The Beaver as an Ecosystem Engineer

Effects on Water Quality and Freshwater Ecosystems

Dr. Leonardo Capitani

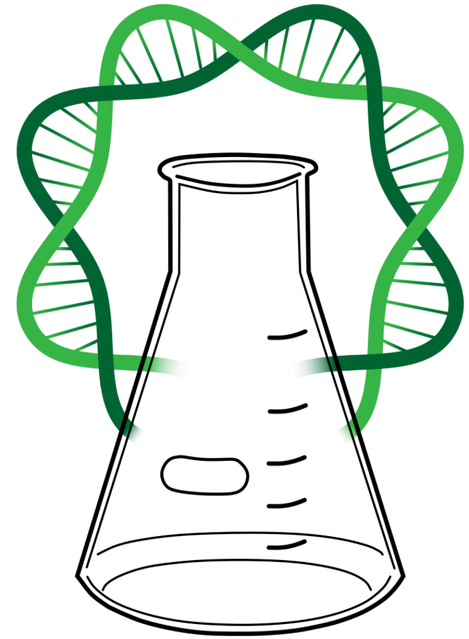
Senior Scientist, Department of Aquatic Ecology, Eawag

leomarameo7.github.io

23 October 2026

Slides and links

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Acknowledgments



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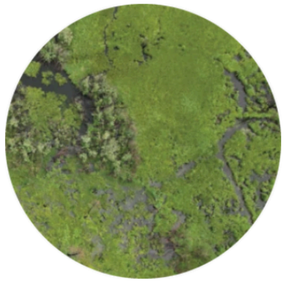
Dr. Joshua R. Larsen

… and many other researchers and stakeholders!

Main message of this talk



EXCAVATION, CANAL DIGGING



+ Wetland area
+ Lateral connectivity
+ Aquatic–terrestrial interface

DAM BUILDING



+ Water storage
+ Groundwater connection
– Flow velocity
+ Sedimentation rate

FORAGING, TREE CUTTING



+ Plant diversity
– Canopy cover
+ Landscape heterogeneity

> Beaver engineering can create locally climate-resistant wetlands

Index of this presentation

1. **Water quality:** carbon and nutrients

2. **Biodiversity:** habitats and species

3. **Resilience:** floods and droughts

4. **Management:** living with beavers

> International synthesis + Swiss 🇨🇭 cases

Beaver life history and diet



Eurasian beaver eating berry leaves

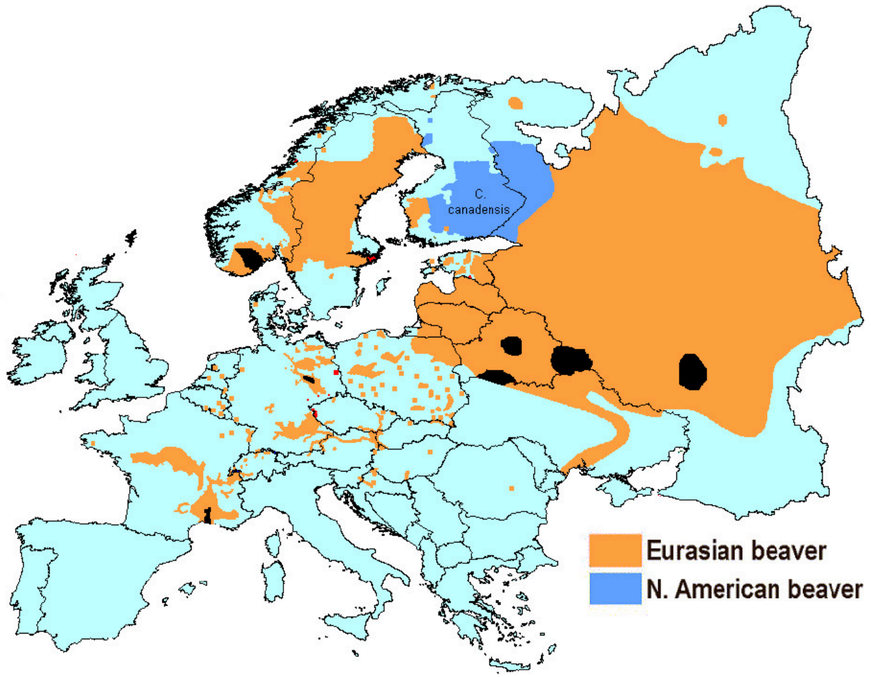
- **Life history**
- **Diet**

17.8 kg average adult body mass	**105–107 d** gestation (about 3.5 months)	**2–3** baby beavers (kits) per birth, once a year
~20 mo age at sexual maturity	**3.8** animals per family (parents + offspring)	**9 yr** average age at death (up to 20–24 yr)
~2 kg woody plants eaten per day (captive)	**86 → 17%** woody share of diet, winter → August	**~1,200 kcal** energy needed per day (15-kg beaver)

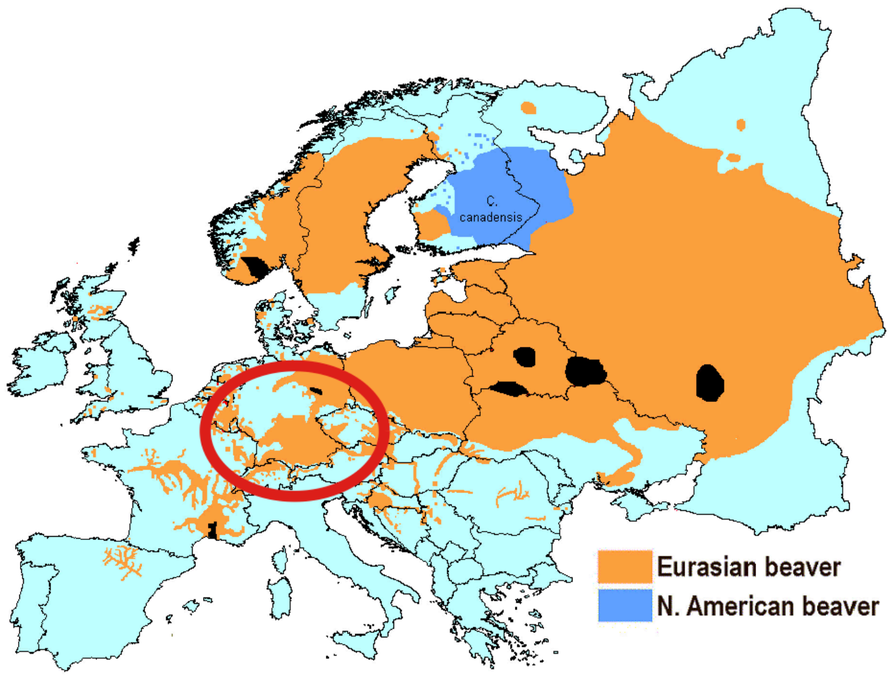
Slow breeders: few kits, long family life

