Temporal developments of longitudinal connectivity: The perspective of potamodromous fish

Johannes Kowal, Gertrud Haidvogl,
Johannes Schützenhofer, Andrea Funk, Thomas Hein

johannes.kowal@boku.ac.at

Introduction

Several potamodromous fish species are highly mobile (e.g. spawning migrations)

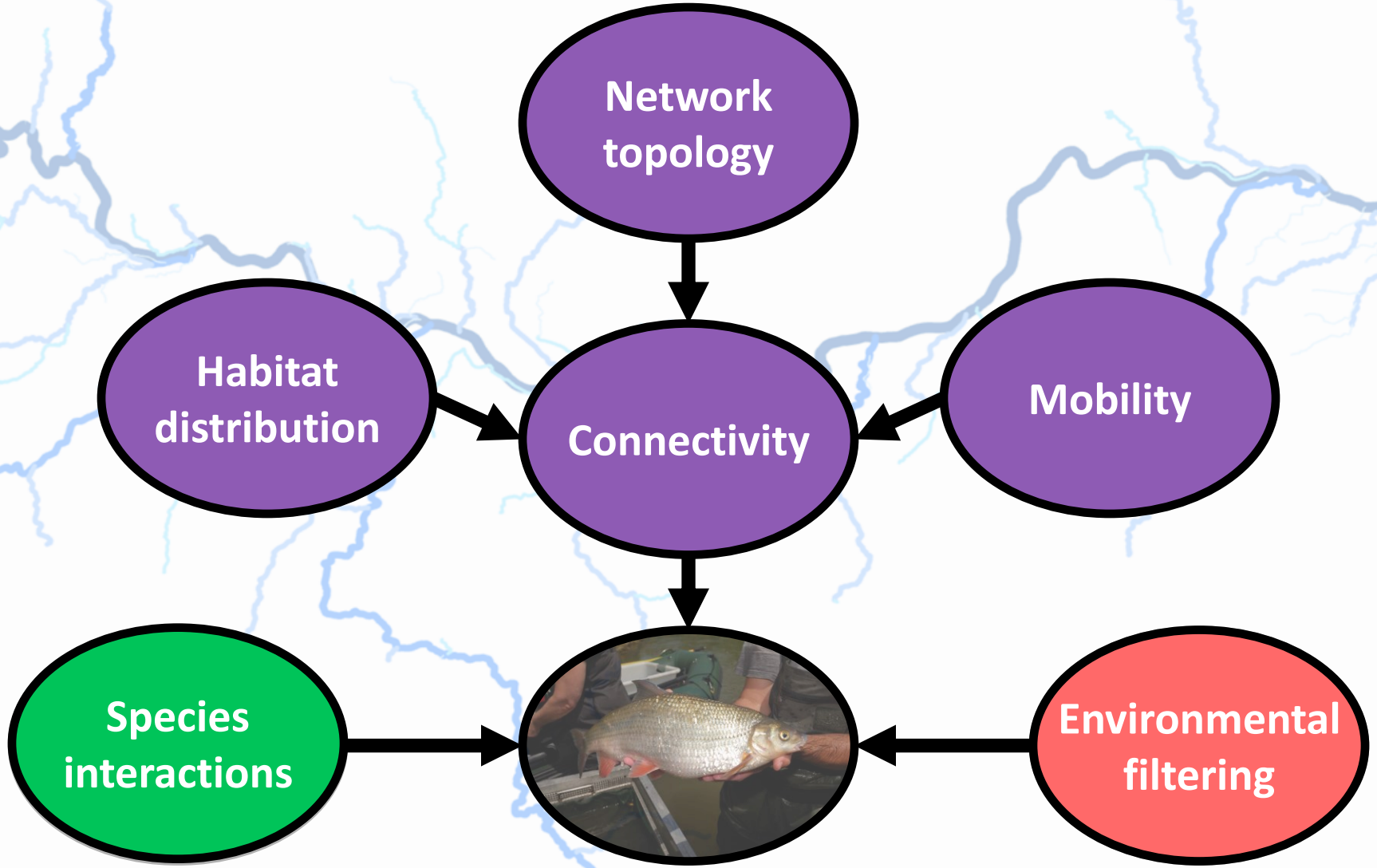
Research questions:

- How has longitudinal connectivity developed **historically**?
- Effect of **dam removals** and **fish pass** installations?
- When did longitudinal connectivity reach its **lowest point**?

