Climate change in the context of Environmental flows and changed hydrology in three basin areas in Sweden

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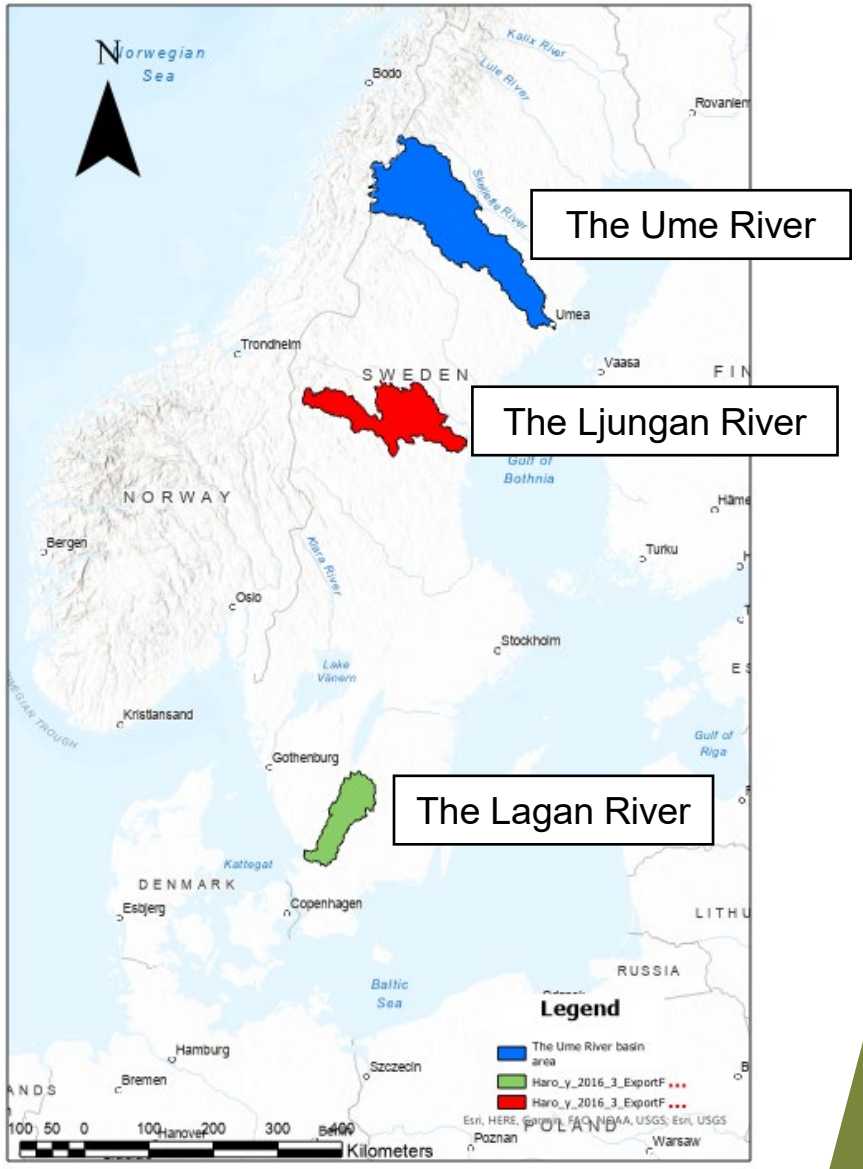
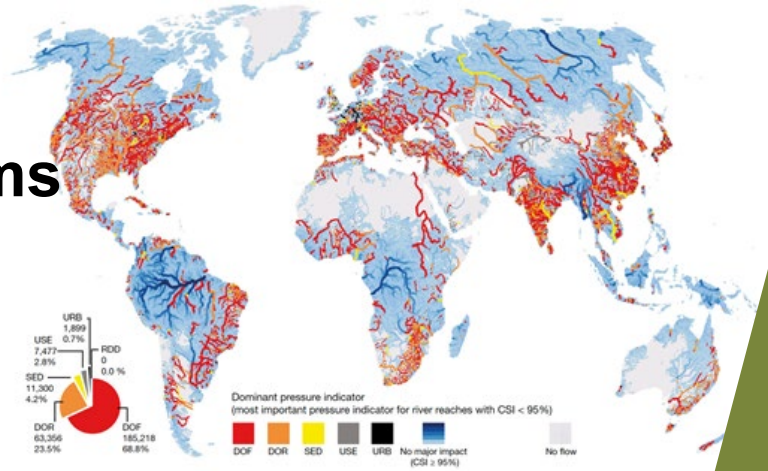
Ecosystem management at catchment areas with large scale hydro power

Collaboration with hydropower companies, authorities, NGOs and stakeholders.



Background - status of the world's river systems

- Hydropower plays a key role in the conversion into renewable electricity systems –mitigate **climate crisis** and to overcome **energy crisis**
- Affects ecosystems negatively – one cause of **diversity crisis**
- Increased **pressures** on riverine ecosystem
- Call for environmental assessments
- Enhance the **ecological status of river systems**