Beavers are back across Europe

2002



2020

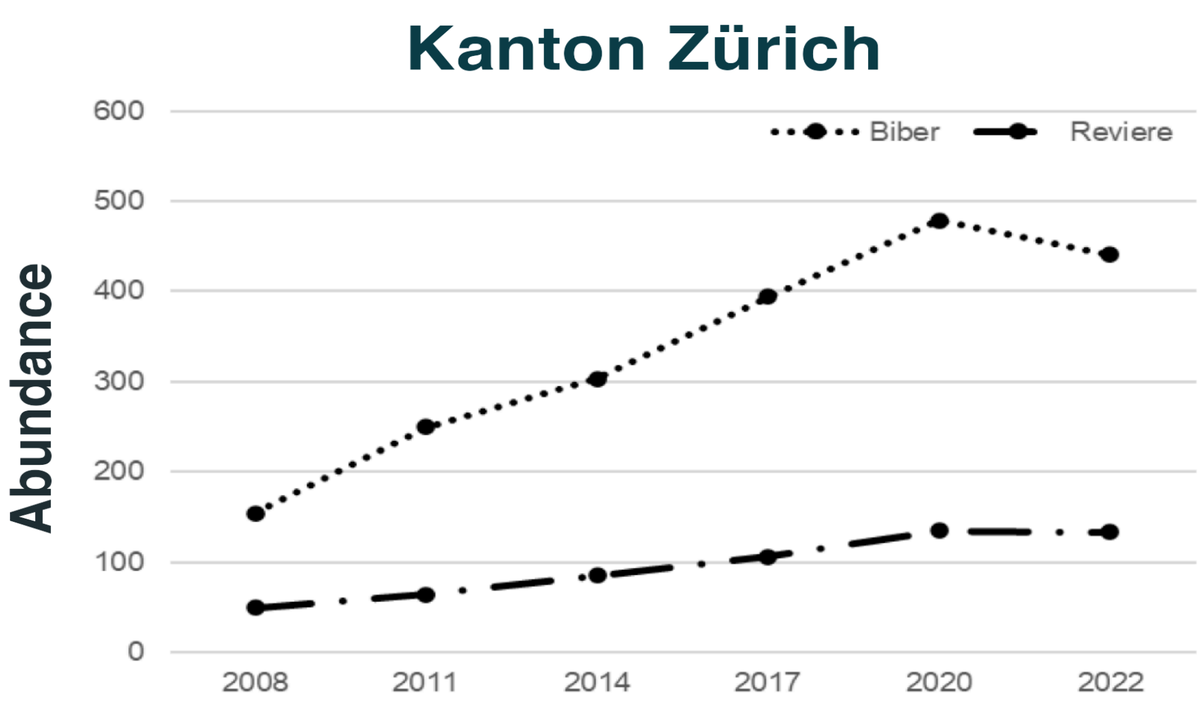


Switzerland, 2022: 4,900 beavers

info fauna

Beavers are recolonising Europe

How many beavers?

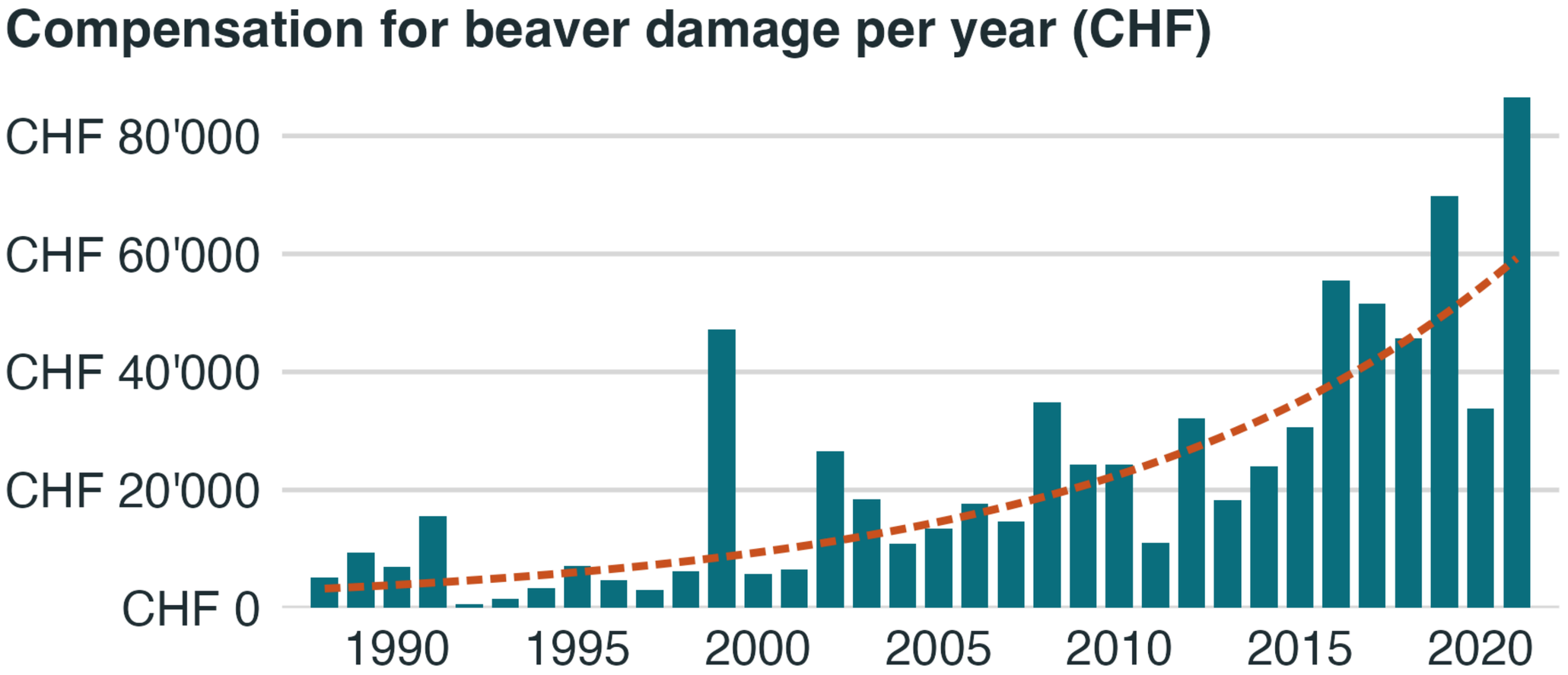


info fauna

- 150 beavers in 2008
- 400+ beavers in 2022
- Growth slows after 2020

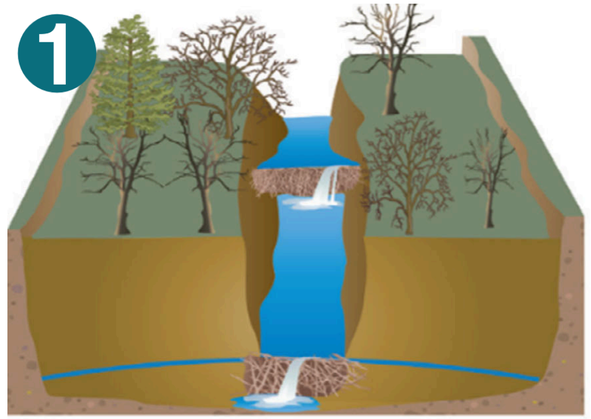
Rebound now levelling off

Living with beavers: the cost of damage



Damage compensation increased over 30 years (1988–2021)

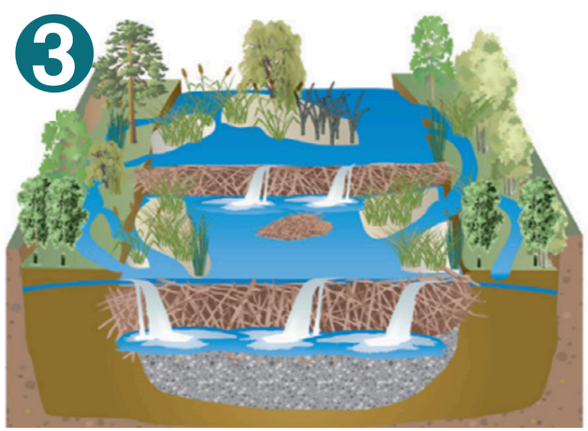
Hydrological impacts



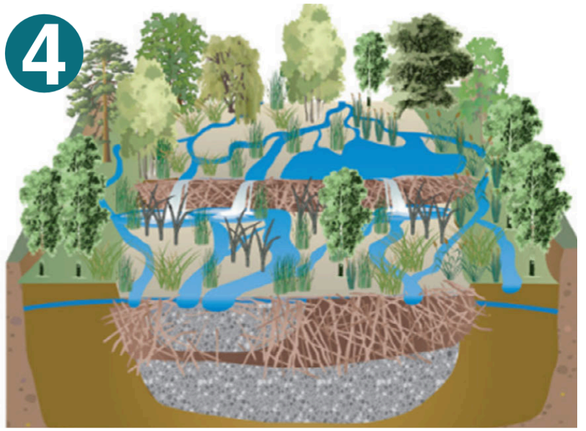
Incised channel, dams blow out



Wider channel, stable dams



Sediment builds, water table rises



Floodplain reconnected

Beavers reduce longitudinal connectivity, while increasing lateral connectivity

Water quality · Why nutrient cycling?

