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des ETH-Bereichs

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Ecological impacts of small hydropower plants

Katharina Lange,
Christine Weber,
Martin Schmid

Connectivity in river systems

Willamette River: Daniel Coe; Oregon Dept. of Geology and Mineral Industry; Icons by Adioma

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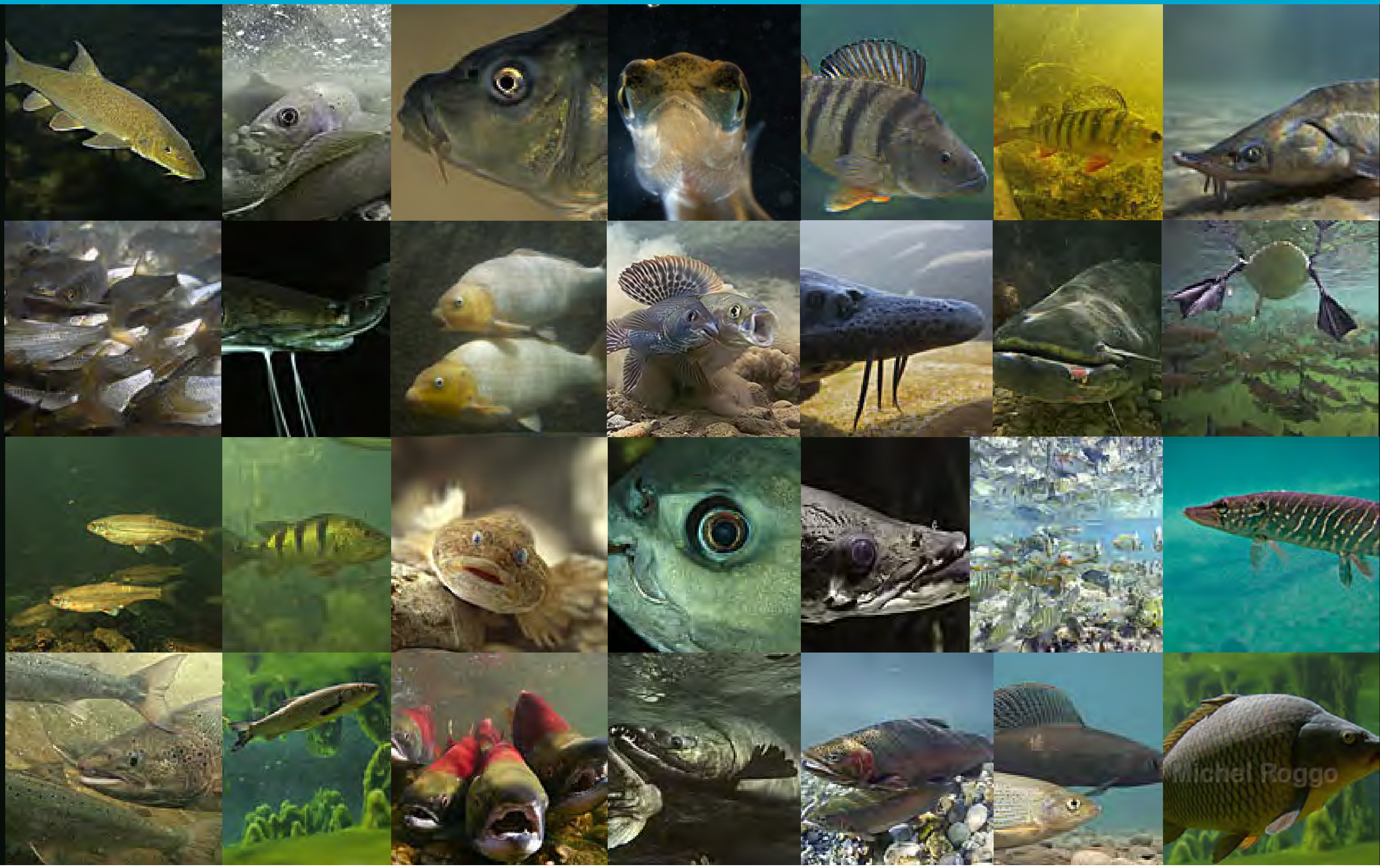
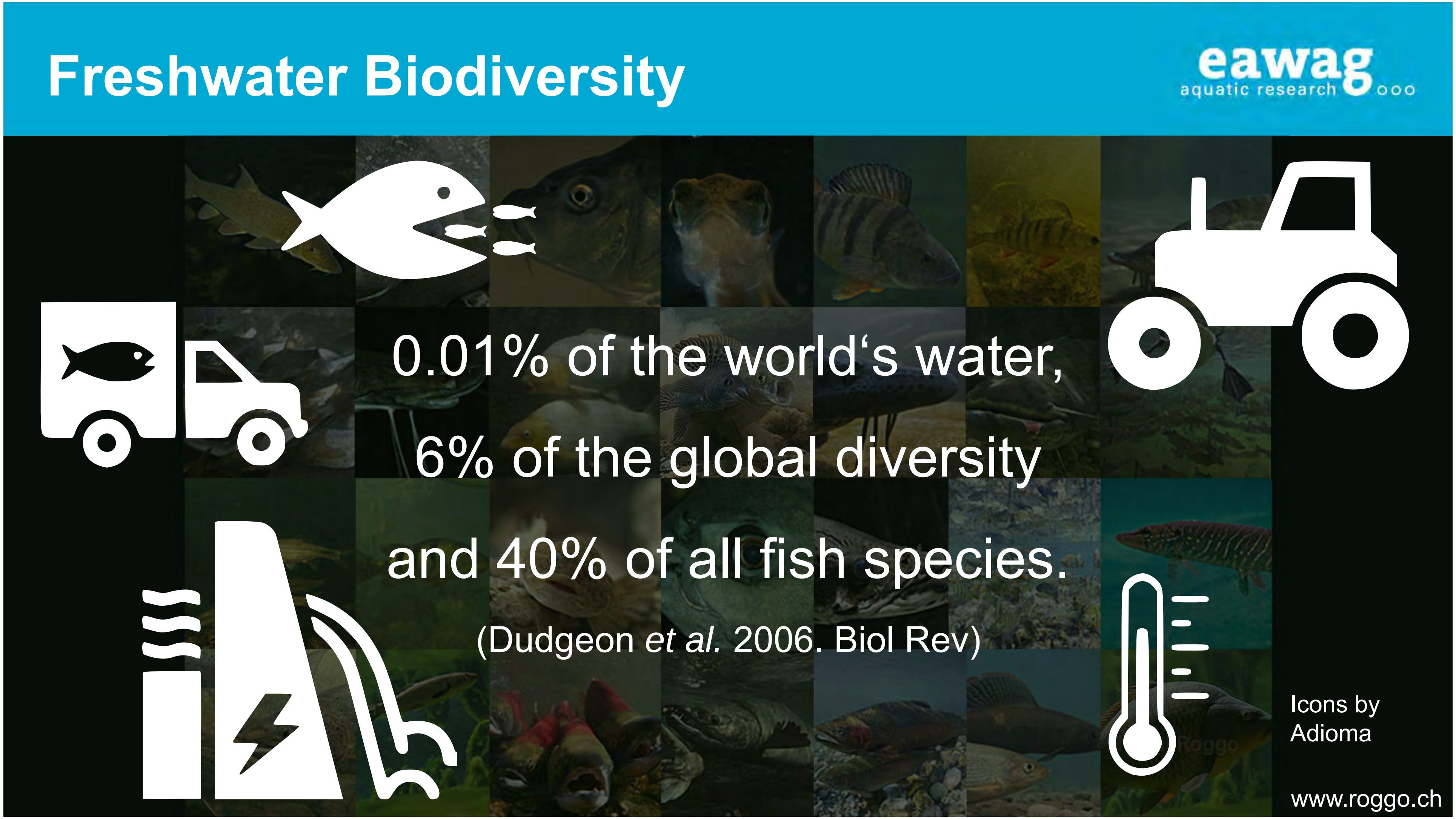
Freshwater Biodiversity