The nase *(Chondrostoma nasus)*

- Spawning migration in March - May
- Rheophilic gravel spawner
- **Individuals found to migrate up to 300km**

Methods – The concept



Methods - Habitat availability

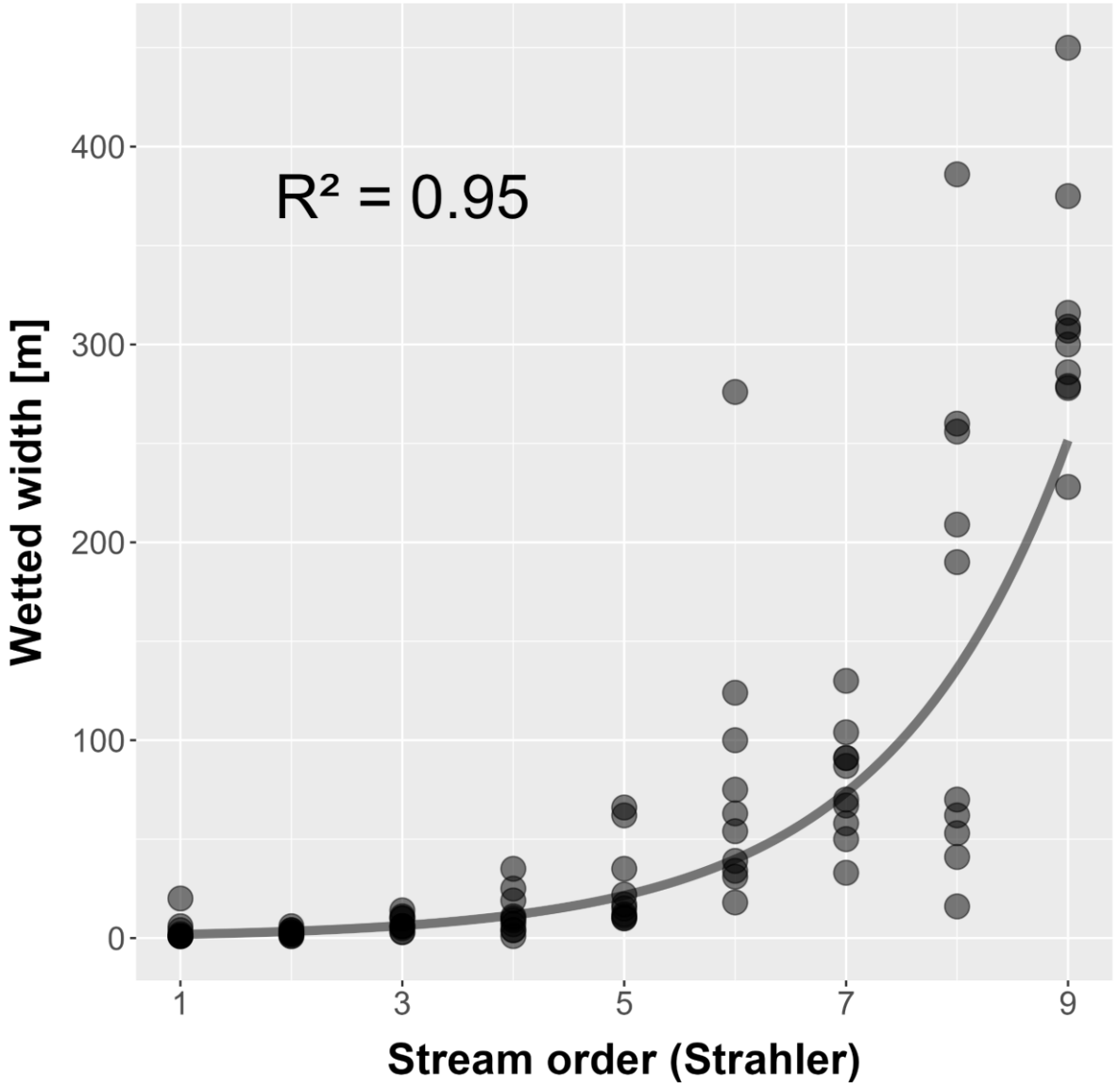
- **Water surface area as a proxy** for the **relative amount of available habitat** in each river reach