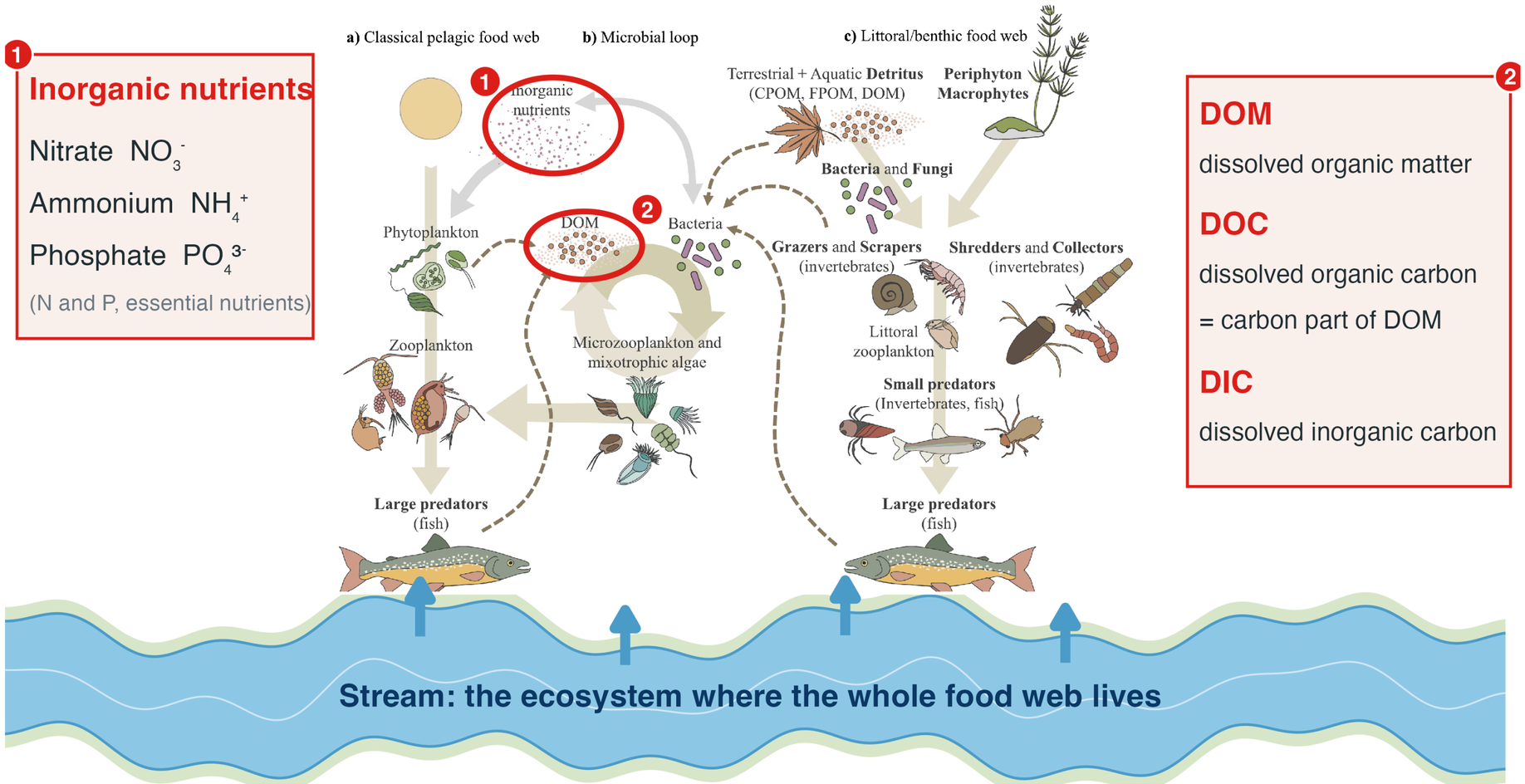
1 Inorganic nutrients

Nitrate NO_3^-

Ammonium NH_4^+

Phosphate PO_4^{3-}

(N and P, essential nutrients)



2

DOM

dissolved organic matter

DOC

dissolved organic carbon

= carbon part of DOM

DIC

dissolved inorganic carbon

Nutrients and organic matter drive ecosystems

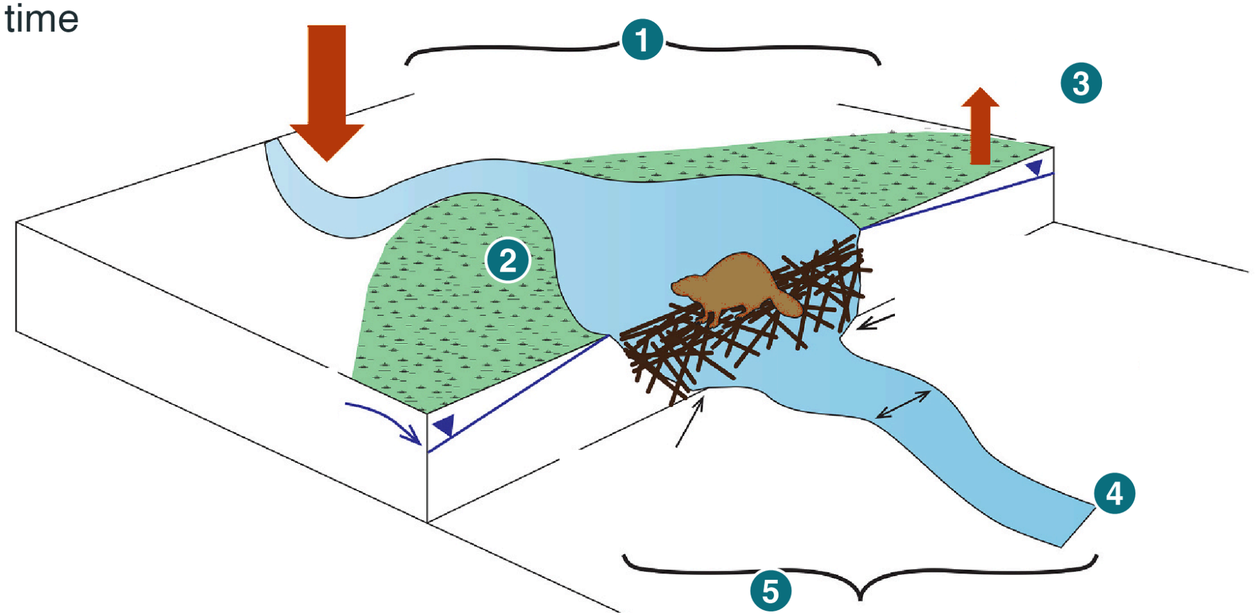
Water quality · International synthesis: C and nutrients