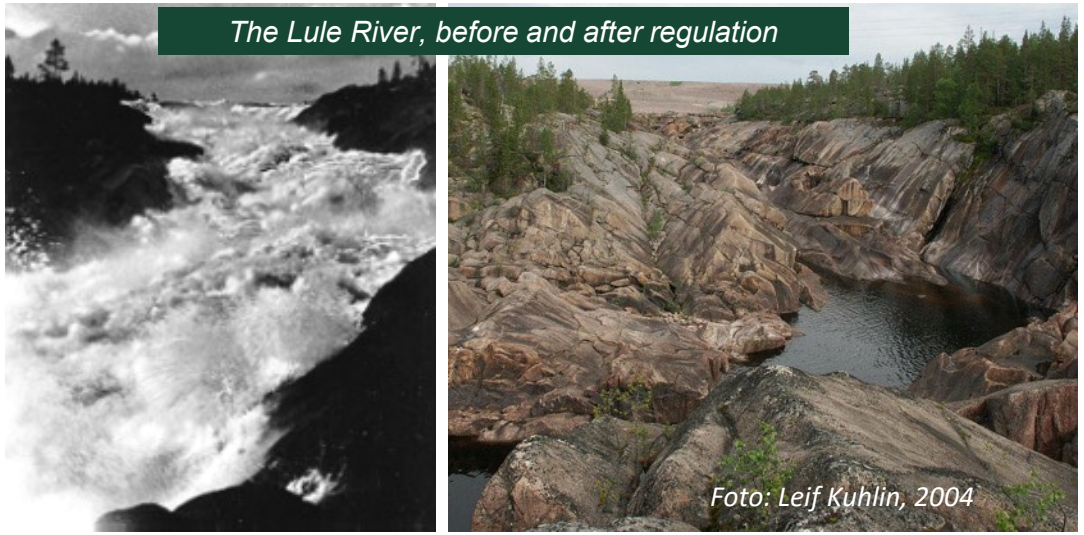
Grill et al. (2019) *Nature*

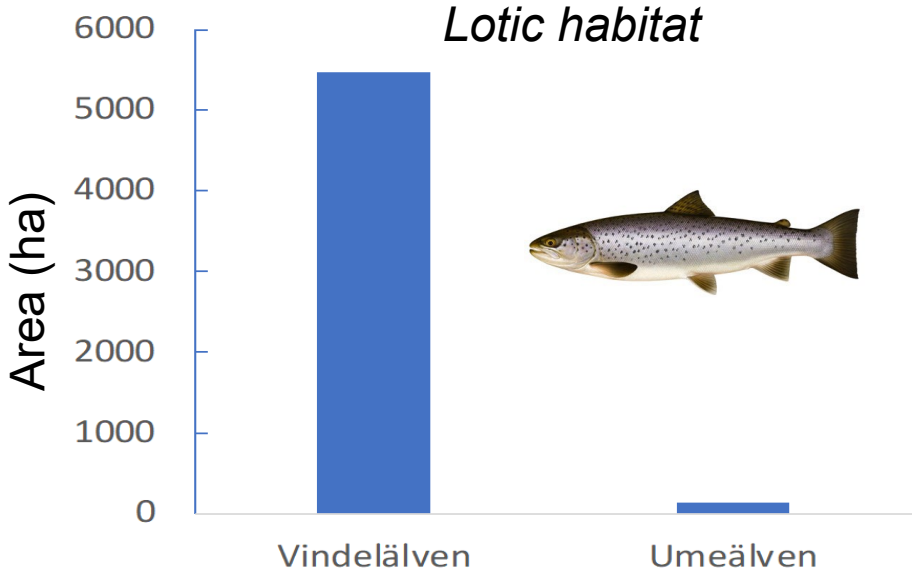
How to find the balance? Win-win solutions?

- Energy system
- River ecology – diversity
- With consideration of climate change

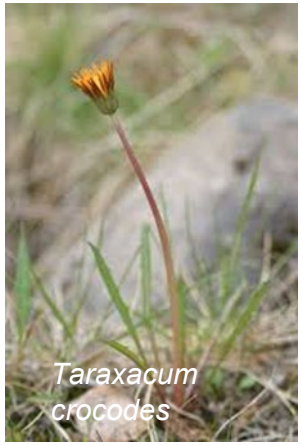
Loss of riverine ecosystems due to hydropower and regulation

