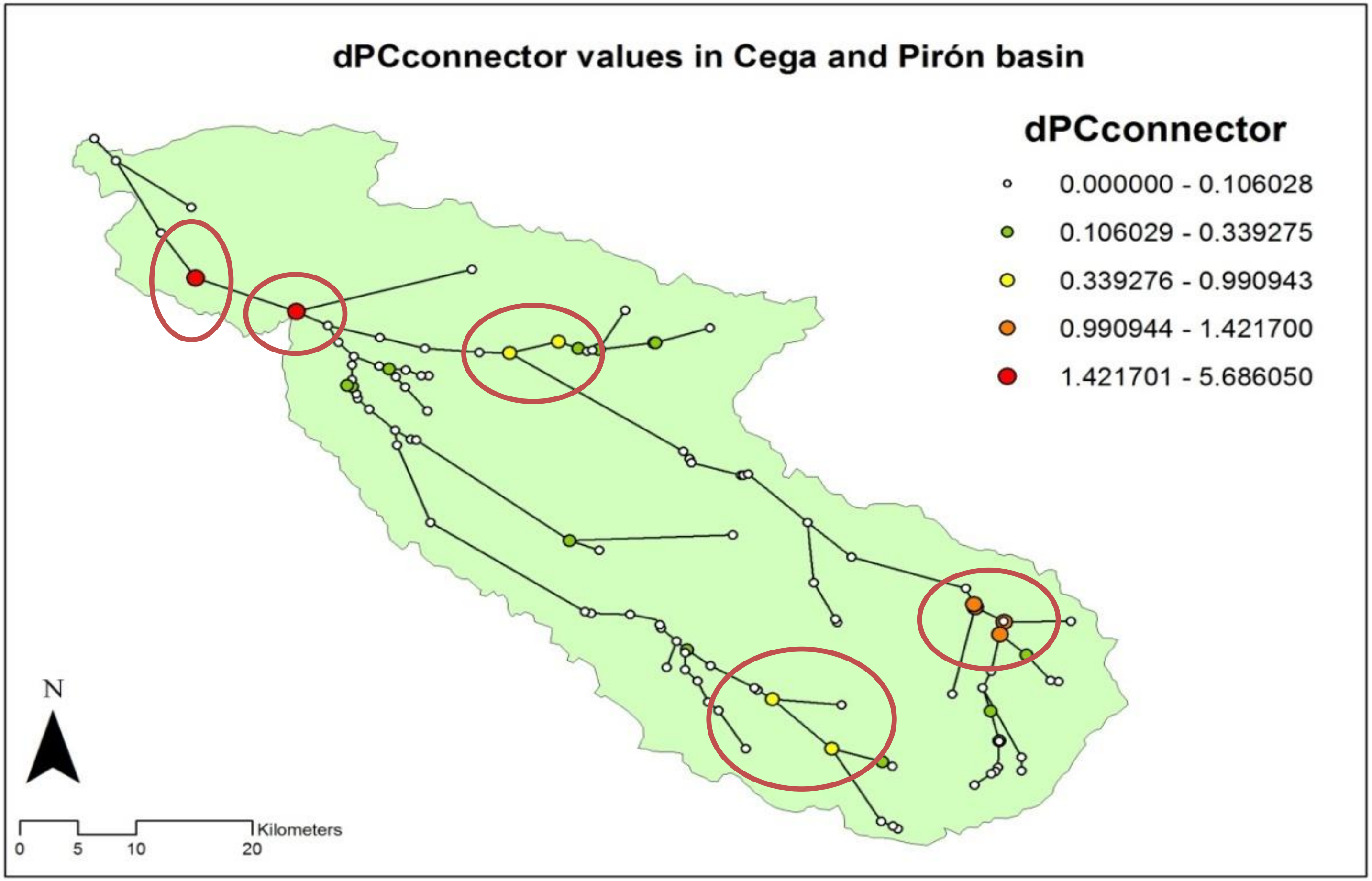
Prioritizing river segments

Node	6	22	5	8	4	75	28	77	33	55	56	99	34	13	80	12	40	11	36	7
dPC	27.77	19.91	17.78	13.17	8.51	6.03	5.02	4.5	4.17	3.31	3.12	2.82	2.44	2.21	2.16	1.94	1.64	1.61	1.49	1.48



Prioritizing river segments

Node	6	5	38	40	35	34	12	99	97	13	41	75	20	17	14	48	68	50	67	58
dPCconn	5.68	4.04	1.42	1.35	1.32	1.19	0.99	0.76	0.69	0.59	0.33	0.29	0.28	0.27	0.26	0.2	0.18	0.17	0.171	0.16



The importance of connections: *link improvement*

Link improvement will calculate the positive potential impacts of **improving** as much as possible the **direct connection between each pair of nodes** (only one at time).