① Upstream of dam

- More open water
- Longer residence time
- Less oxygen

② Storage

- C carbon
- N nitrogen
- P phosphorus
- sediment



③ To the atmosphere

- N_2 nitrogen gas
- CO_2 carbon dioxide
- CH_4 methane

④ Export downstream

- DOC organic C ↑ 14 of 18
- NH_4^+ ammonium ↑ 8 of 10
- NO_3^- nitrate ↓ 13 of 19
- PO_4^{3-} phosphate mixed (n = 15)

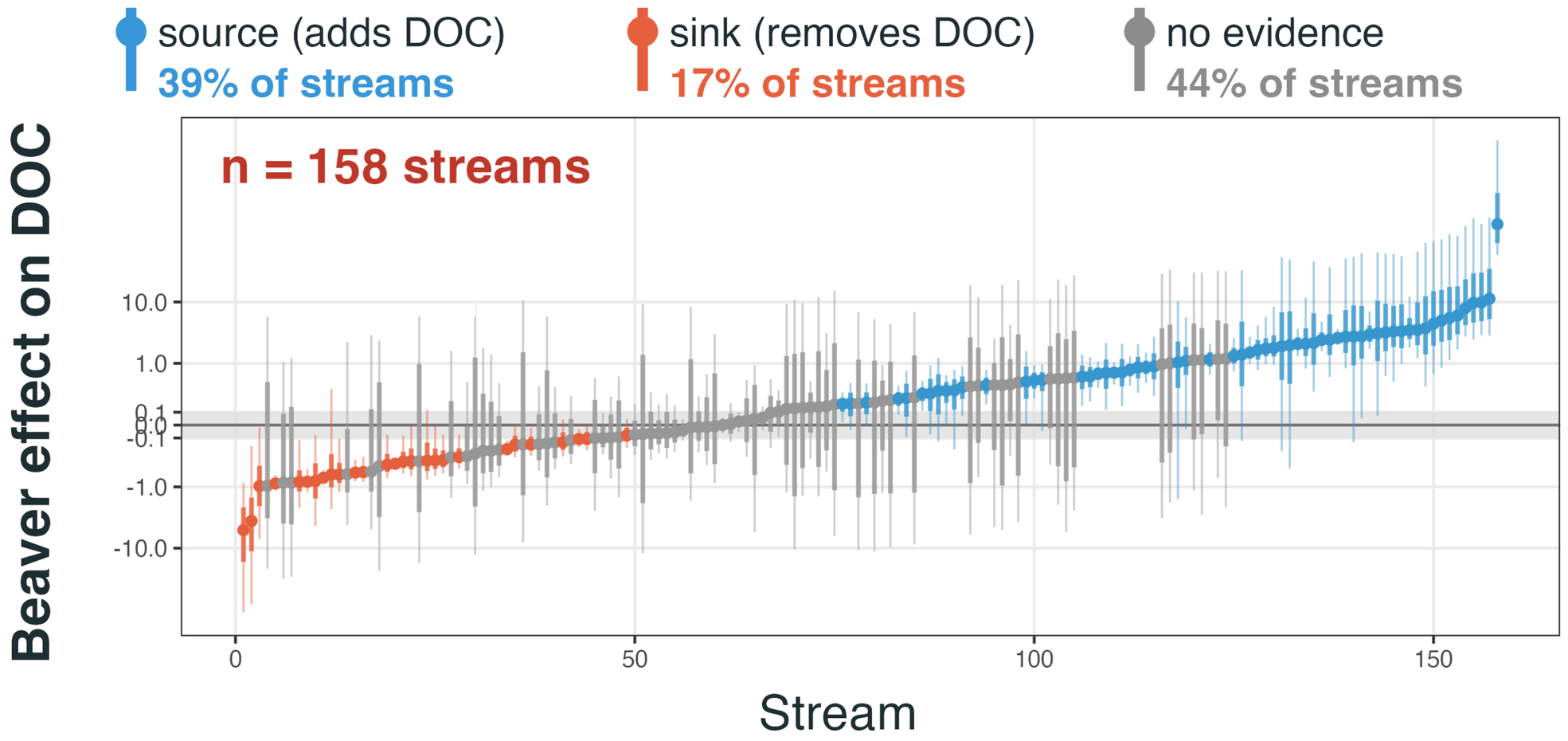
⑤ Downstream of dam

- Less open water
- Oxygen returns

Carbon and nutrient budgets: no unique direction

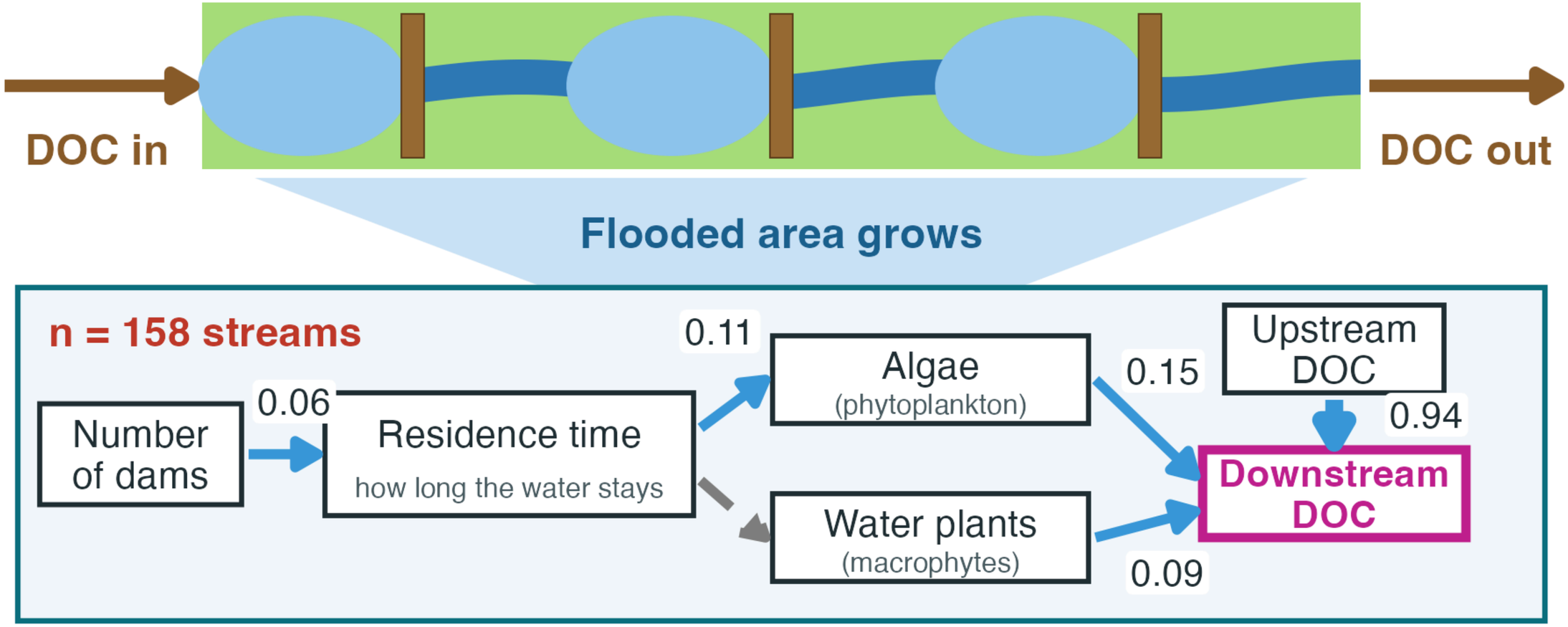
Modified from Larsen et al. 2021, Earth-Science Reviews 218, 103623, Fig. 15: conceptual model; arrows and counts (studies with that direction of all