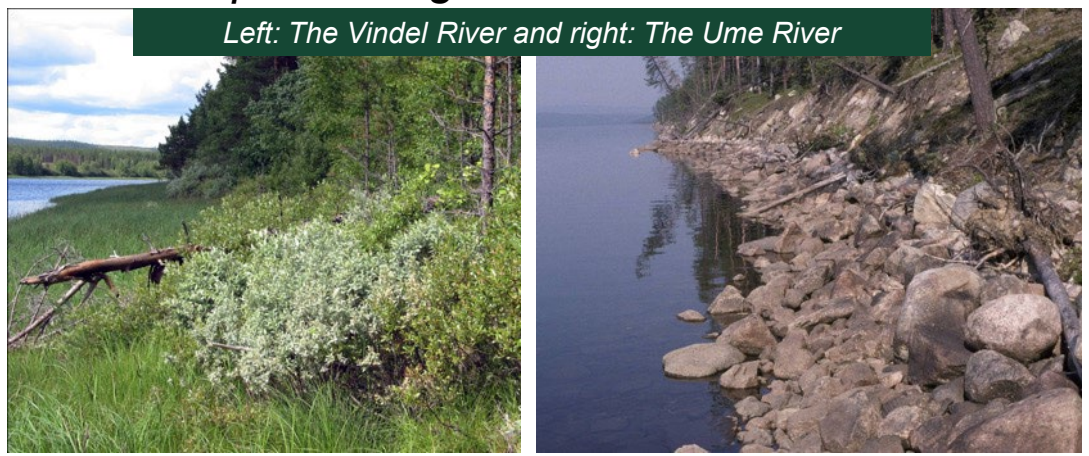
Lotic habitat

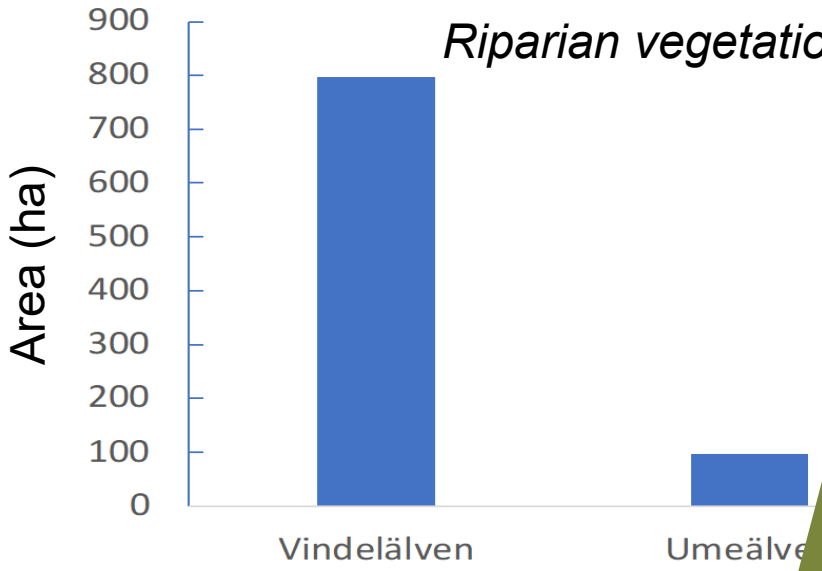




Habitat - riparian vegetation



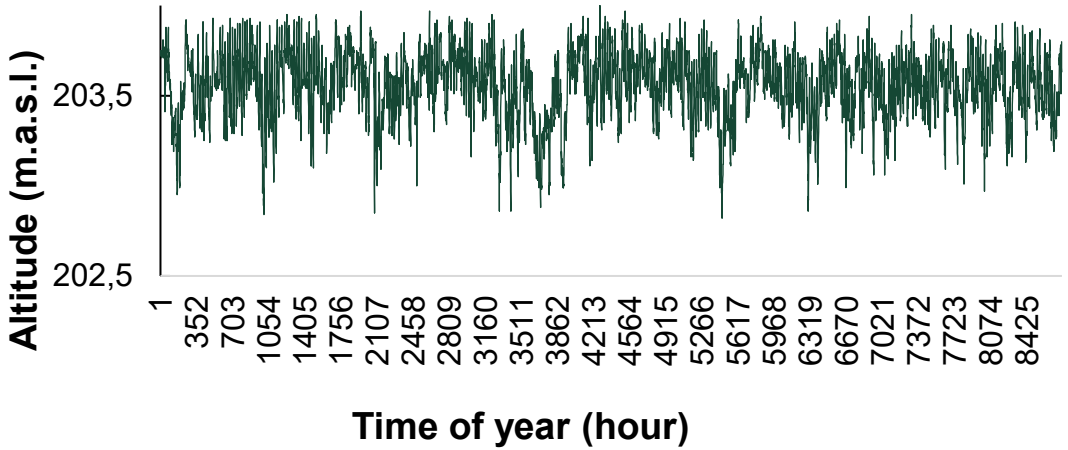


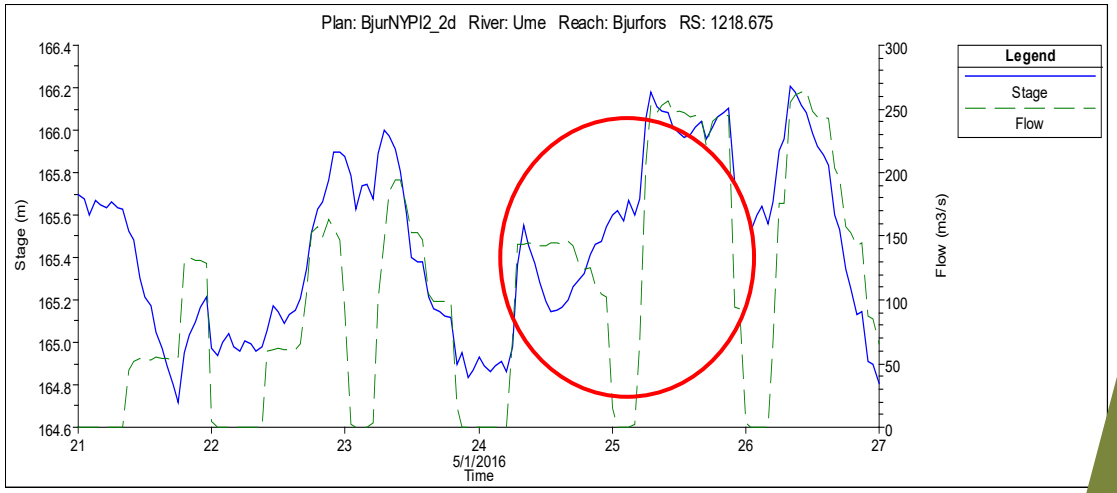


Widén et al. (2021) *Water Resources Research*

Hydropeaking

- Definition fast changes of;
- Flow
- Water level
- Zero flow events (start/stop of turbines)
- Interactions (flow & water level)