www.roggo.ch


Freshwater Biodiversity
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0.01% of the world's water,
6% of the global diversity
and 40% of all fish species.
(Dudgeon et al. 2006. Biol Rev)
Icons by
Adioma
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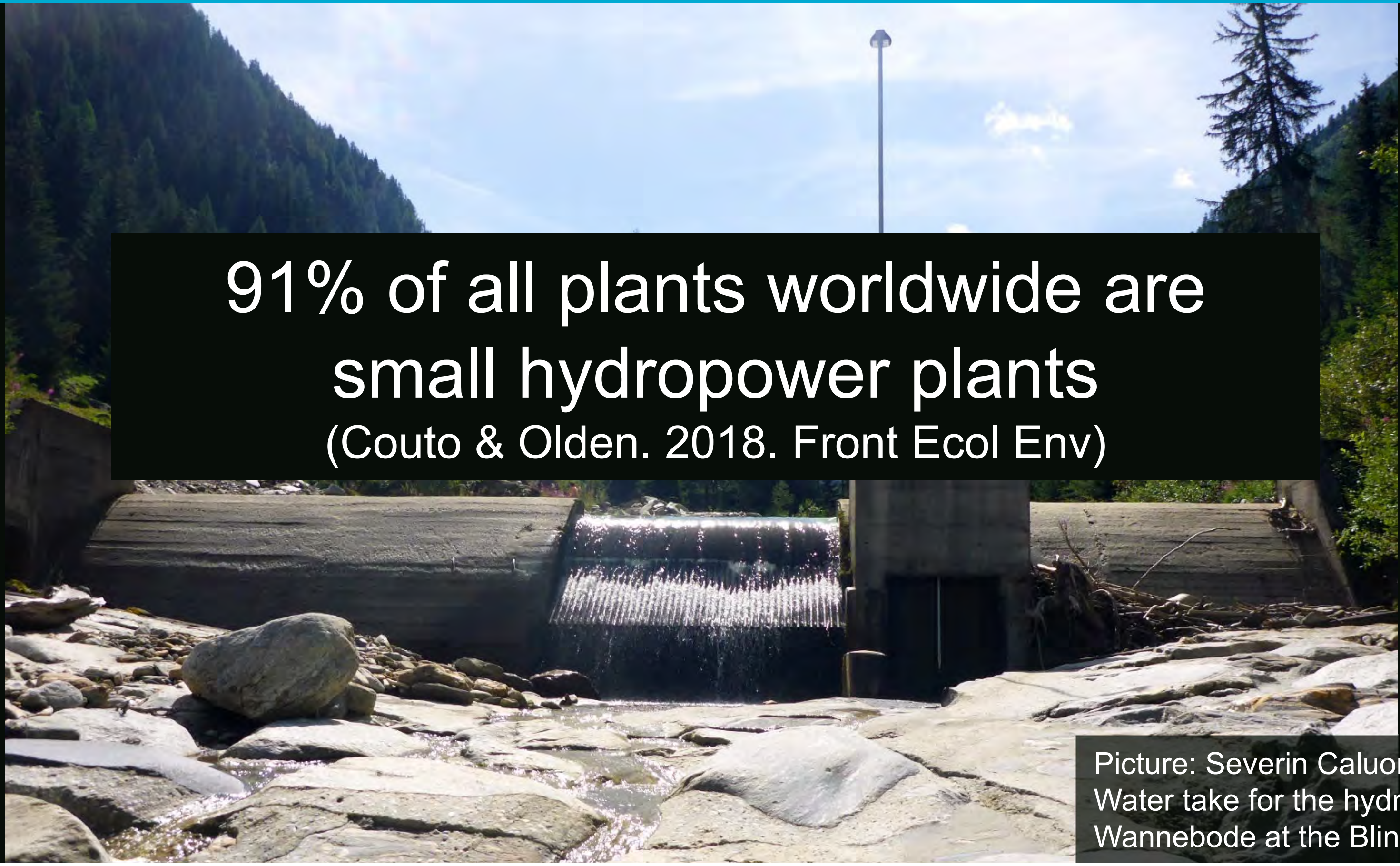
A small hydropower plant