Water quality: the Swiss case



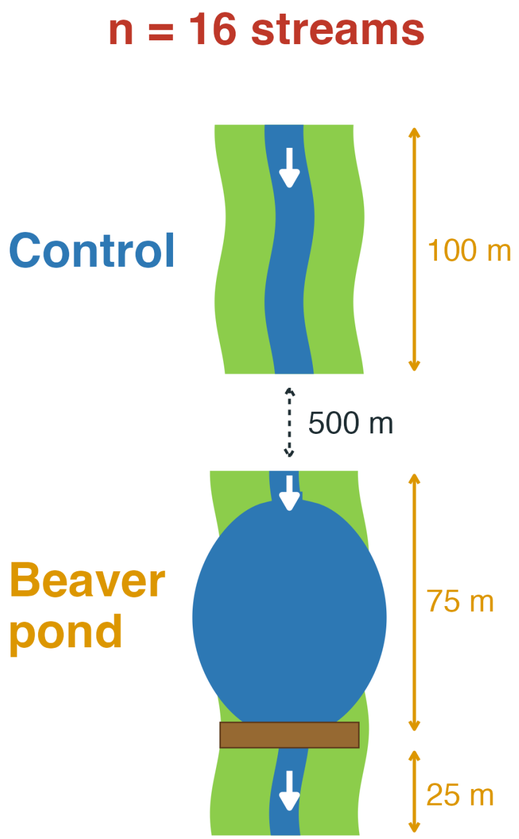
Beaver ponds are local control points of DOC

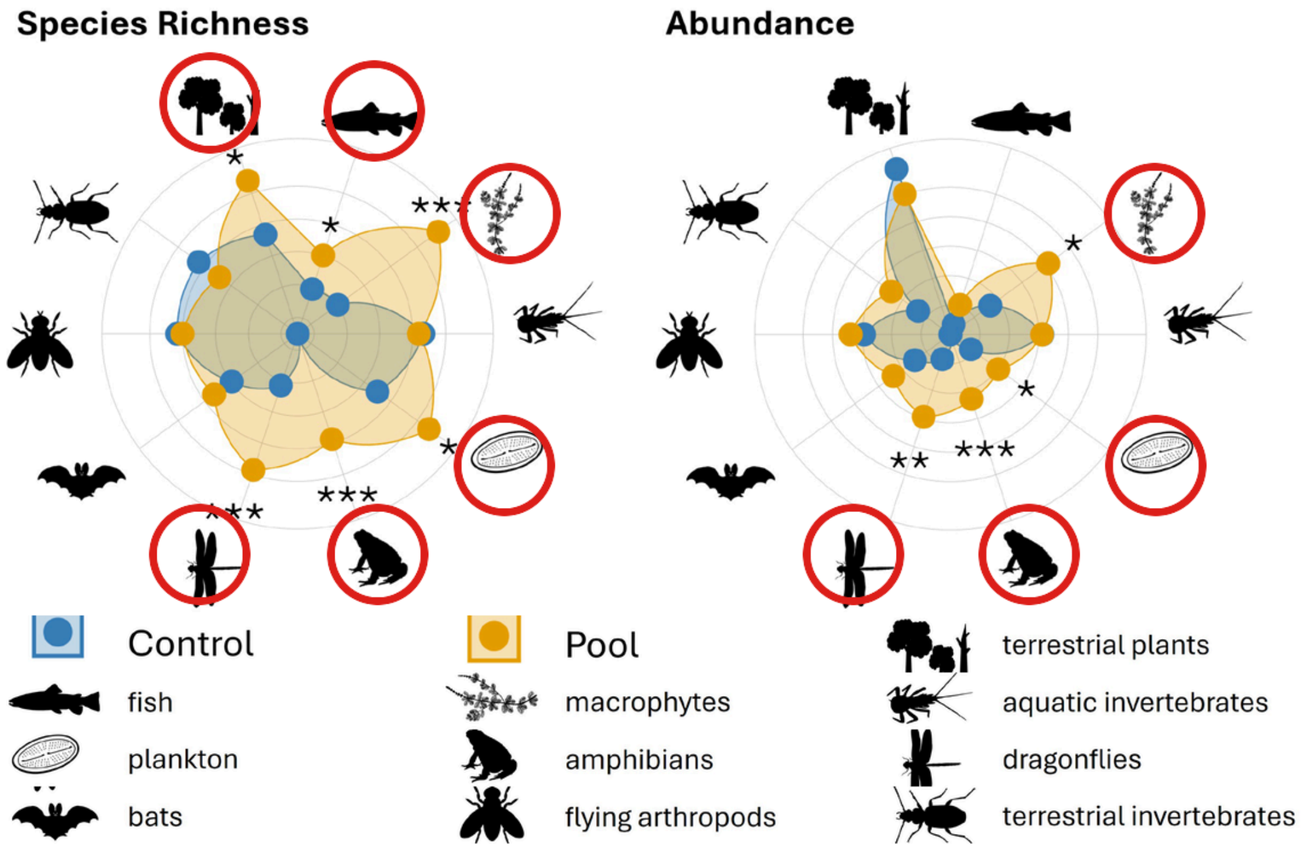
Water quality · drivers of beaver's influence



Beavers slow the water; algae and plants add DOC

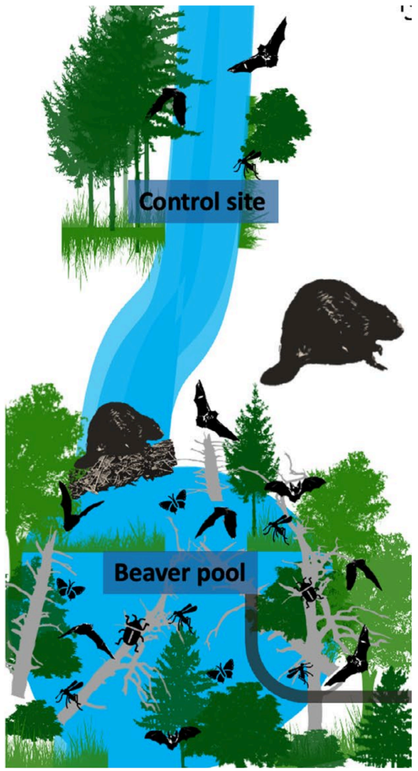
Biodiversity: the Swiss case





Beavers influence stream biodiversity

Biodiversity · Bats at beaver pools



Increased canopy heterogeneity

Increased standing deadwood density

Increased arthropod abundance

Echolocation guild	*Species richness*	*Activity*	*Feeding*
Short-range	n.s.	n.s.	n.s.
Mid-range	+	+	+
Long-range	+	+	*no data*

\+ significant increase at beaver pools n.s. not significant

- Mid-range gain most
- Driver: deadwood
- Endangered bats:



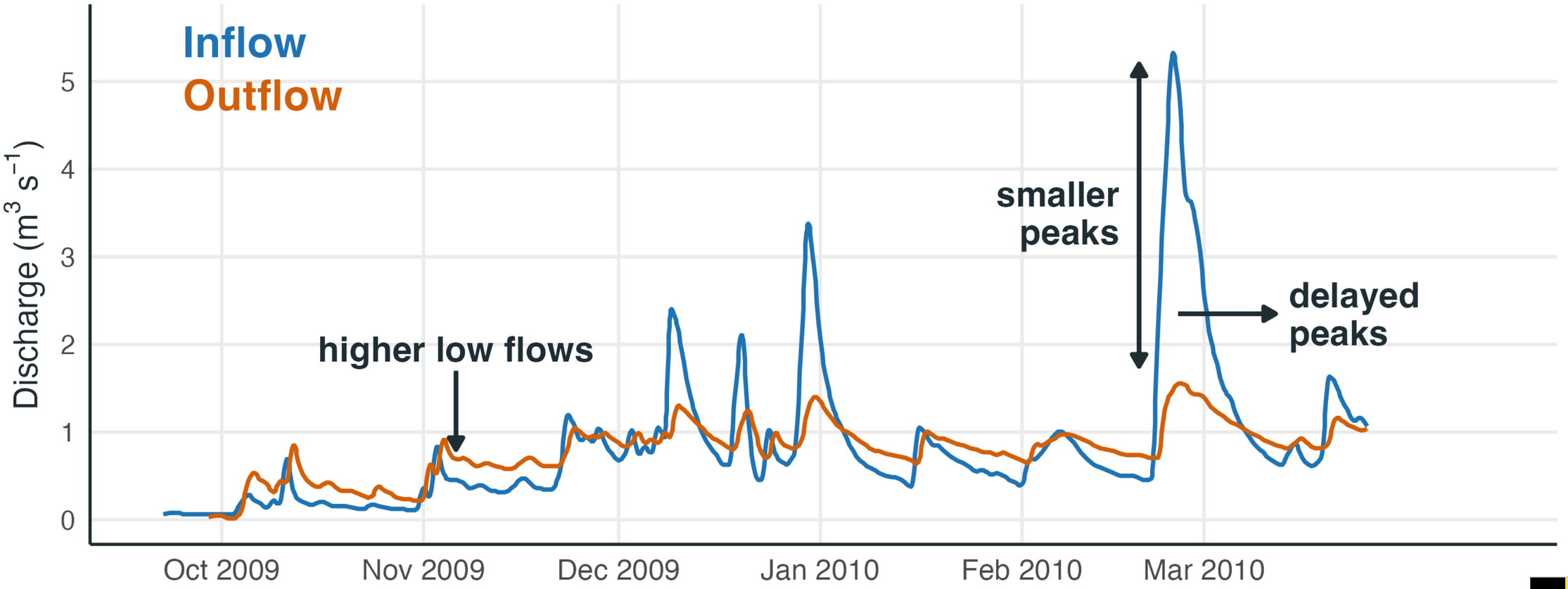
Western barbastelle
Barbastella barbastellus



Geoffroy's bat
Myotis emarginatus

Beaver contribution: habitat complexity and more food

Resilience: the Belgian case



Study site: Chevral, Ardennes, Belgium

Flatter peaks, higher low flows

Resilience · Storing water, buffering flow

243 m³

surface water stored per 100 m of stream (first year)

Dittbrenner et al. 2022

+60%

more water held in dry summers (incl. water table)

Hood 2012

–2.3 °C

cooler summer base flow downstream of dams (mean; varies by site)

Dittbrenner et al. 2022

–30%

peak flow in storms below beaver ponds, vs. water entering

Puttock et al. 2017

Dams buffer droughts and floods

Beaver management: conflicts and solutions

Conflict	Solutions
Foraging crop and ornamental tree loss	**fence or wrap trees in wire; plant species beavers avoid**
Burrowing bank erosion, undermined infrastructure	**leave a vegetated strip along the bank; strengthen the bank with stone or mesh**
Damming flooded crops, trees, roads	**pipe through the dam to keep the water low; cut a gap in the dam; wider pipes under roads**

Each conflict has a practical fix

Beaver management: zoning in the Czech Republic

Zone A

Full protection

links key conservation sites (Natura 2000)