- **Wetted width** estimated based on **10 measurements** per stream order

$$\text{Water surface area} = L\ 10^{(0.27\ S)}$$

L = reach length [m]

s = stream order

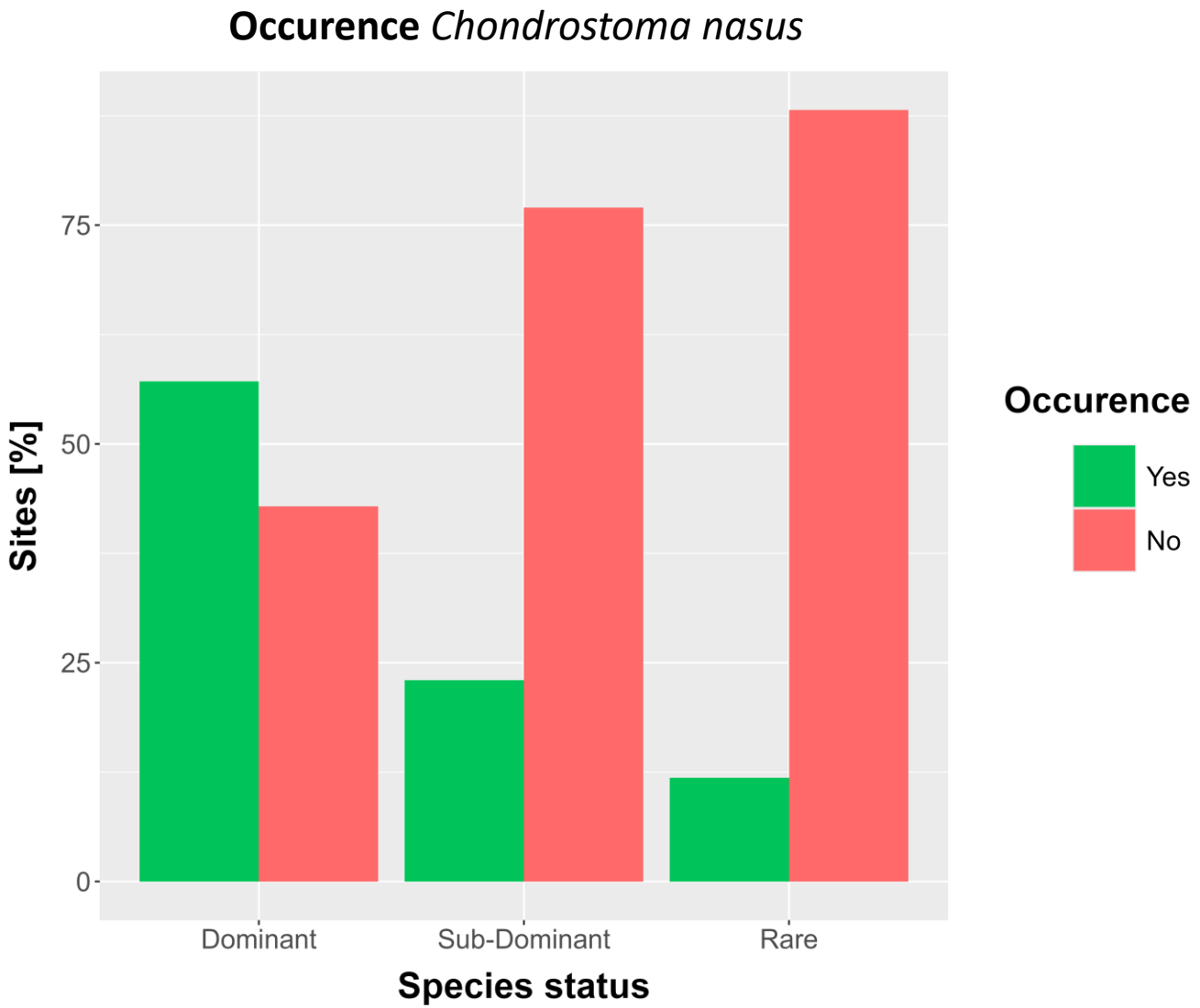


Methods - Habitat suitability

- Habitat suitability according to **Fish Index Austria (FIA)** (Haunschmid et al. 2006)