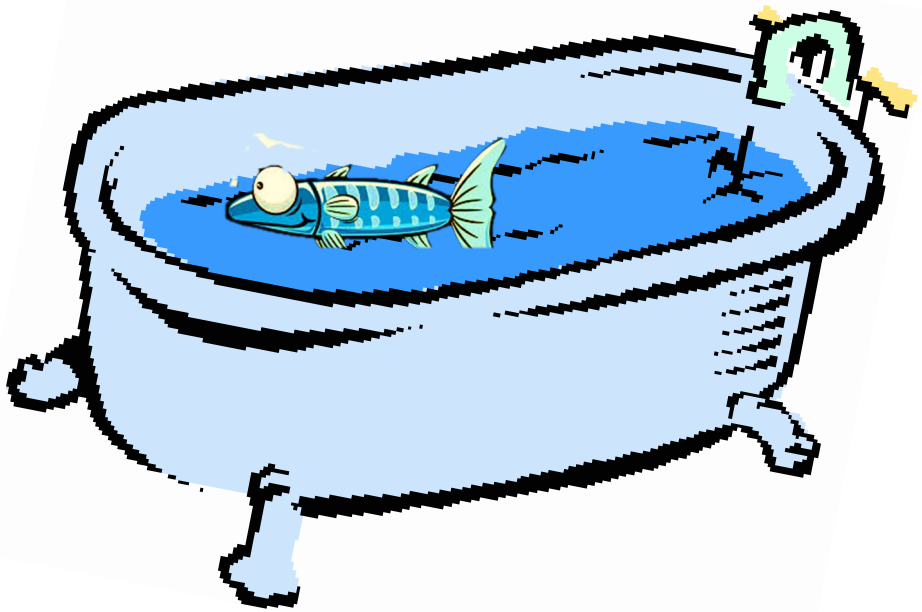


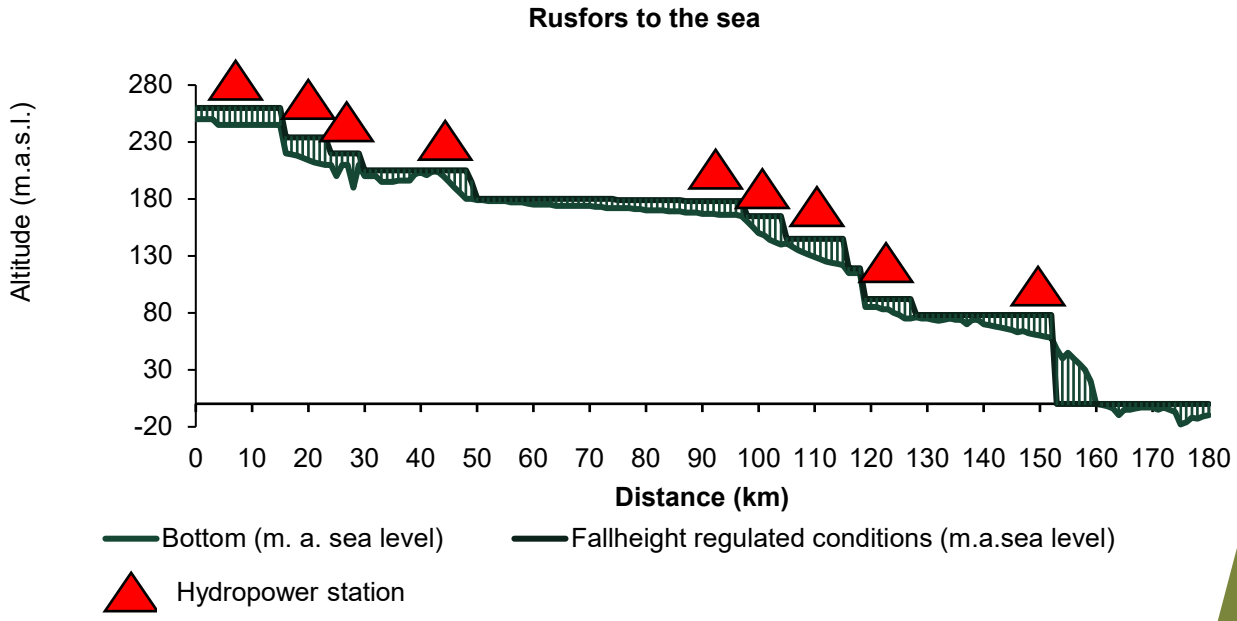


Widén et al 2021. STOTEN

Hydropower stations in cascade – almost no fall height remain - Sweden

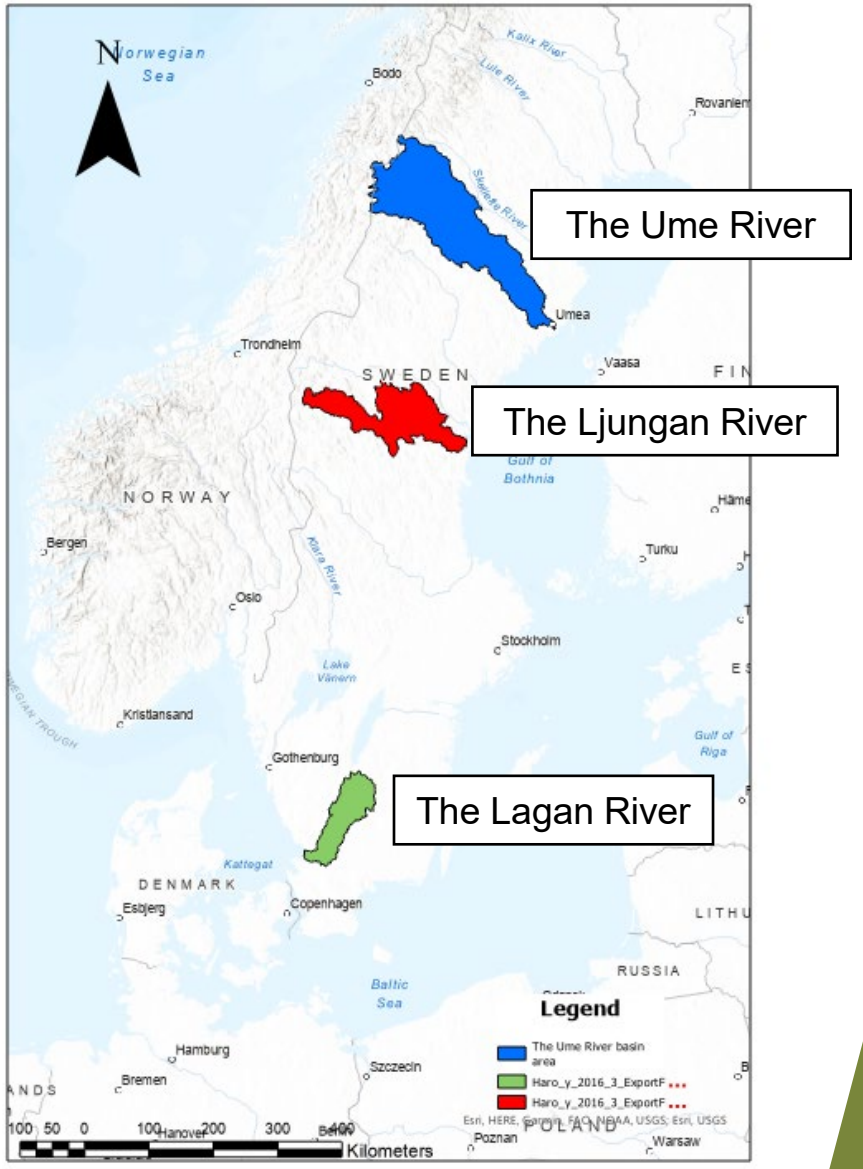
Ongoing research project
”EKOFALL”





Three catchment areas with large hydro power

- Collaboration with Statkraft, where Statkraft in Trondheim ran the models.
- Climate scenario: A1B
- 83 historical years
- Projections until 2040



Measures mapped at catchments

- Morphology restoration
- Flow restoration
- Connectivity restoration

1. Combination of measures assessed as scenarios
2. Consequencys on energy system
3. Projected environmental benefits

Environmental flows scenarios in combination as hydropower operational rules

TURBINES

- **Minimum flows-forbidden zero flow**
- Adapted flows
- Water levels changes
- Restrictions of hydropeaking

SPILL WATER

- By-pass channel affected by diversion of water
- Connectivity

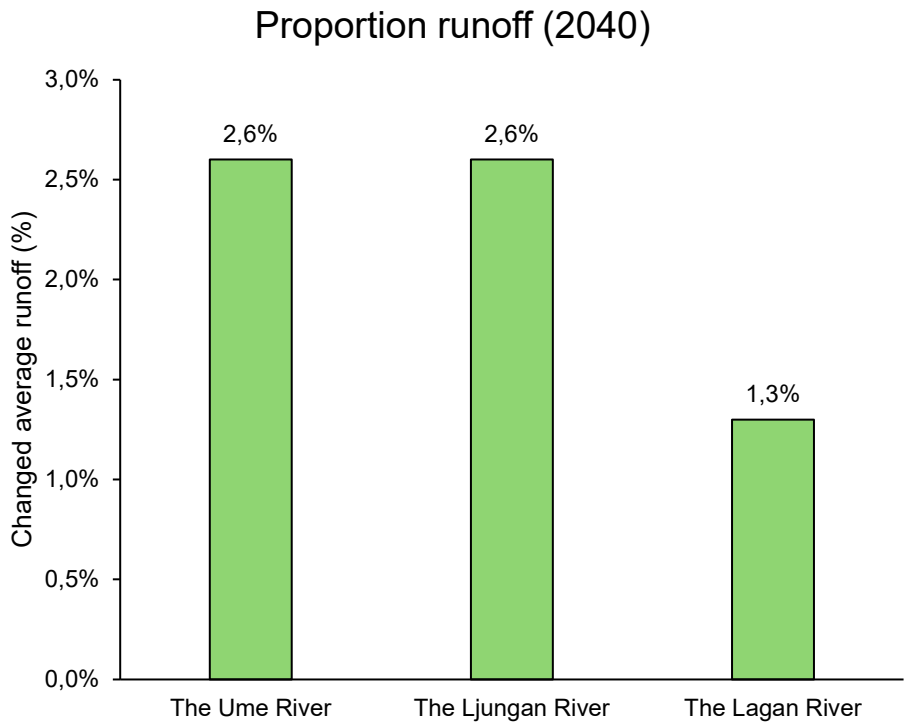
Combined into environmental flow scenarios different for each river catchment with projections of climate change