smallest area

Zone B

Managed, with limits

dam management; removal if non-lethal methods fail

85.5%

Zone C

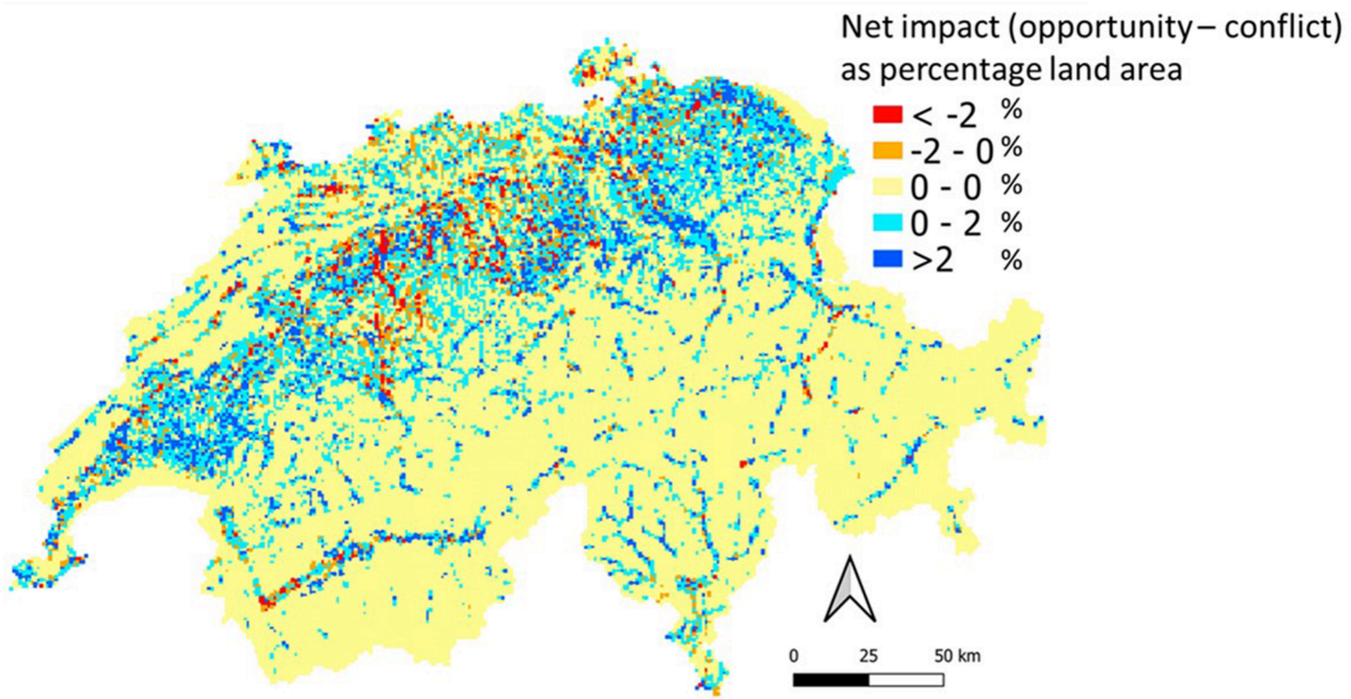
Not tolerated

farmed-fish ponds and infrastructure at high risk of beaver damage

13.3%

> Zoning separates protection from conflict areas

Beaver management: the Swiss case



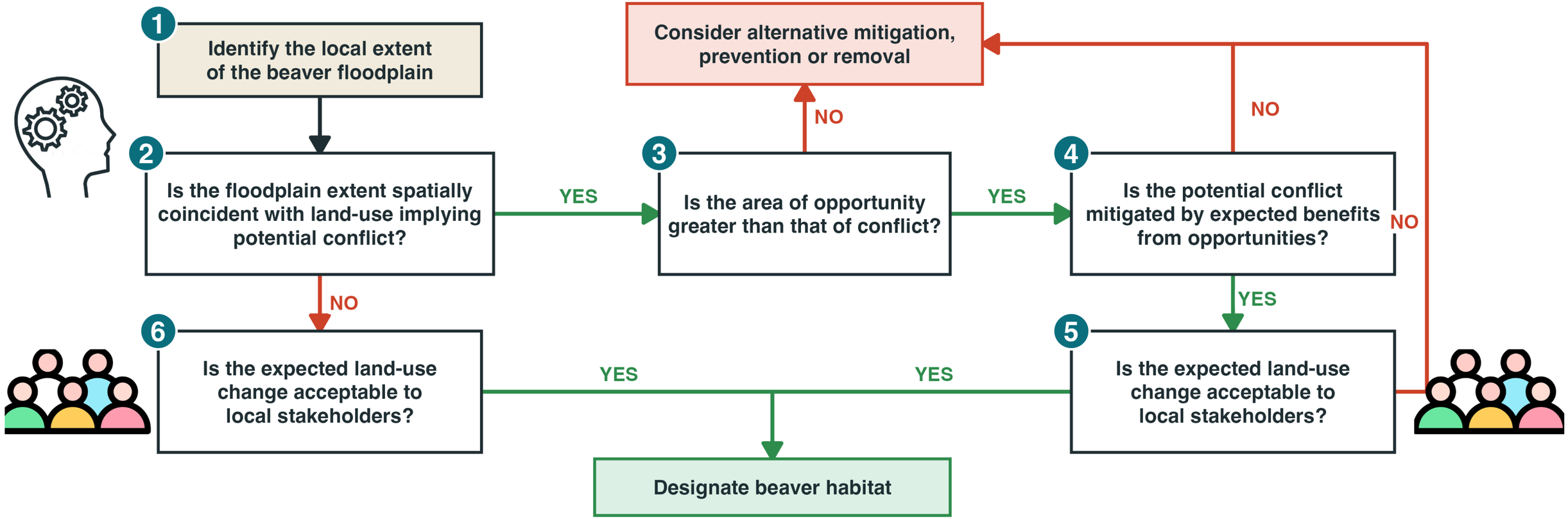
info fauna Biber-Auenmodell

Beaver floodplain: 450 km²

- Driver: channel gradient
- **298 km²** (66%) opportunity
- **132 km²** (29%) conflict

Maximise restoration, minimise conflicts

Beaver management: how should we proceed?

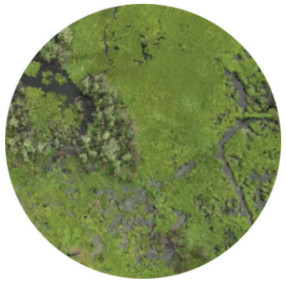


Beaver management should consider social context

Main message: take-home



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DAM BUILDING



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> Beaver engineering can create locally climate-resistant wetlands

Thank you



Photo: Dominic Tinner

Dr. Leonardo Capitani
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Acknowledgments

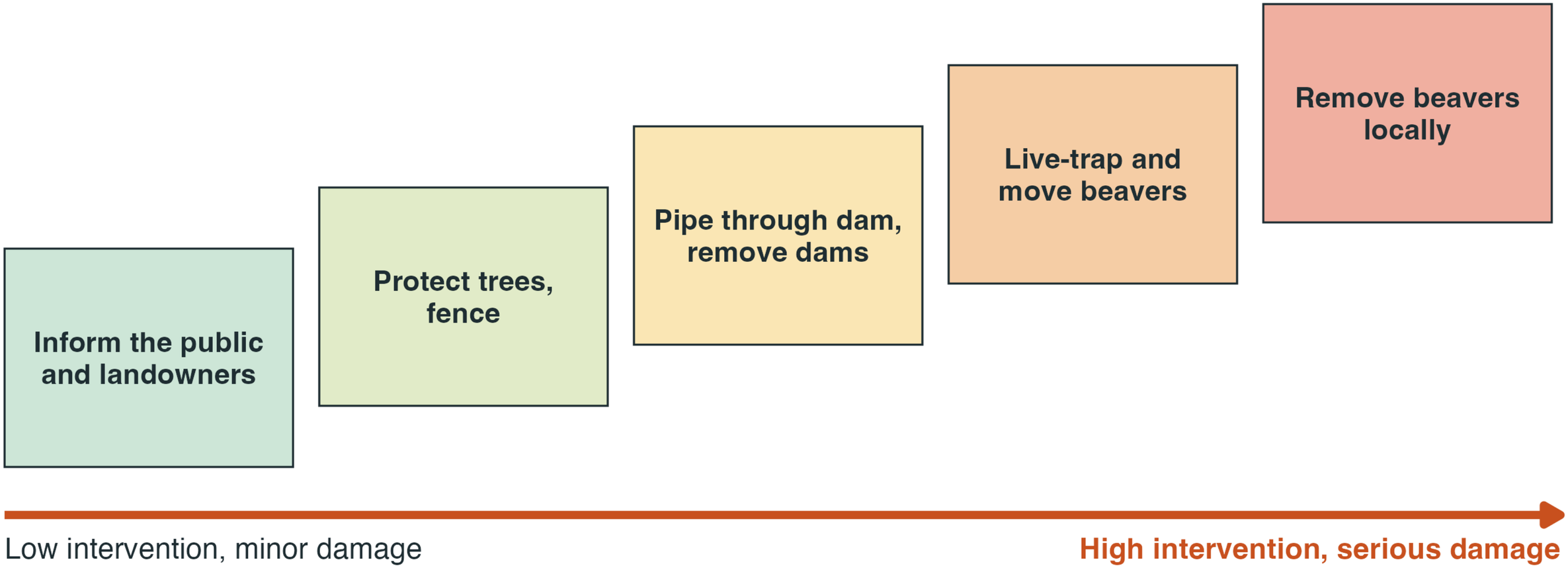
Dr. Leonardo Capitani is financed by the grant **“SeeWandel-Climate: Modelling the consequences of climate change and neobiota for Lake Constance”** within the framework of the Interreg VI programme **“Alpenrhein-Bodensee-Hochrhein (Germany/Austria/Switzerland/Liechtenstein)”**. The funds are provided by the European Regional Development Fund as well as the Swiss cantons.

The funders had no role in the content of this presentation.