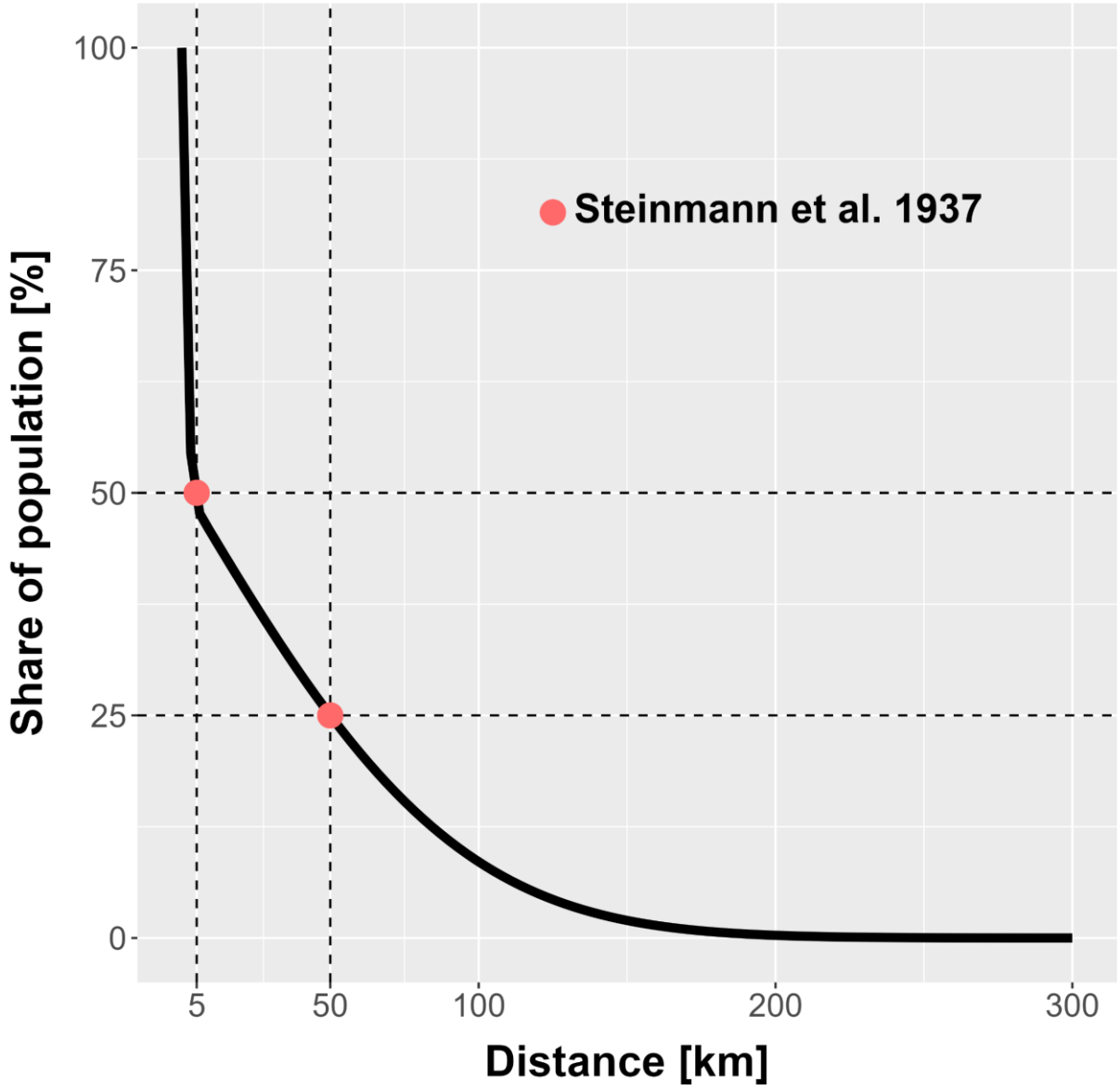
- Three species specific types of occurrence:
  - **Dominant**
  - **Sub-Dominant**
  - **Rare**