Picture: Severin Caluori
Water take for the hydropower plant Wannebode at the Blinne (VS)

A small hydropower plant



Literature studies

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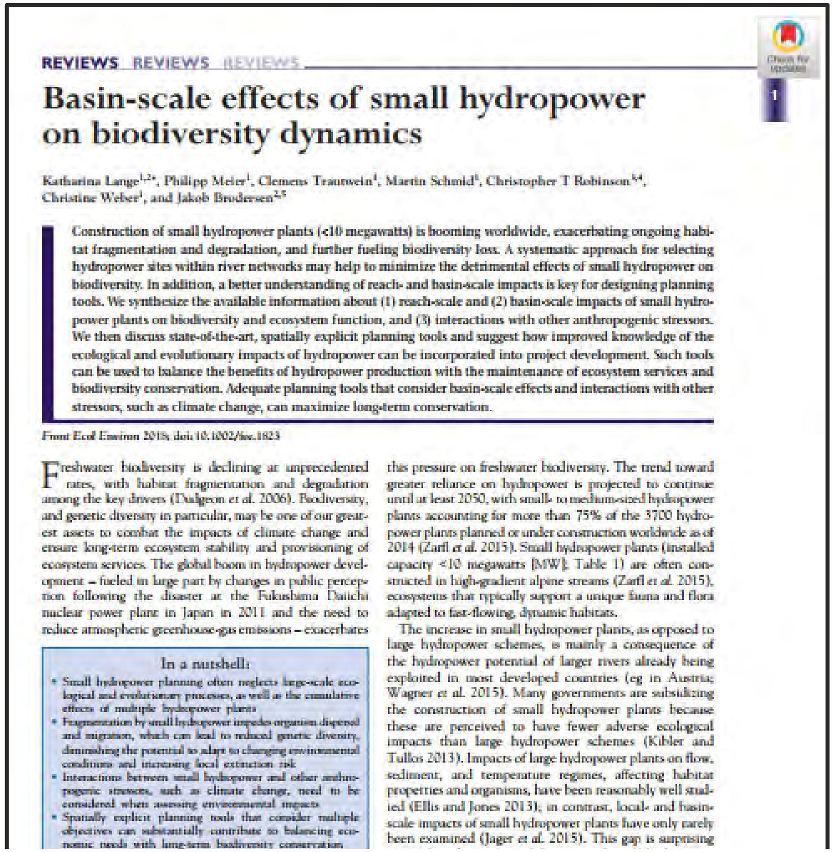

REVIEWS REVIEWS REVIEWS

Basin-scale effects of small hydropower on biodiversity dynamics

Katharina Lange[1,2*], Philipp Meier[1], Clemens Trautwein[1], Martin Schmid[1], Christopher T Robinson[3,4], Christine Weber[1], and Jakob Brodersen[2,5]

Construction of small hydropower plants (<10 megawatts) is booming worldwide, exacerbating ongoing habitat fragmentation and degradation, and further fueling biodiversity loss. A systematic approach for selecting hydropower sites within river networks may help to minimize the detrimental effects of small hydropower on biodiversity. In addition, a better understanding of reach- and basin-scale impacts is key for designing planning tools. We synthesize the available information about (1) reach-scale and (2) basin-scale impacts of small hydropower plants on biodiversity and ecosystem function, and (3) interactions with other anthropogenic stressors. We then discuss state-of-the-art, spatially explicit planning tools and suggest how improved knowledge of the ecological and evolutionary impacts of hydropower can be incorporated into project development. Such tools can be used to balance the benefits of hydropower production with the maintenance of ecosystem services and biodiversity conservation. Adequate planning tools that consider basin-scale effects and interactions with other stressors, such as climate change, can maximize long-term conservation.

Front Ecol Environ 2018; doi:10.1002/fee.1823

Freshwater biodiversity is declining at unprecedented rates, with habitat fragmentation and degradation among the key drivers (Dudgeon et al. 2006). Biodiversity, and genetic diversity in particular, may be one of our greatest assets to combat the impacts of climate change and ensure long-term ecosystem stability and provisioning of ecosystem services. The global boom in hydropower development – fueled in large part by changes in public perception following the disaster at the Fukushima Daiichi nuclear power plant in Japan in 2011 and the need to reduce atmospheric greenhouse-gas emissions – exacerbates this pressure on freshwater biodiversity. The trend toward greater reliance on hydropower is projected to continue until at least 2050, with small- to medium-sized hydropower plants accounting for more than 75% of the 3700 hydropower plants planned or under construction worldwide as of 2014 (Zarfl et al. 2015). Small hydropower plants (installed capacity <10 megawatts [MW]; Table 1) are often constructed in high-gradient alpine streams (Zarfl et al. 2015), ecosystems that typically support a unique fauna and flora adapted to fast-flowing, dynamic habitats.

The increase in small hydropower plants, as opposed to large hydropower schemes, is mainly a consequence of the hydropower potential of larger rivers already being exploited in most developed countries (eg in Austria; Wagner et al. 2015). Many governments are subsidizing the construction of small hydropower plants because these are perceived to have fewer adverse ecological impacts than large hydropower schemes (Kibler and Tullos 2013). Impacts of large hydropower plants on flow, sediment, and temperature regimes, affecting habitat properties and organisms, have been reasonably well studied (Ellis and Jones 2013); in contrast, local- and basin-scale impacts of small hydropower plants have only rarely been examined (Jager et al. 2015). This gap is surprising

In a nutshell:

- Small hydropower planning often neglects large-scale ecological and evolutionary processes, as well as the cumulative effects of multiple hydropower plants
- Fragmentation by small hydropower impedes organism dispersal and migration, which can lead to reduced genetic diversity, diminishing the potential to adapt to changing environmental conditions and increasing local extinction risk
- Interactions between small hydropower and other anthropogenic stressors, such as climate change, need to be considered when assessing environmental impacts
- Spatially explicit planning tools that consider multiple objectives can substantially contribute to balancing economic needs with long-term biodiversity conservation

Lange *et al.* 2018. Basin-scale effects of small hydropower on biodiversity dynamics. Front Ecol Env

