Morphological measures to promote biodiversity in hydropeaking reservoirs

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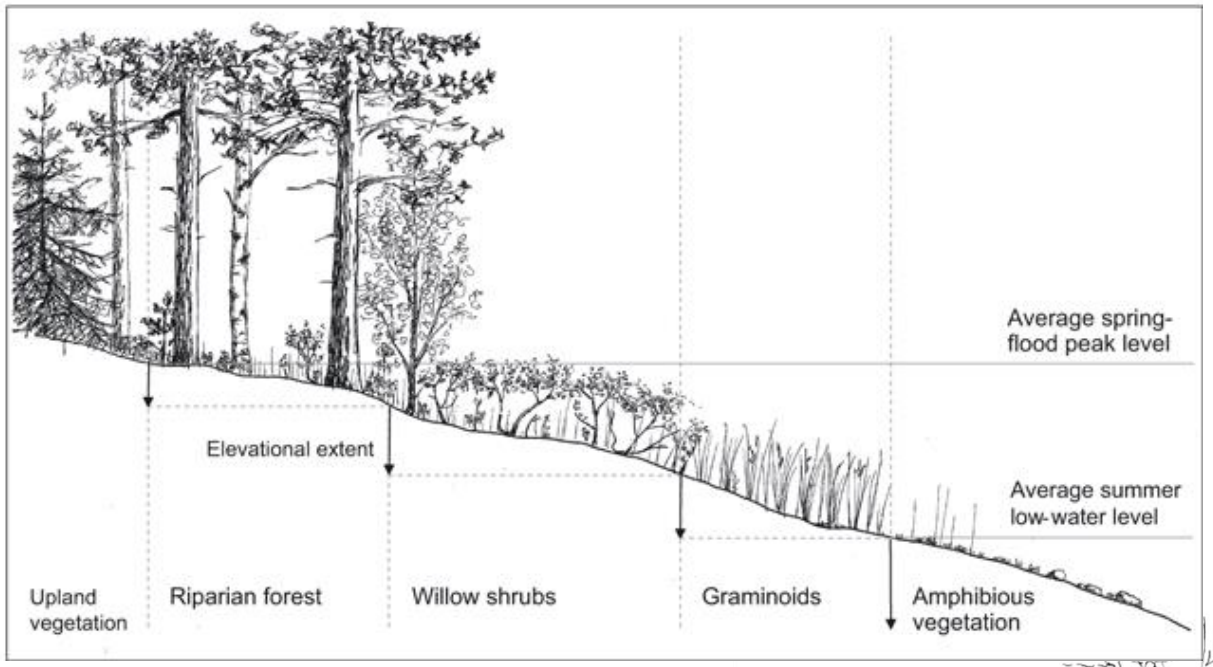