- **Probability of occurrence** as proxy for habitat suitability



Methods - Mobility

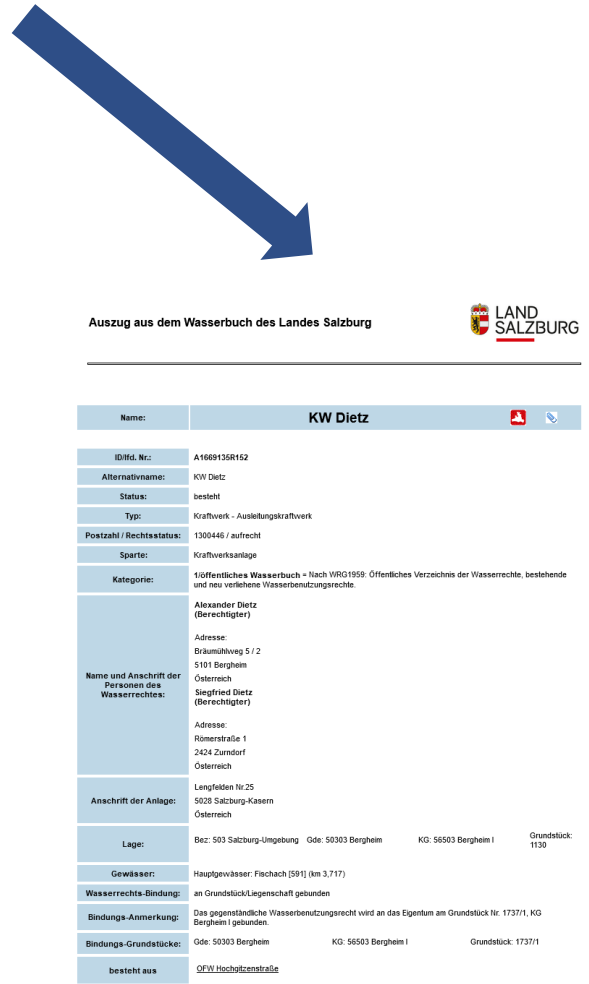
- Mobility according to **leptokurtic dispersal** function
- Function fitted according to **Steinmann et al. 1937** (study conducted prior to the construction of hydropower plants in the Austrian Danube)
- Indication of a **static and highly mobile fraction** in populations



Methods – Barrier data and passability

Dataset on 512 barriers (Austrian register for water uses):

- Year of construction approval
- Has a fish pass been installed?
- Year when the construction of the fish pass was approved



Auszug aus dem Wasserbuch des Landes Salzburg

LAND SALZBURG

Name:	KW Dietz
ID/lfd. Nr.:	A1669135R152
Alternativname:	KW Dietz
Status:	besteht
Typ:	Kraftwerk - Ausleitungskraftwerk
Postzahl / Rechtsstatus:	1300446 / aufrecht
Sparte:	Kraftwerksanlage
Kategorie:	1/öffentliches Wasserbuch = Nach WRG1959: Öffentliches Verzeichnis der Wasserrechte, bestehende und neu verliehene Wasserbenutzungsrechte.
Name und Anschrift der Personen des Wasserrechtes:	Alexander Dietz (Berechtigter) Adresse: Bräumühlweg 5 / 2 5101 Bergheim Österreich Siegfried Dietz (Berechtigter) Adresse: Römerstraße 1 2424 Zurndorf Österreich
Anschrift der Anlage:	Lengfelden Nr.25 5028 Salzburg-Kasern Österreich
Lage:	Bez: 503 Salzburg-Umgebung Gde: 50303 Bergheim KG: 56503 Bergheim I Grundstück: 1130
Gewässer:	Hauptgewässer: Fischach [591] (km 3,717)
Wasserrechts-Bindung:	an Grundstück/Liegenschaft gebunden
Bindungs-Anmerkung:	Das gegenständliche Wasserbenutzungsrecht wird an das Eigentum am Grundstück Nr. 1737/1, KG Bergheim I gebunden.
Bindungs-Grundstücke:	Gde: 50303 Bergheim KG: 56503 Bergheim I Grundstück: 1737/1
besteht aus	OFW Hochgitzenstraße

Barrier passability based on Noonan et al. (2011):

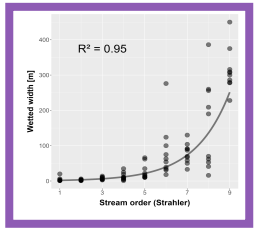
Direction	Fish pass YES	Fish pass NO
↑	30%	0%
↓	60%	30%

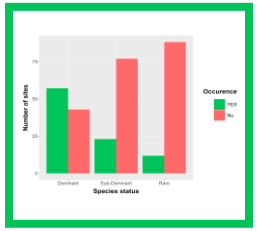
Methods - Index calculations (Baldan et. al. 2022)