Literature studies

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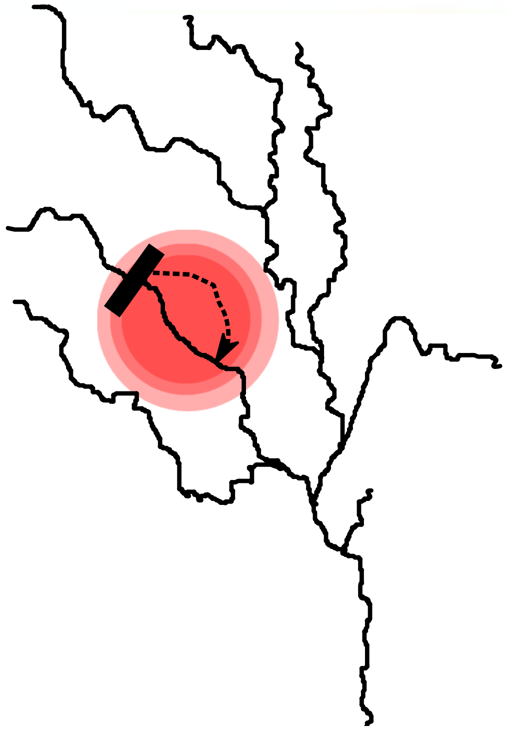
Open research questions

- Range of effects
  (longitudinal and lateral connectivity)



Lange *et al.* 2018. Basin-scale effects of small hydropower on biodiversity dynamics. Front Ecol Env

Literature studies

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Open research questions

- Range of effects
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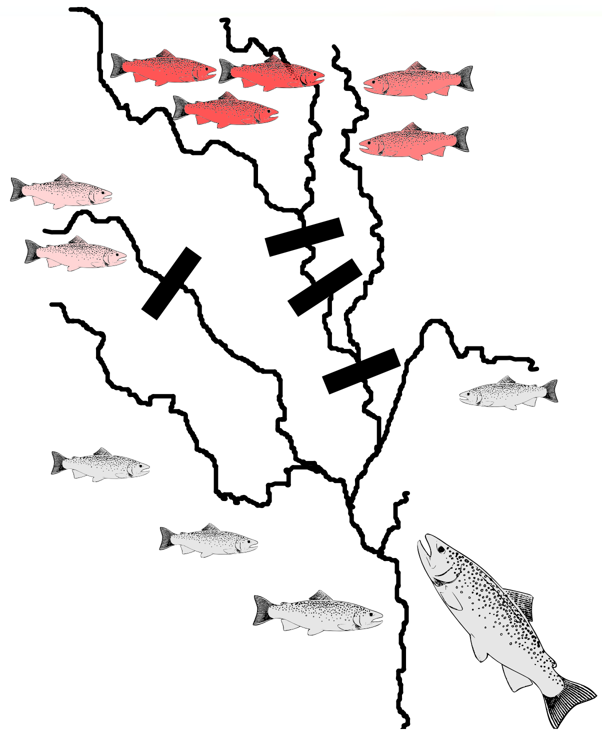
- Interation among multiple hydropower plants
  (cumulative effects)
- Effect on eco-evolutionary processes
  (e.g. intraspecific diversity)



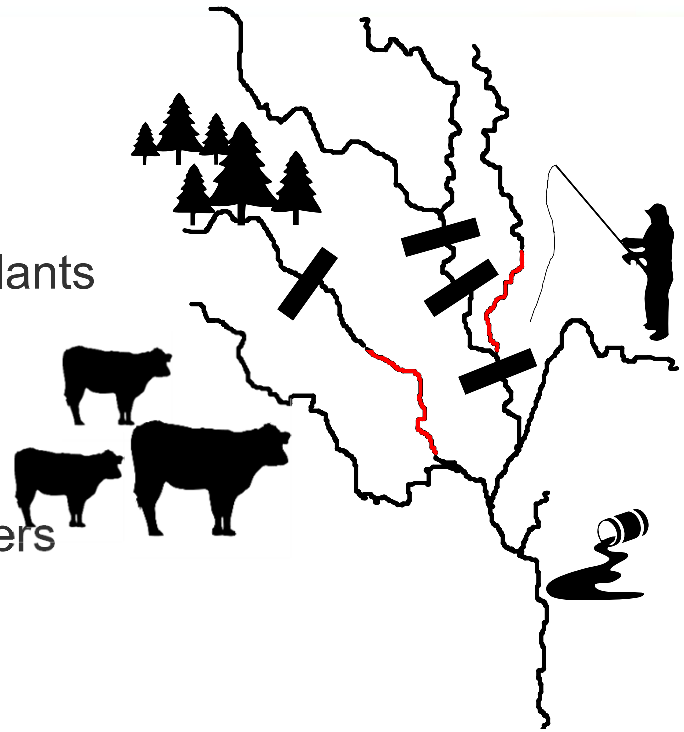
Lange *et al.* 2018. Basin-scale effects of small hydropower on biodiversity dynamics. Front Ecol Env

Literature studies

Open research questions

- Range of effects
  (longitudinal and lateral connectivity)
- Interation among multiple hydropower plants
  (cumulative effects)
- Effect on eco-evolutionary processes
  (e.g. intraspecific diversity)
- Interactions among multiple human drivers
  (multiple stressors)

Important for planning, e.g. selection of locations for constructing new small hydropower plants



Lange *et al.* 2018. Basin-scale effects of small hydropower on biodiversity dynamics. Front Ecol Env

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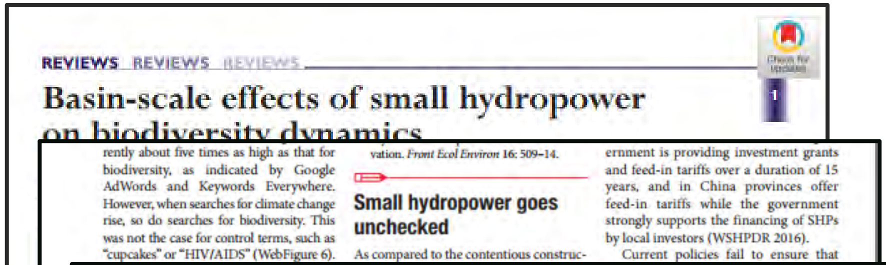

REVIEWS REVIEWS REVIEWS

Basin-scale effects of small hydropower on biodiversity dynamics

rently about five times as high as that for biodiversity, as indicated by Google AdWords and Keywords Everywhere. However, when searches for climate change rise, so do searches for biodiversity. This was not the case for control terms, such as "cupcakes" or "HIV/AIDS" (WebFigure 6).

vation. *Front Ecol Environ* 16: 509–14.