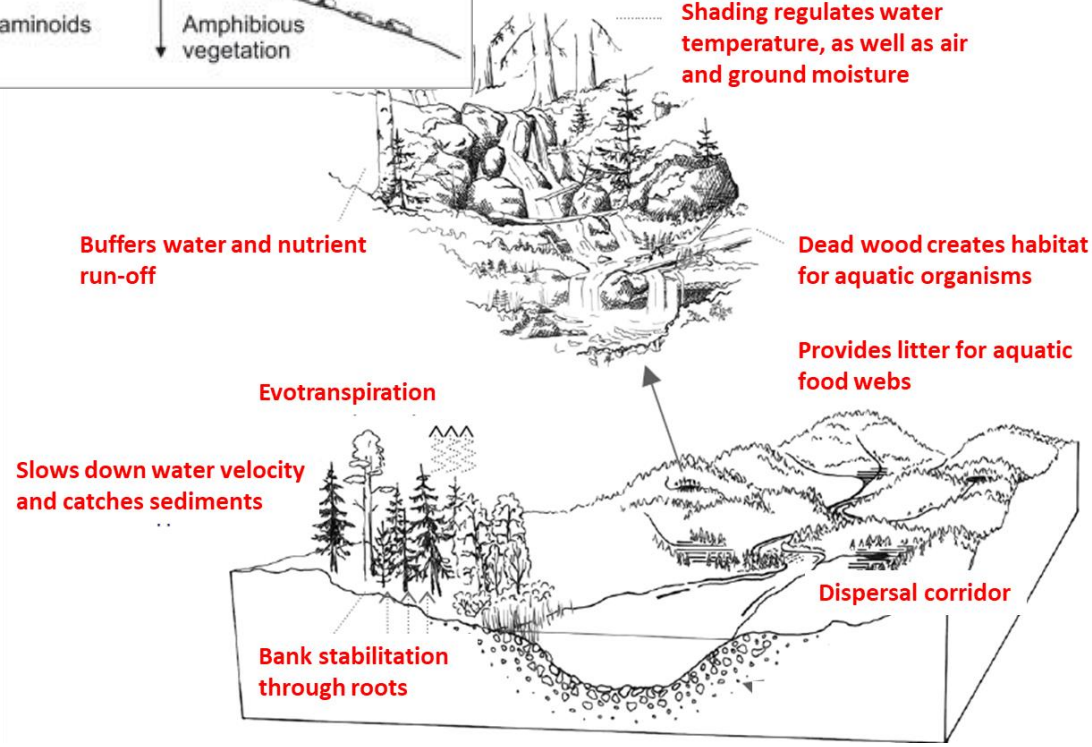
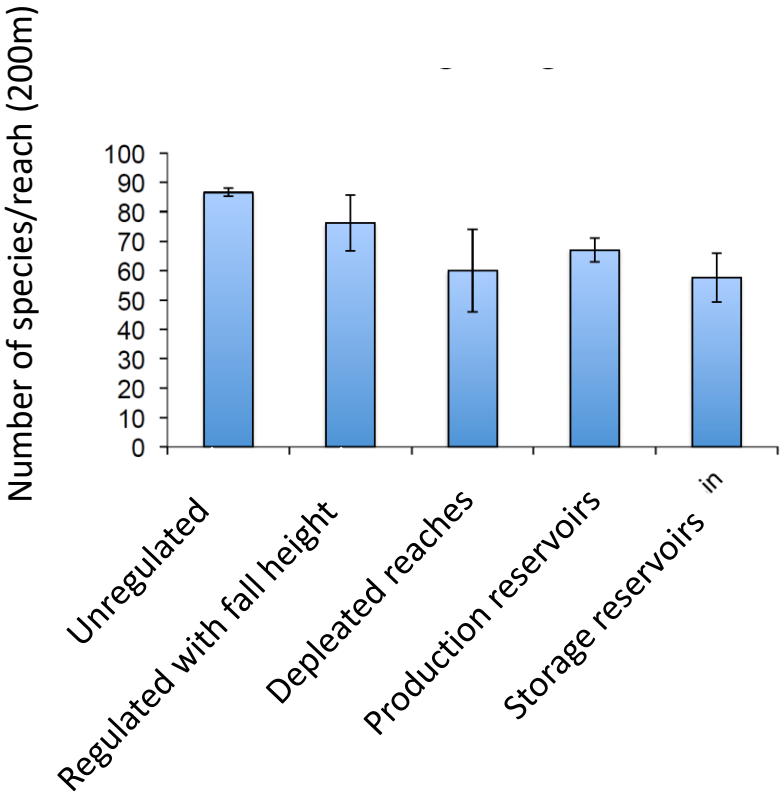
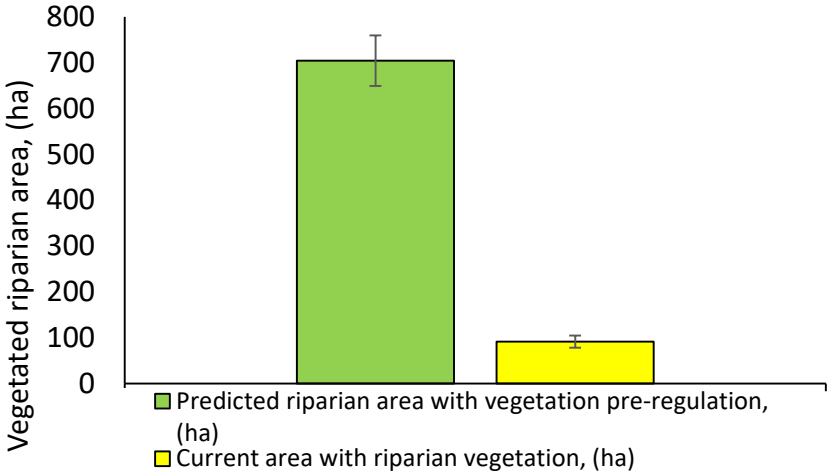
Ecosystem structure and functions of riparian zones