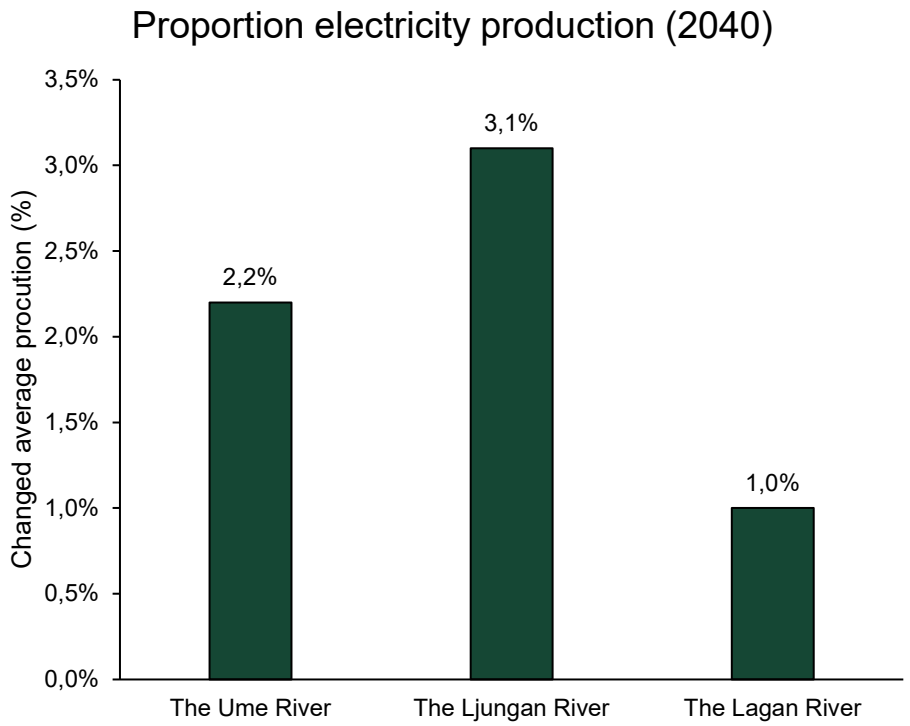
Environmental flows scenarios
Forbidden zero flows with water through turbines

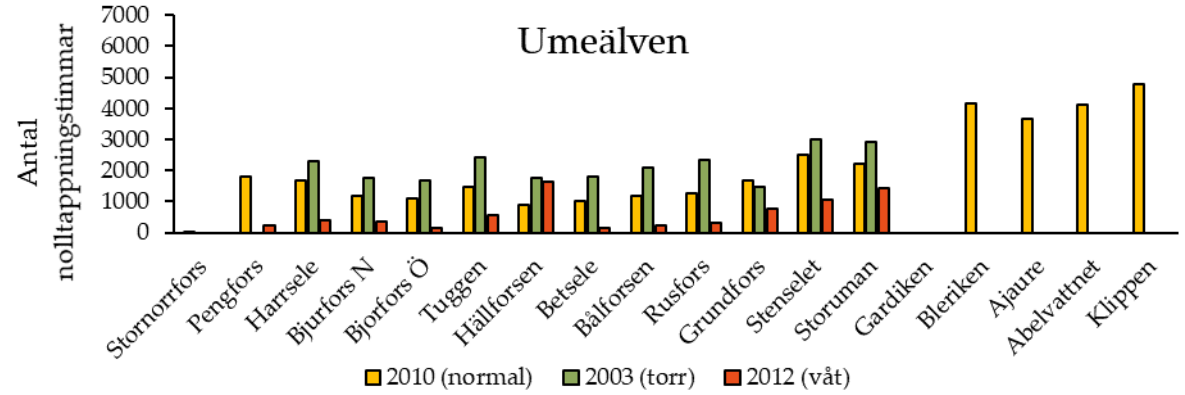
- Least minimum discharge was Mean Annual Low Flow (MALF)
- Water through turbines to produce electricity
- With technical consideration of turbines (Qmin)
- If not possible we spilled water in the model
- Models for The Ume, Ljungan and Lagan River

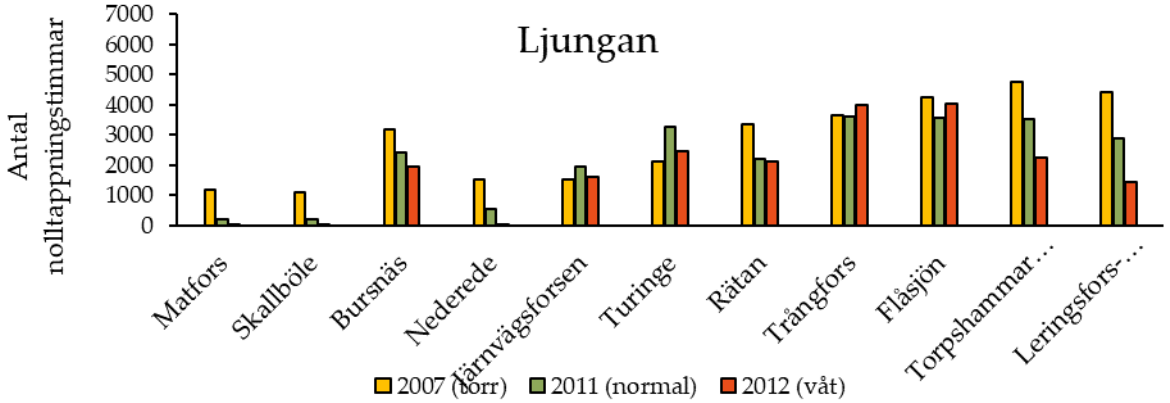
Combined into environmental flow scenarios different for each river catchment with projections of climate change

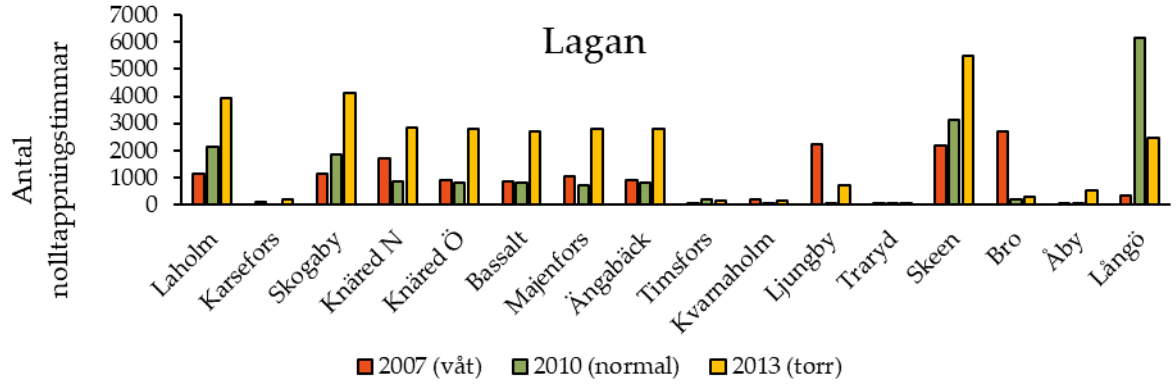
Result hydrology & electricity production