Small hydropower goes unchecked

As compared to the contentious construc-

ernment is providing investment grants and feed-in tariffs over a duration of 15 years, and in China provinces offer feed-in tariffs while the government strongly supports the financing of SHPs by local investors (WSHPDR 2016).

Current policies fail to ensure that

Lange et al 2019. Small hydropower goes unchecked. Front Evol Env

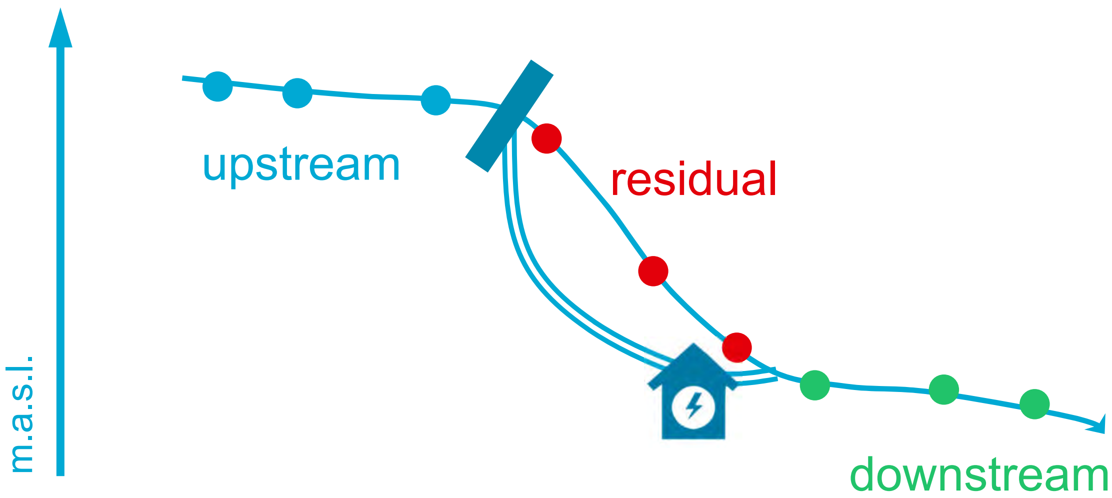
Systematic literature review and quantitative analysis