The idea is to assign **values of 1 to the connection of each pair of nodes**, which means that the strength or frequency of use of the direct connection between two river segments, *i* and *j,* will be improved for all the pairs of patches.

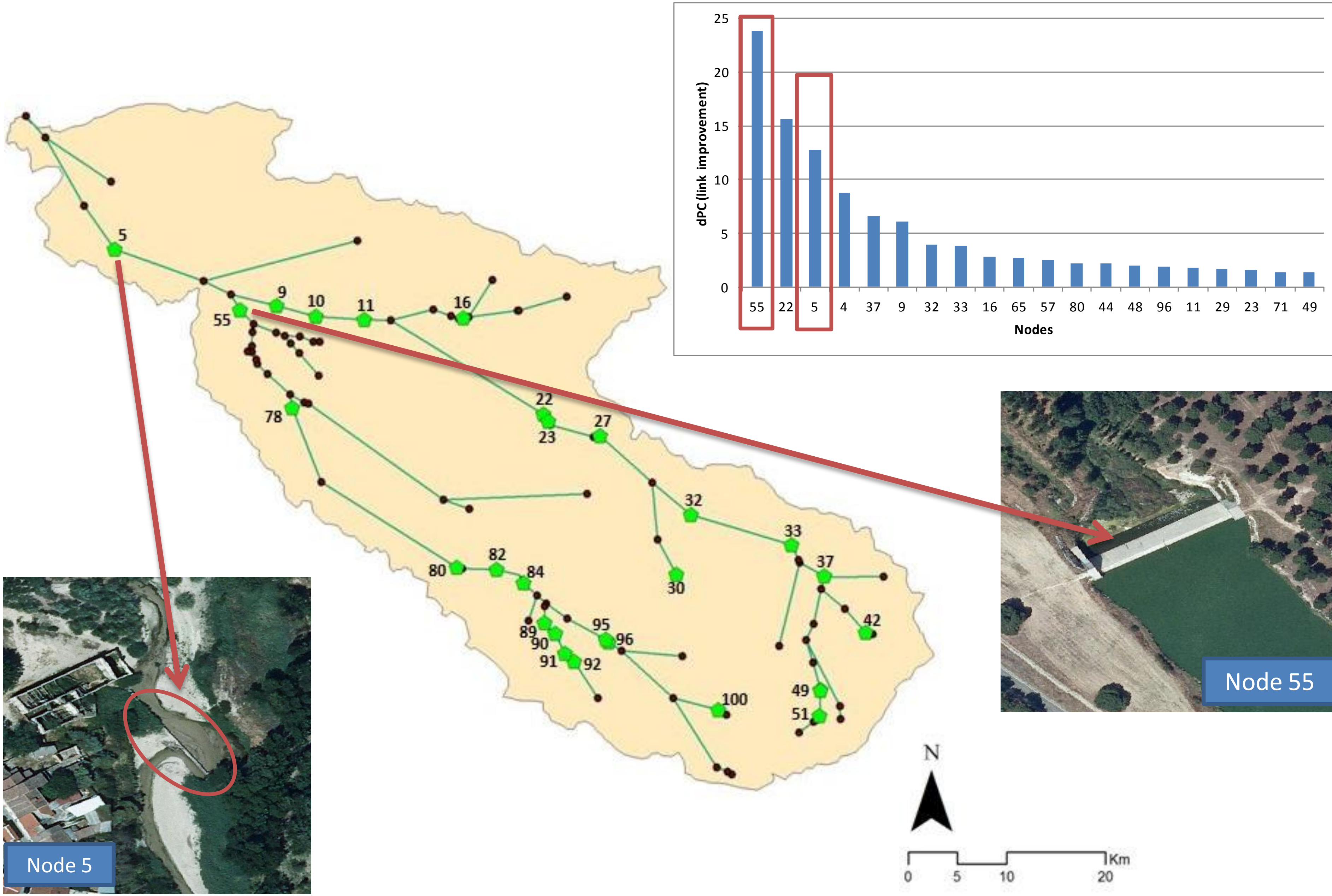
Examples:

PI = 70 → probability of passability = 0.3 → quite far away from 1

PI = 15 → probability of passability = 0.85 → easier to reach 1

In a riverine network, we only take into account **the pair of segments with direct connection** between them.

Barrier ranking



The tools developed for terrestrial connectivity could be **implemented successfully in fluvial connectivity.**

Graph modeling allows us to quantify the **loss of global connectivity and the most sensitive river segments** to its interruption.

Barriers will be **prioritized** with the aim to develop **efficient management and intervention plans** in which the **minimum possible actions recover high values of connectivity.**

THANKS FOR YOUR ATTENTION

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