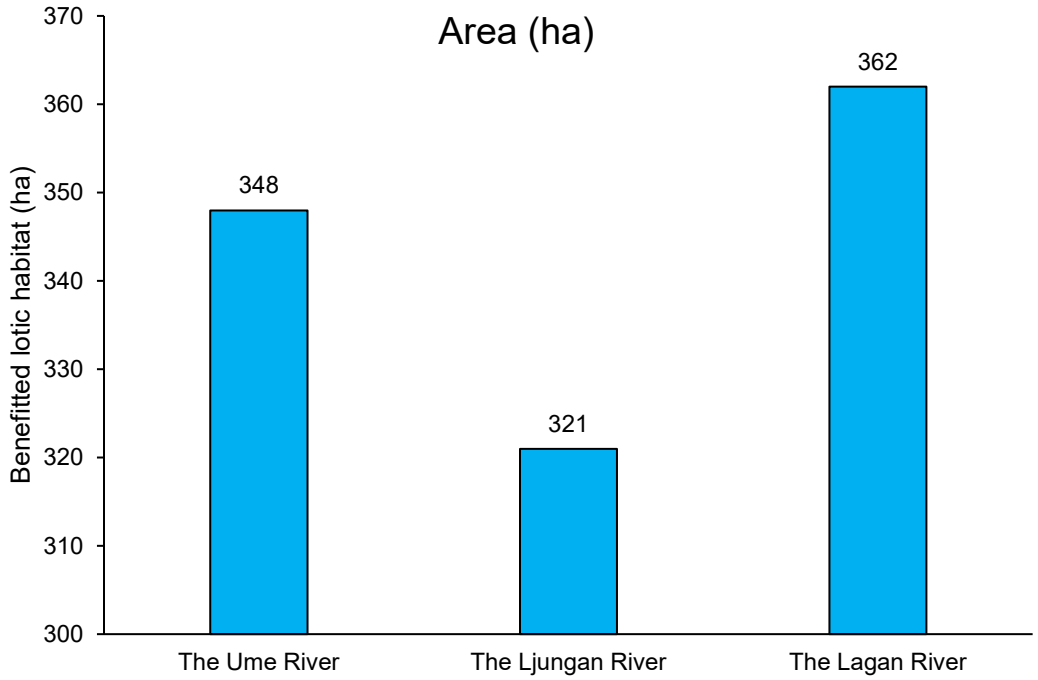






Number of hours with zero flows and start/stop of turbines

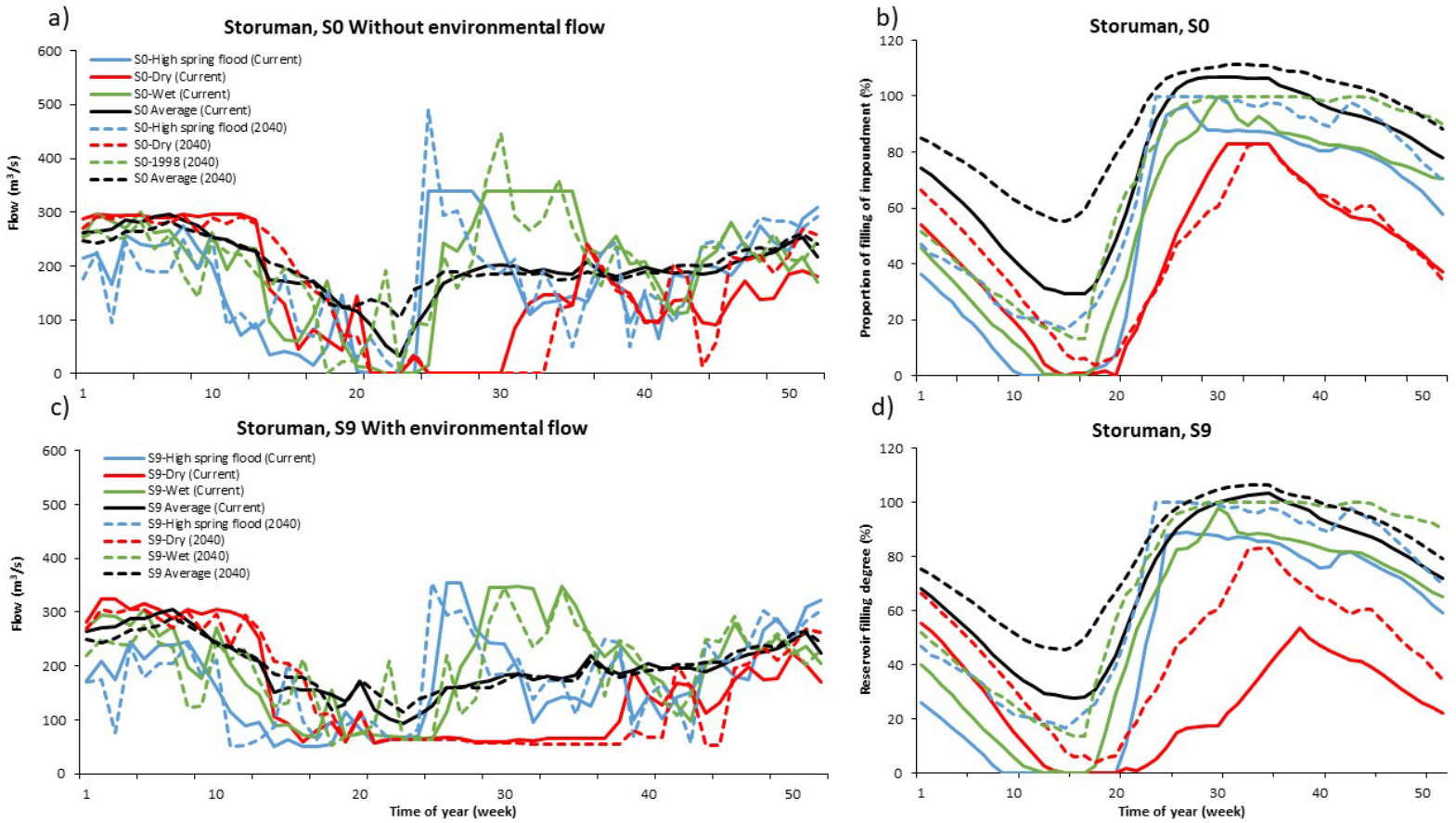
Environmental benefits – hydropower operational rules with water through turbines – forbidden zero-flow



- Avoidance of standing water
- Increased water velocity
- Increased ecosystem function
- Decreased degree of hydropeaking