21 articles

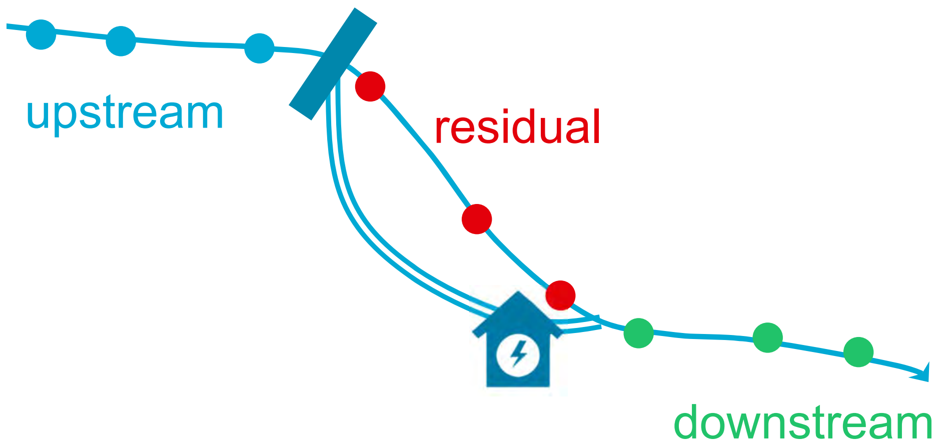
73 small hydropower plants

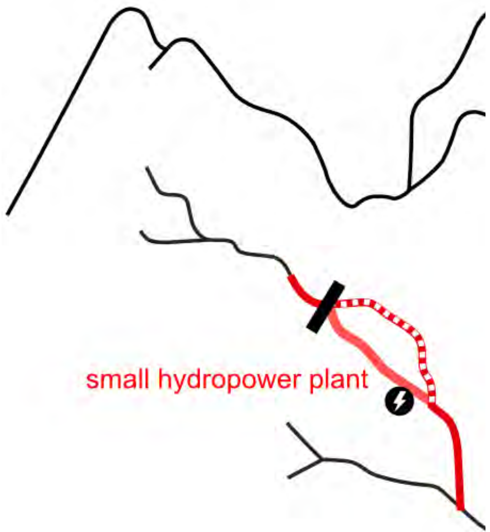
- habitat
- invertebrates
- fish

Field study



Field study





Field study

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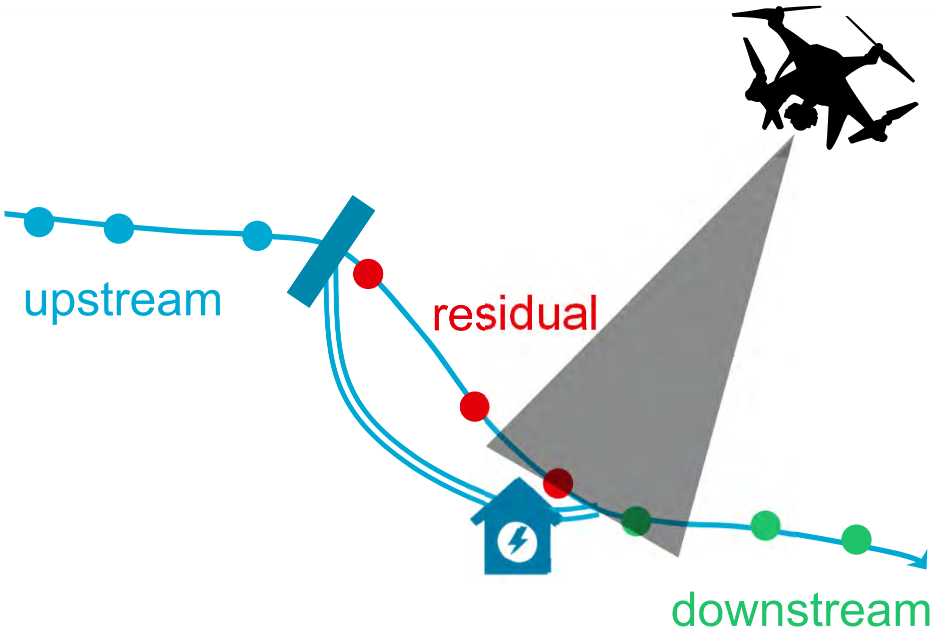
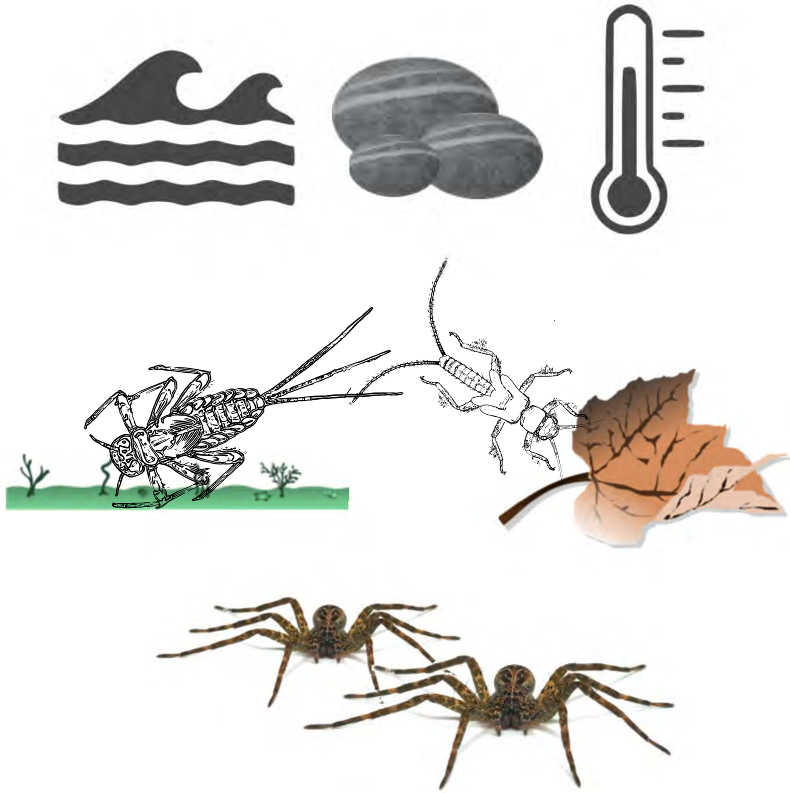
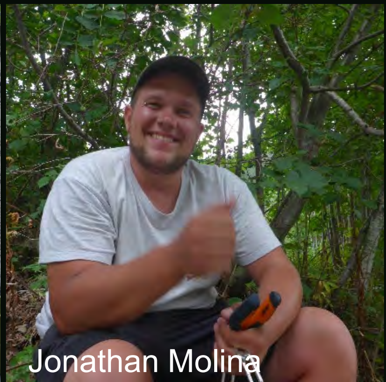
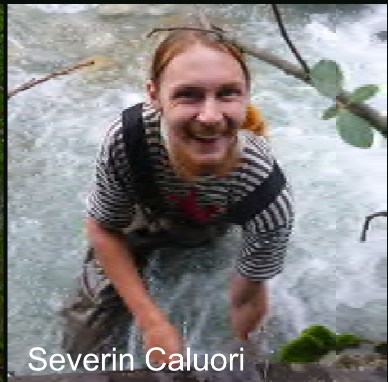




Team


Lisa Wilmsmeier


Jonathan Molina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Jenny Rieger


Samuel Sieder


Lioba Rath


Pierre Chanut


Christine Weber


Martin Schmid

Water take

Water return

Picture: Jonathan Molina
Hydropower plant Wannebode (VS)