Reach connectivity index

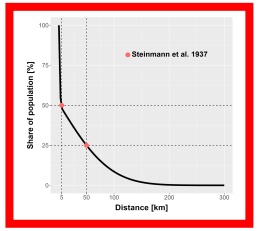
$$RCI_i = \sum_{j=1}^{n} I_{ij} \frac{w_j}{W}$$

$$w_j = L\ 10^{(0.27\ S)}\ P$$





$$I_{ij} = c_{ij}\ B_{ij}$$



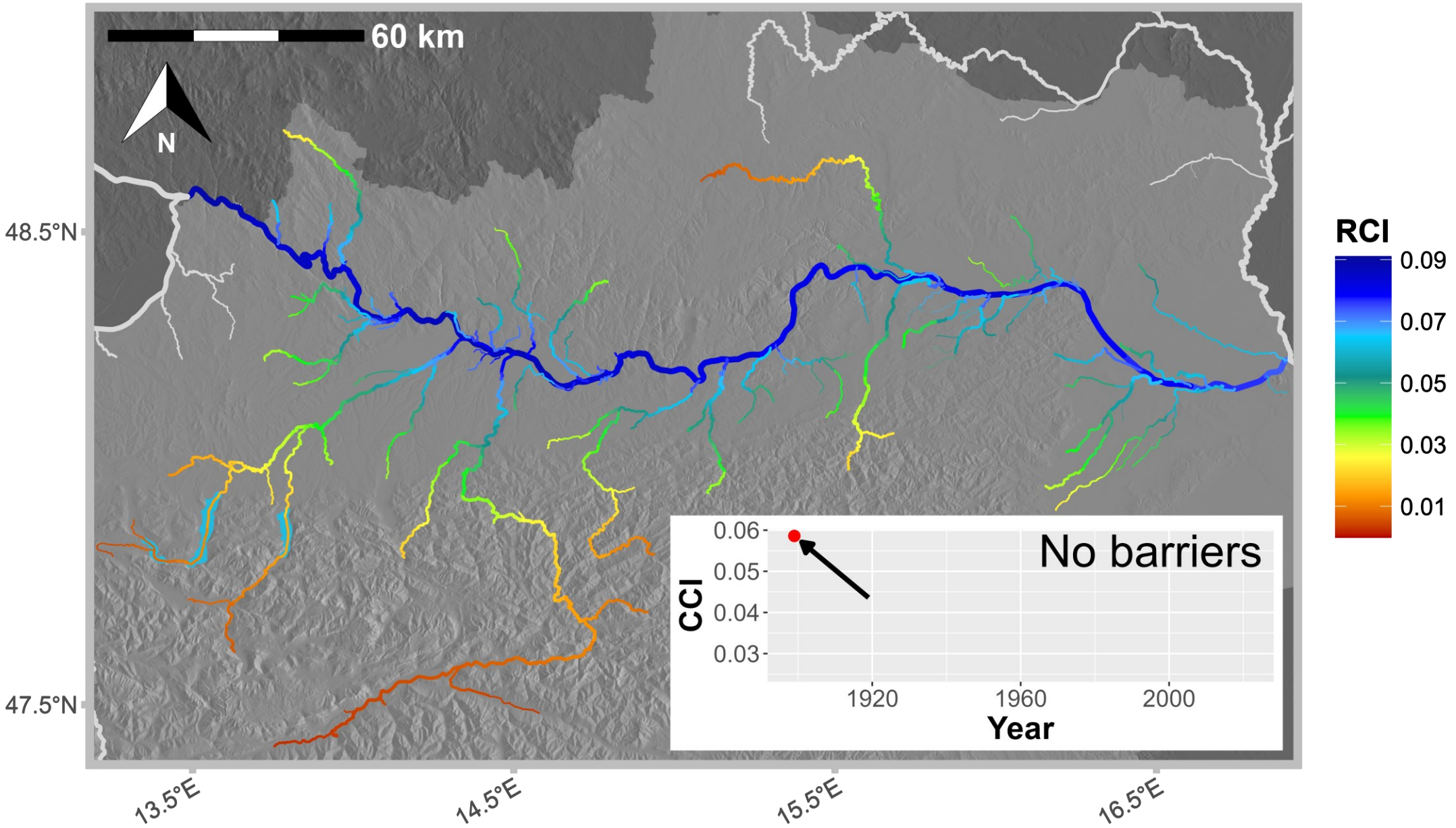