Habitat with increased function after morphological restoration measures

Storuman Reservoir (2030) in the Ume River



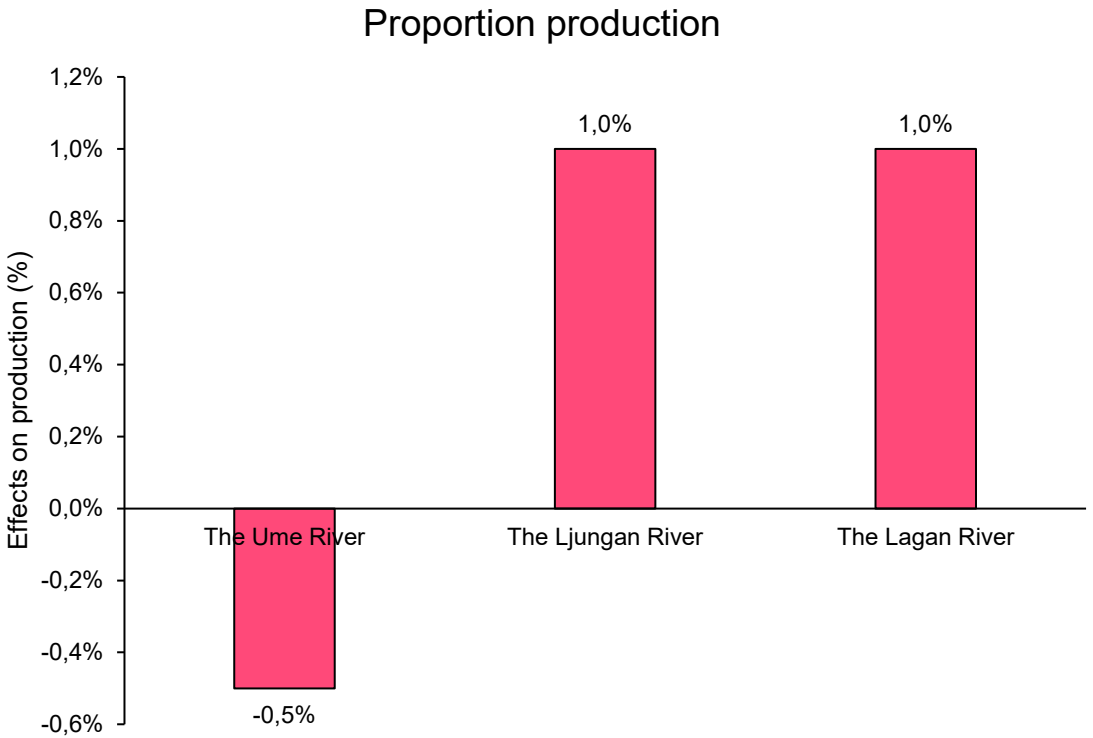
Widen et al 2021

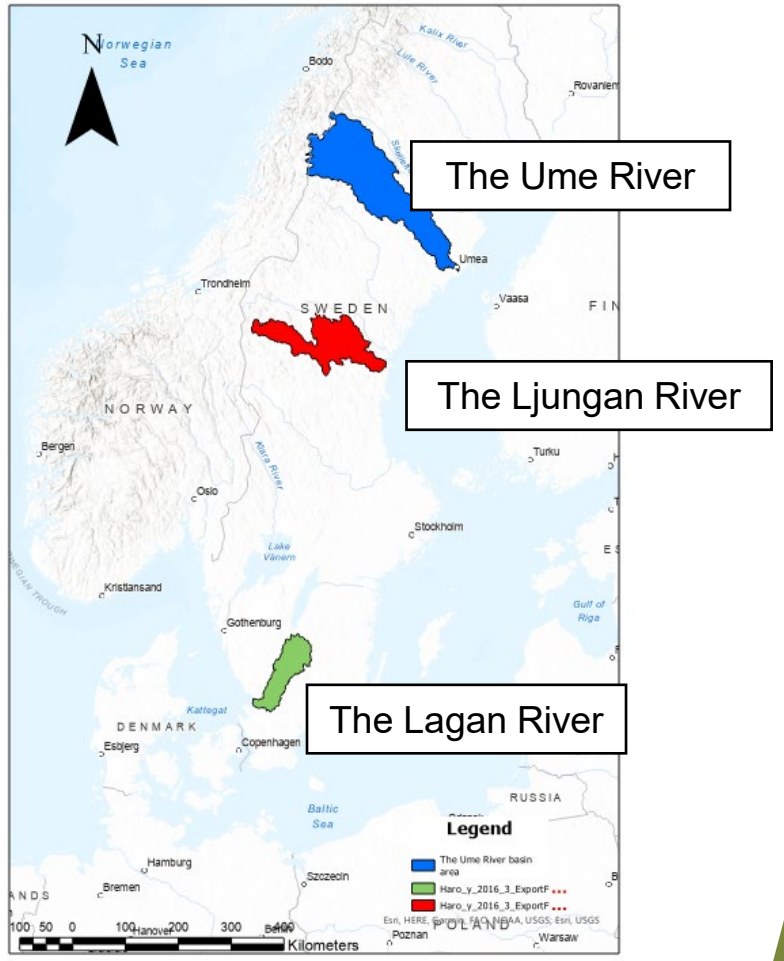
Increased time with zero flow with 30% (8 weeks to12 weeks)