Regulation effects in riparian vegetation





- Flooded long periods during growing season
- Wave erosion
- Ice erosion

Hydropeaking effects on riverine ecosystems

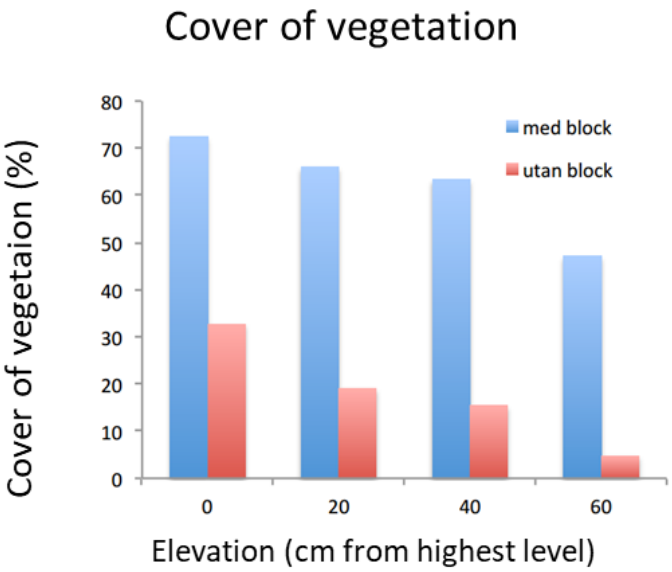
- loss of cover and species richness of riparian vegetation
- affects germination success negatively, especially for flood intolerant species
- reduced habitat diversity and reduced density and diversity of aquatic and riparian organisms
- reduced reproductive success and decreased survival rates
- alter transportation patterns of organic matter which in turn can affect the ecosystem food webs negatively
- In rivers with ice cover during winter, erosion is substantially increased with water level changes causing the ice to break adjacent to the shorelines.

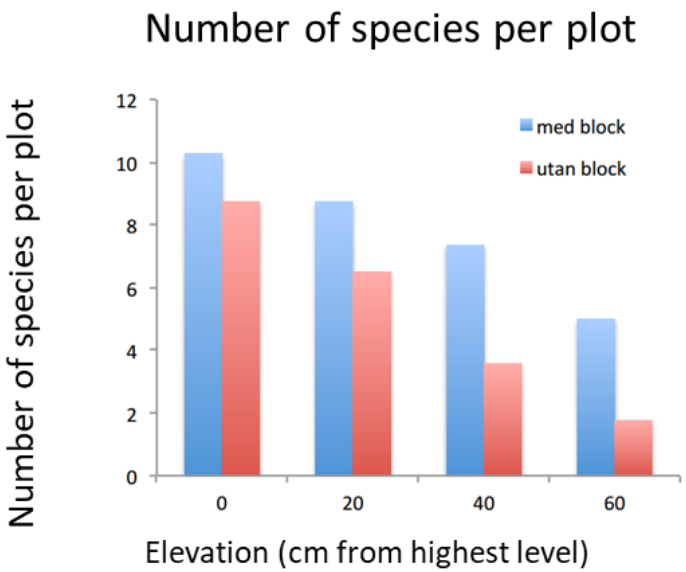
Effects of ice in hydropeaking impoundments