Catchment connectivity index

$$CCI = \sum_{i=1}^{n} \sum_{j=1}^{n} I_{ij} \frac{w_i w_j}{W^2}$$

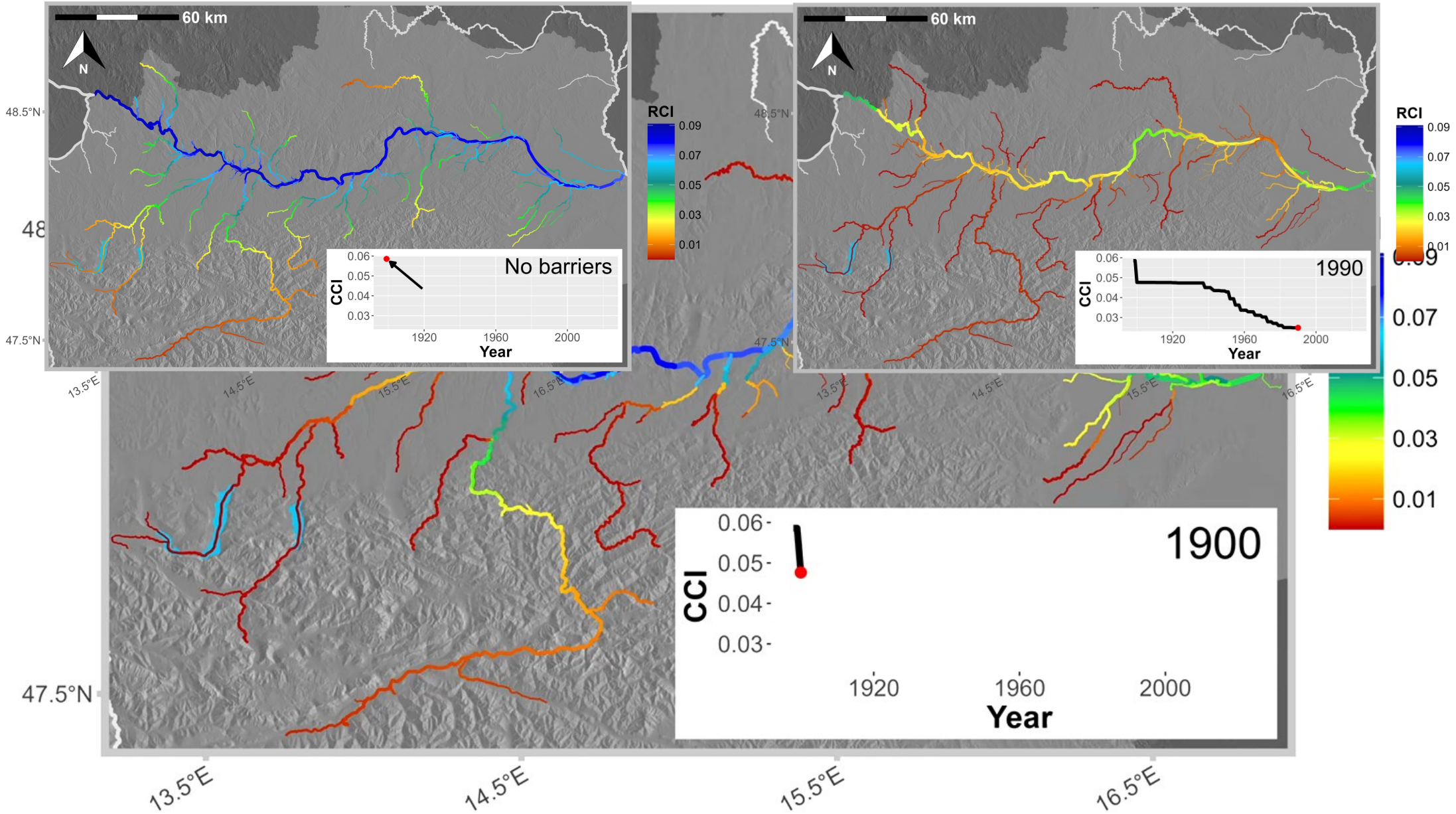
$$c_{ij} = \prod_{m=1}^{k} p_m$$

p_m = Passability barrier m

Results – Reach connectivity index (RCI)