Supplementary material

Additional slides

Beaver management: a ladder of options



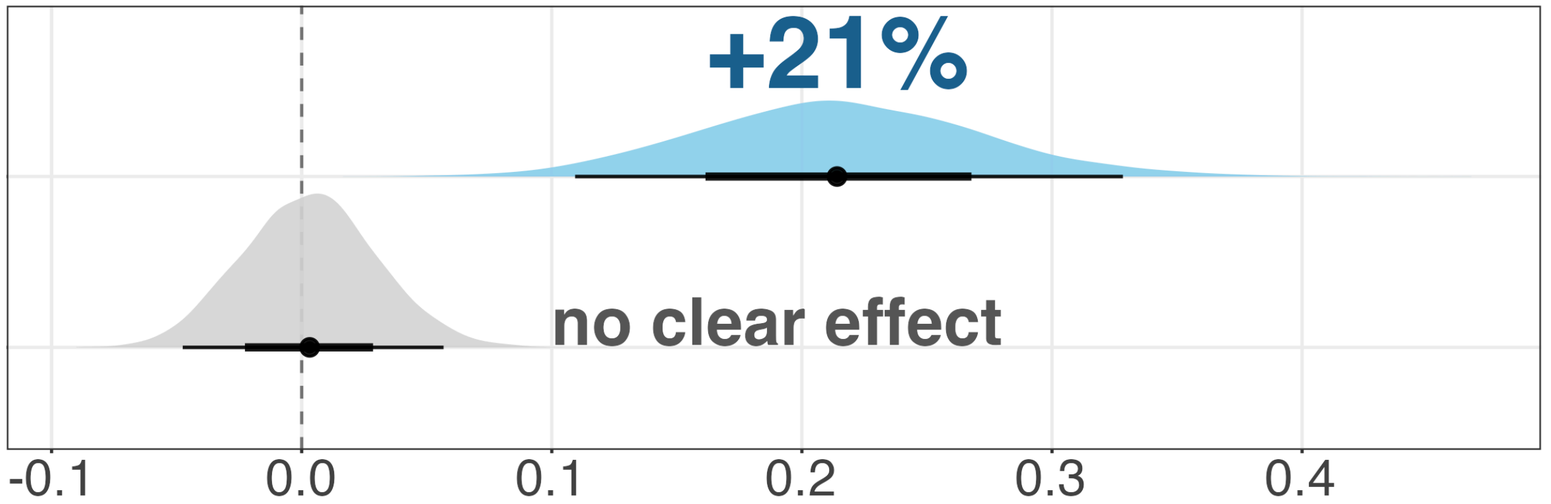
> Start with information; remove beavers last

Summer vs winter: change in DOC

n = 158 streams

Summer

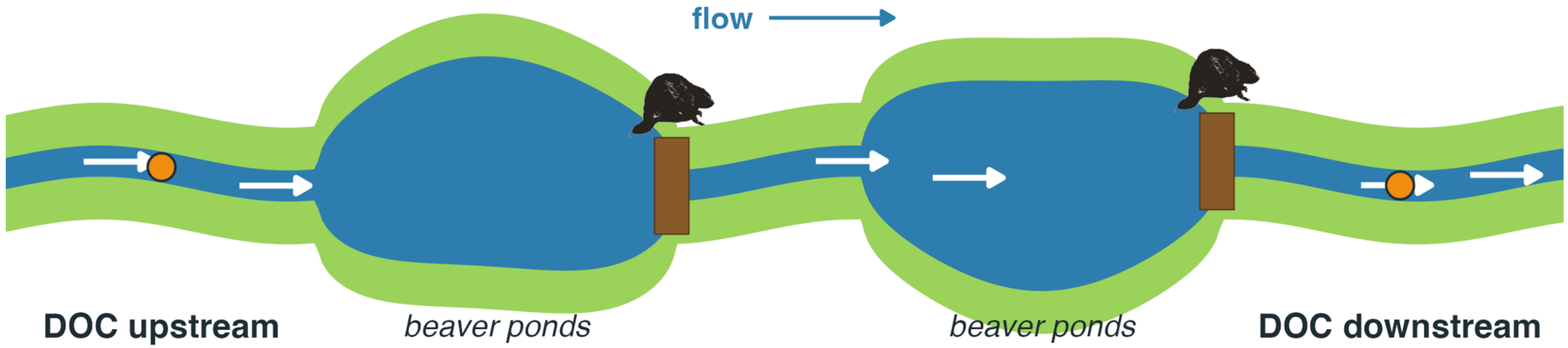
Winter

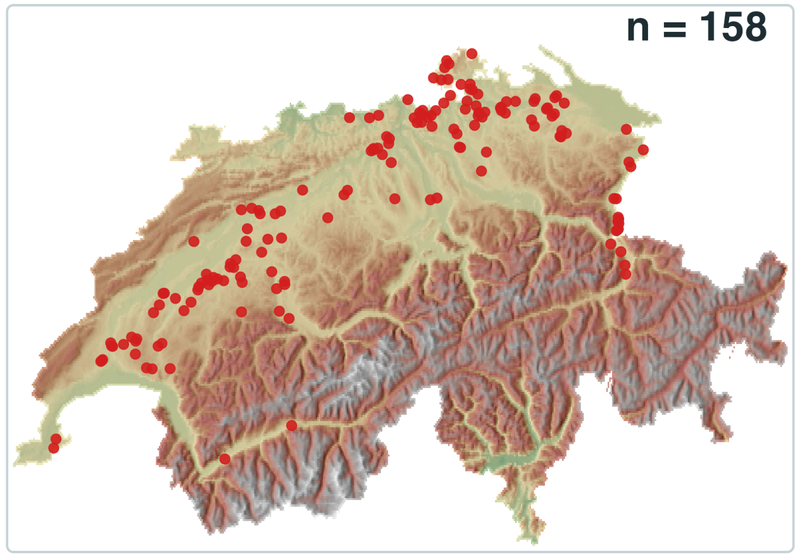


Beaver effect on DOC (× seasonal DOC contrast)

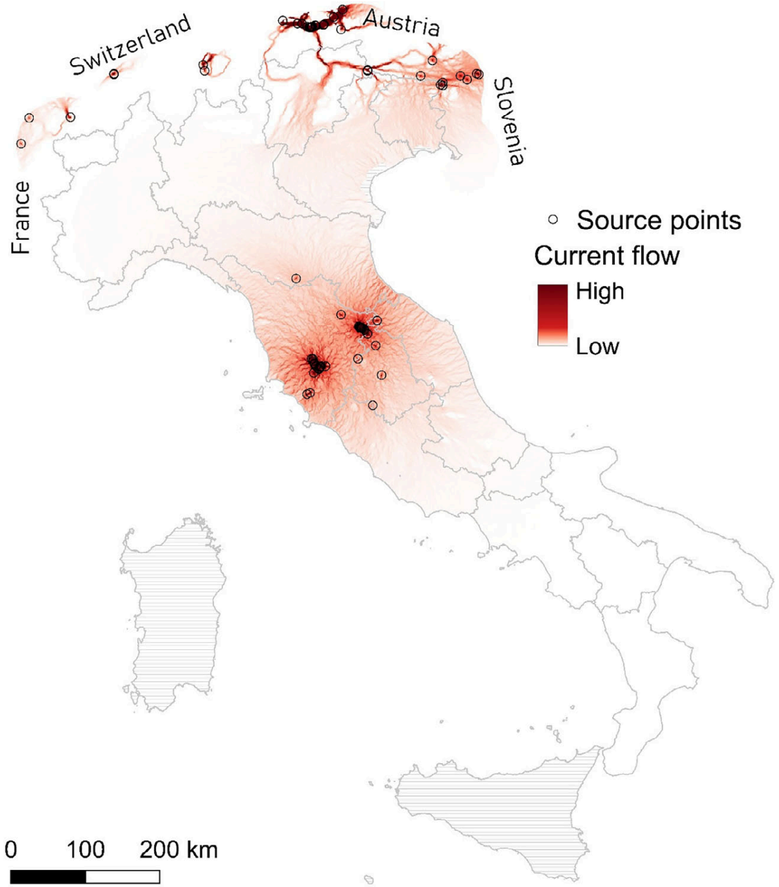
Beavers add DOC in summer, not in winter

Sampling design and sites





Connectivity and expansion



Isolated northern populations expand slowly

Fig. 3 in Falaschi et al. 2024, Animal Conservation 27, 324–337: connectivity map of Eurasian beaver in Italy and surrounding countries. Source points

Beavers dam streams in human-used landscapes



Hersiwil
Canton Solothurn (SO)

Beaver dam

Beaver lodge

Dams and lodge sit next to a field

Beavers dam streams right next to farmland

Beaver dams beside paths and railways





Herzogenbuchsee
Canton Bern (BE)

Beaver dam
Beaver lodge

Territory between a footpath and a railway

Beaver territories can sit next to infrastructure

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