Scenario S9

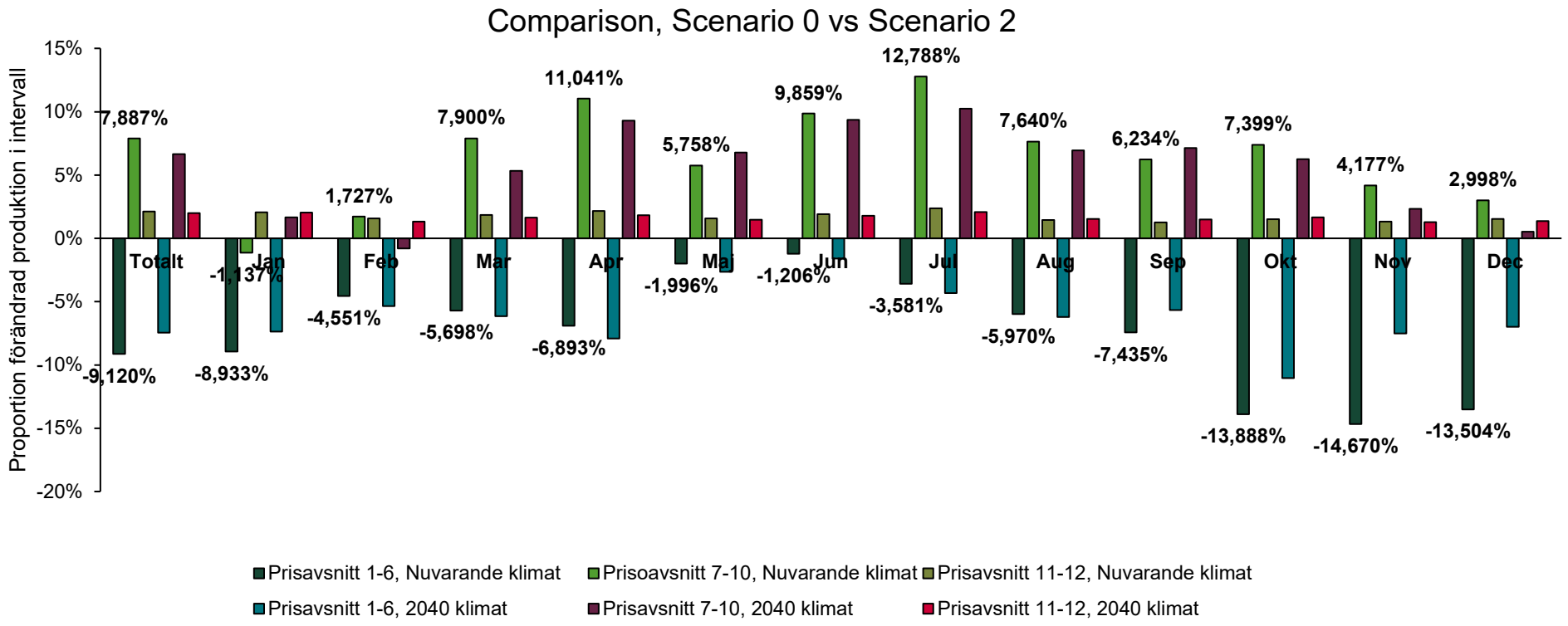
- Forbidden zero flow
- Water to by-pass channels
- Water to fish-ways

Impact at hydropower electricity production (GWh) as a consequence of forbidd





Impact on regulatory ability in the energy system



Widén et al 2022. Ljungan River. DiVA. Umeå University.

Some conclusions and thoughts……

- The feasibility of introducing environmental flows
- Move the occasion of electricity production from day to night and thus affect the energy system
- Alter the patterns of reservoir filling degree. Critical during extreme droughts?
- Necessary from a climate perspective

IN COLLABORATION,

Thanks to Statkraft hydropower in Norweig and Sweden!


Erik Degerman, SLU


Emma Wikner, Statkraft


Birgitta Renöfält UMU


Roland Jansson UMU


Angela Odelberg, Statkraft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SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

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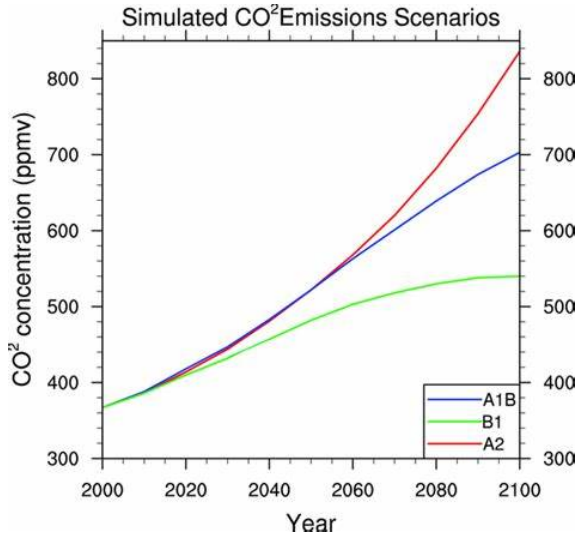
Environmental flow assessment need to consider climate change

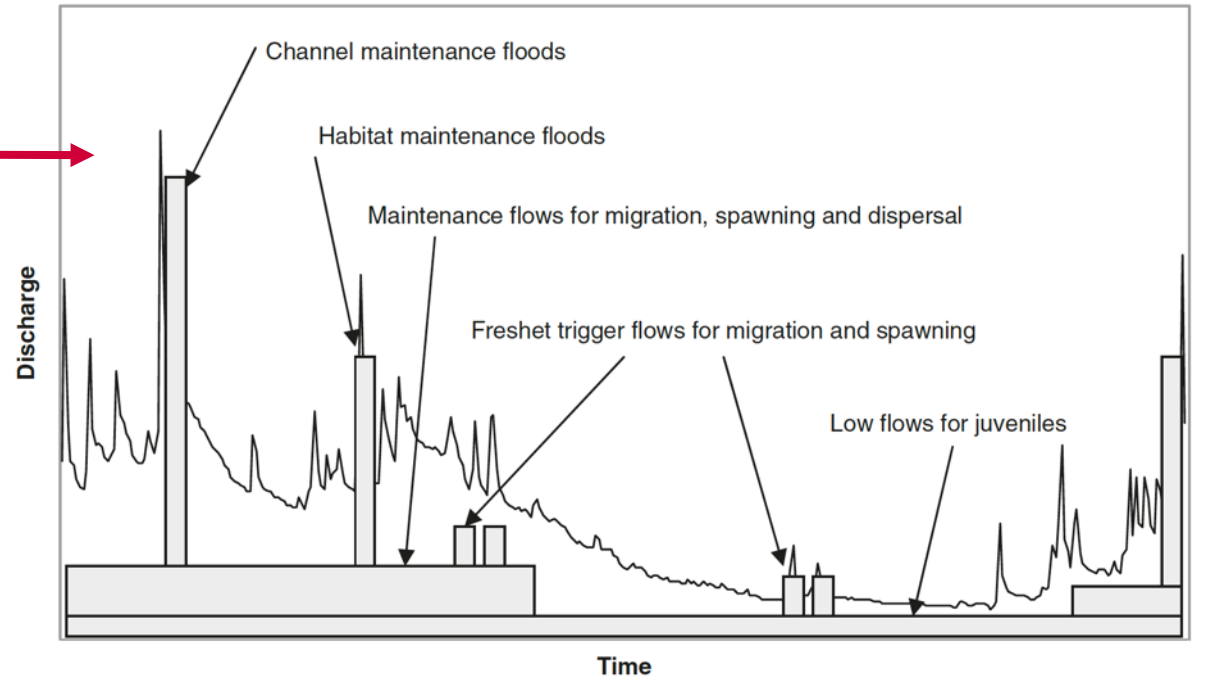
- Consider for climate change
- Changed hydrology
- Affects hydropower operation and electricity production
- Affects riverine ecosystems
- Increased pressures on riverine ecosystem



Environmental flows definition

- *”the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems”* (The 2018 Brisbane Declaration)
- **The Natural flow regimes** *(Poff 1997).*

The Designer Paradigm:
Design flows to achieve specific ecological outcomes, components needed to deliver specific ecological functions (Acreman & Ferguson (2010) *Freshw. Biol.)*



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