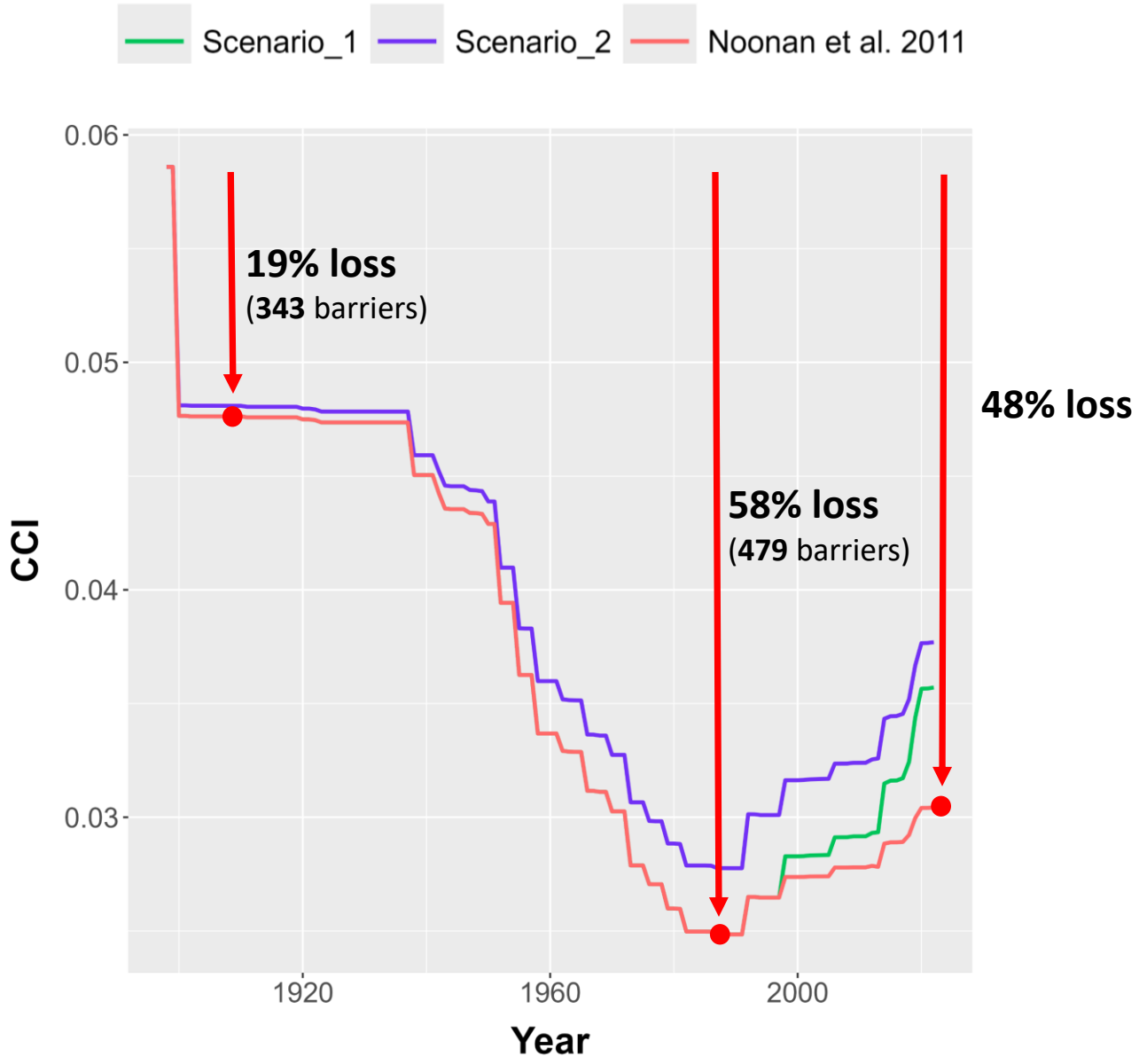
Results – Reach connectivity index (RCI)



Results – Catchment connectivity index (CCI)

Barrier passability

Scenario	Direction	Fish pass YES	Fish pass NO
Noonan et al. 2011	↑	30%	0%
Noonan et al. 2011	↓	60%	30%
1	↑	60%	0%
1	↓	90%	30%
2	↑	60%	0%
2	↓	90%	60%



Conclusion and outlook

- **Mills and Woodmills**: **~19%** connectivity loss **before 1900**
- **Hydropower**: **~39%** connectivity loss **between 1940 until 1990**
- **Fish passes/barrier removal**: **~10%** connectivity gain **since 1990**
- Increased **barrier passability** could substantially increase connectivity

Follow-up research questions:

- How are **connectivity changes affecting potamodromous fish** populations?
- Can we reconstruct **historic populations trends** based on connectivity changes?
- **How much connectivity** do we need (management)?

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