Drohne data: wetted width

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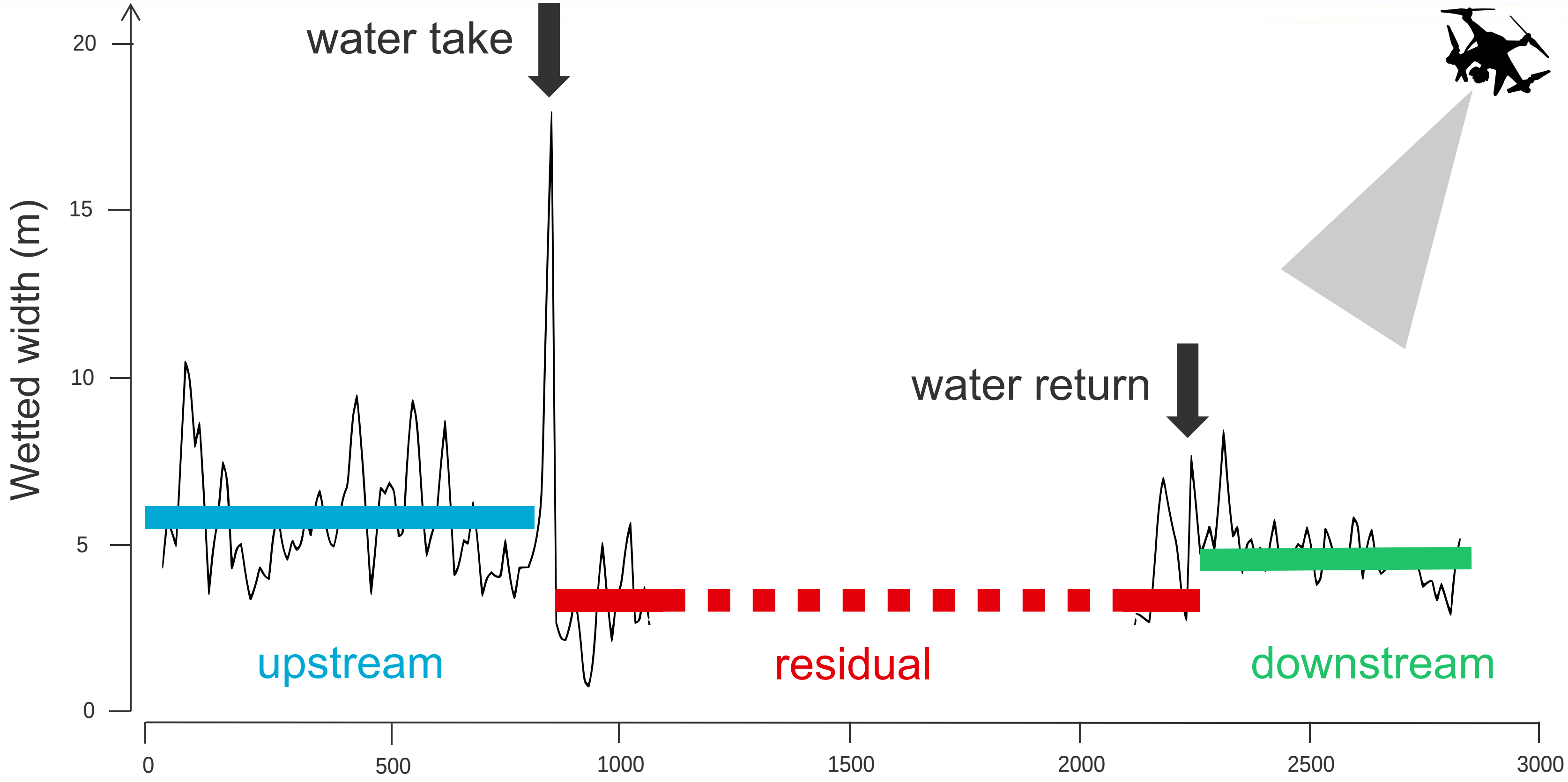
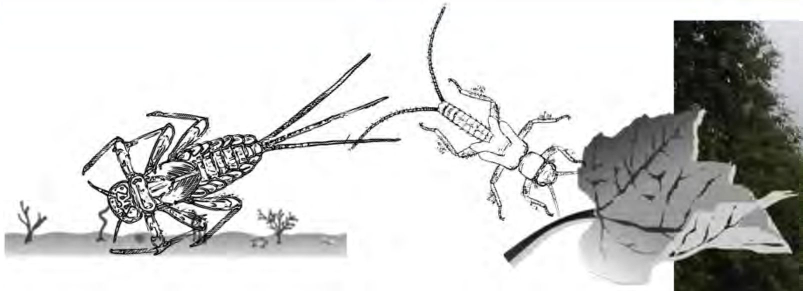
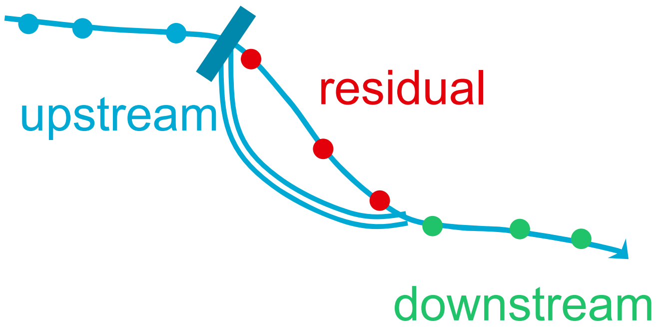


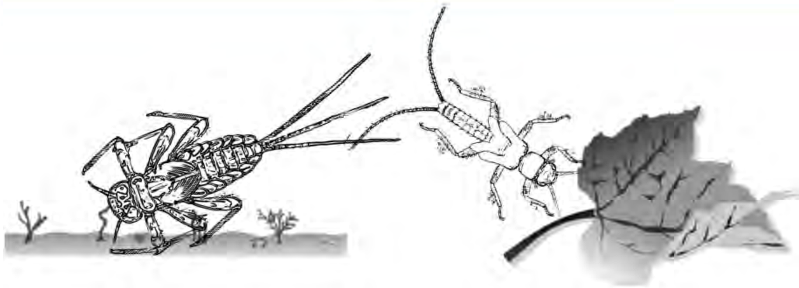
River: Blinne (VS)

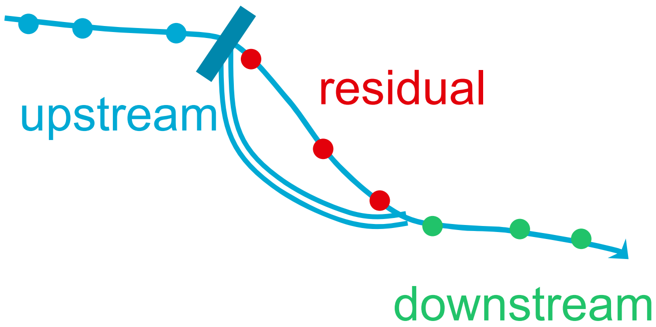
Field study



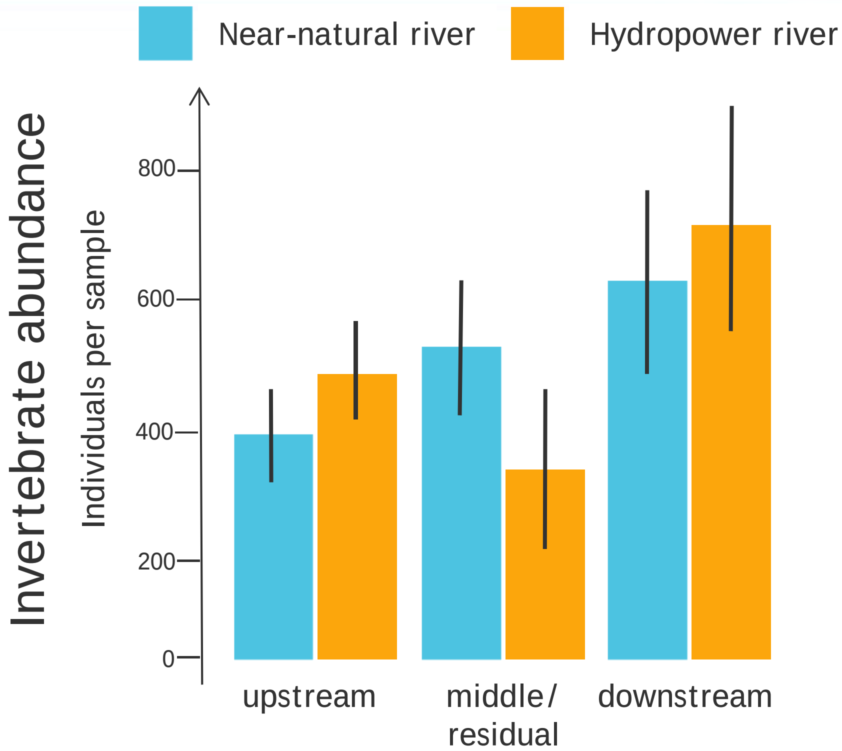


Field study





upstream
residual
downstream



Near-natural river
Hydropower river
Invertebrate abundance
Individuals per sample
800
600
400
200
0
upstream
middle/ residual
downstream

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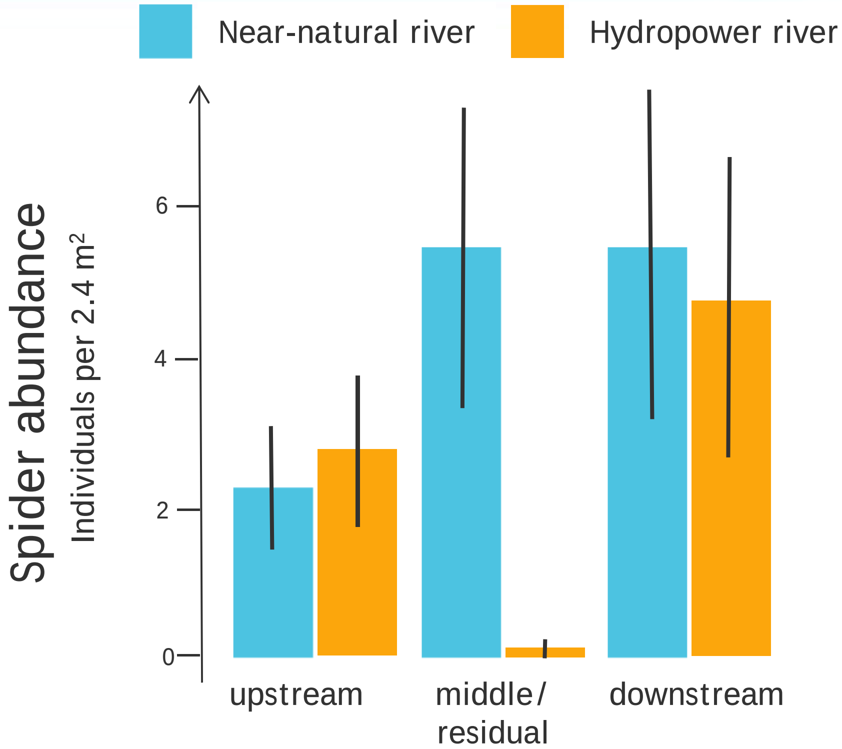
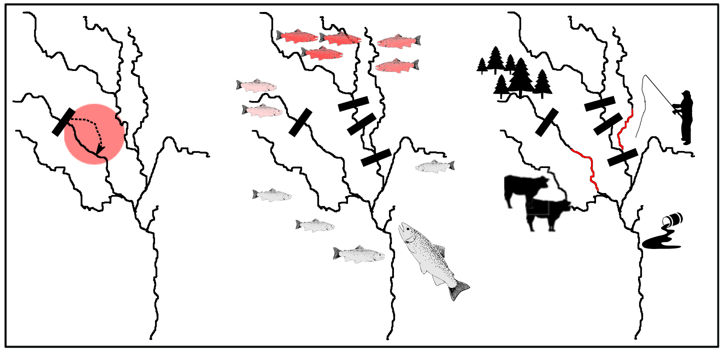
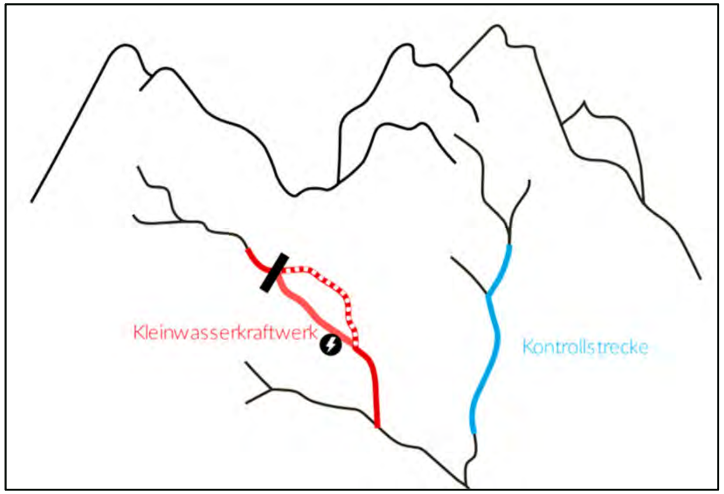
Pardosa waglerii

Piratula knorrii







Literature studies

Basin-scale perspective is important

Cumulative effects of multiple hydropower plants

Multiple stressors, e.g. interaction with climate change

Field study

Comparison with near-natural systems is important

Impacts on habitat and ecosystem functions, e.g. reduction of invertebarte abundance by 45%

Impact on lateral connectivity (water↔land), e.g. reduction of spider abundance by 95%