- Unregulated rivers have ice that is anchored to the bank and protects it. In regulated rivers ice is broken up and loose from the bank.
- Frequent water level fluctuations and rapid starts and stops creates ice chaffing.
- This ice chaffing increase erosion and damage and uproot the vegetation.
- Creates large cavities in riverbank.
- Undermines the riparian zone.
- Loss of biomass and diversity or riparian biota

Effect of erosion protection

Effect of erosion protection

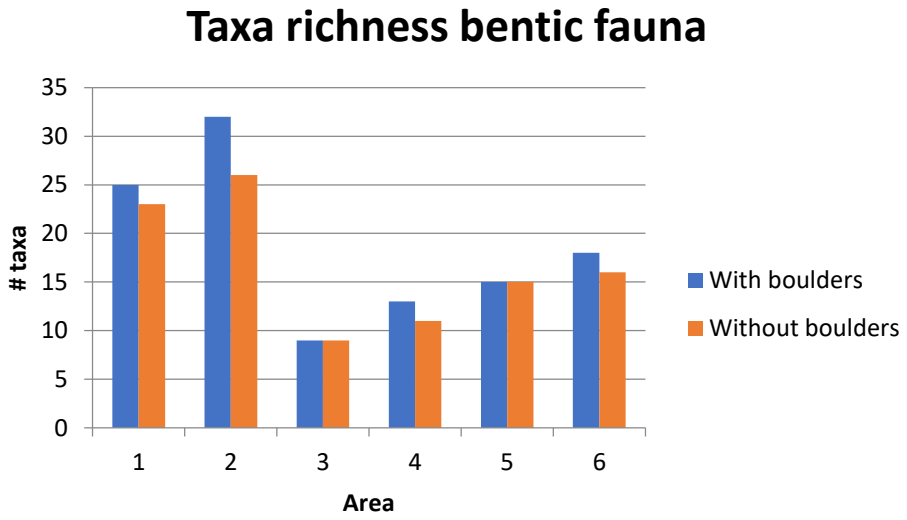


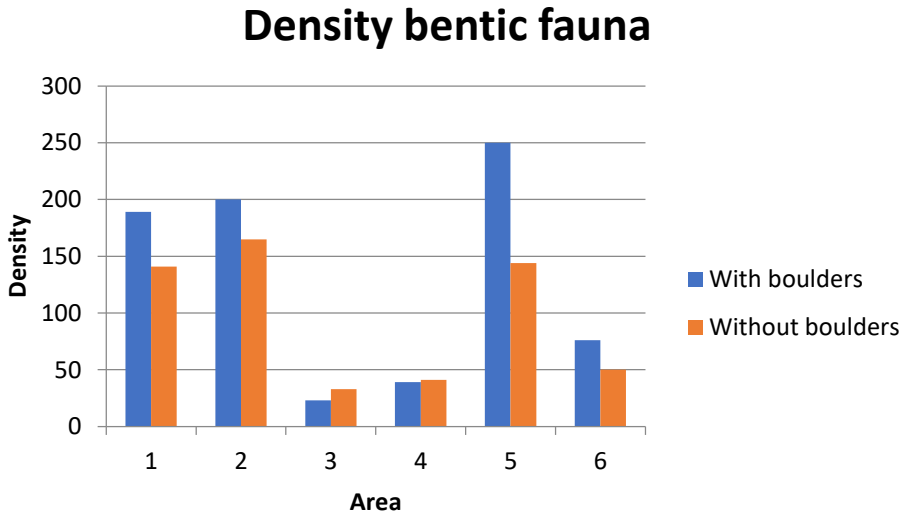


With boulders

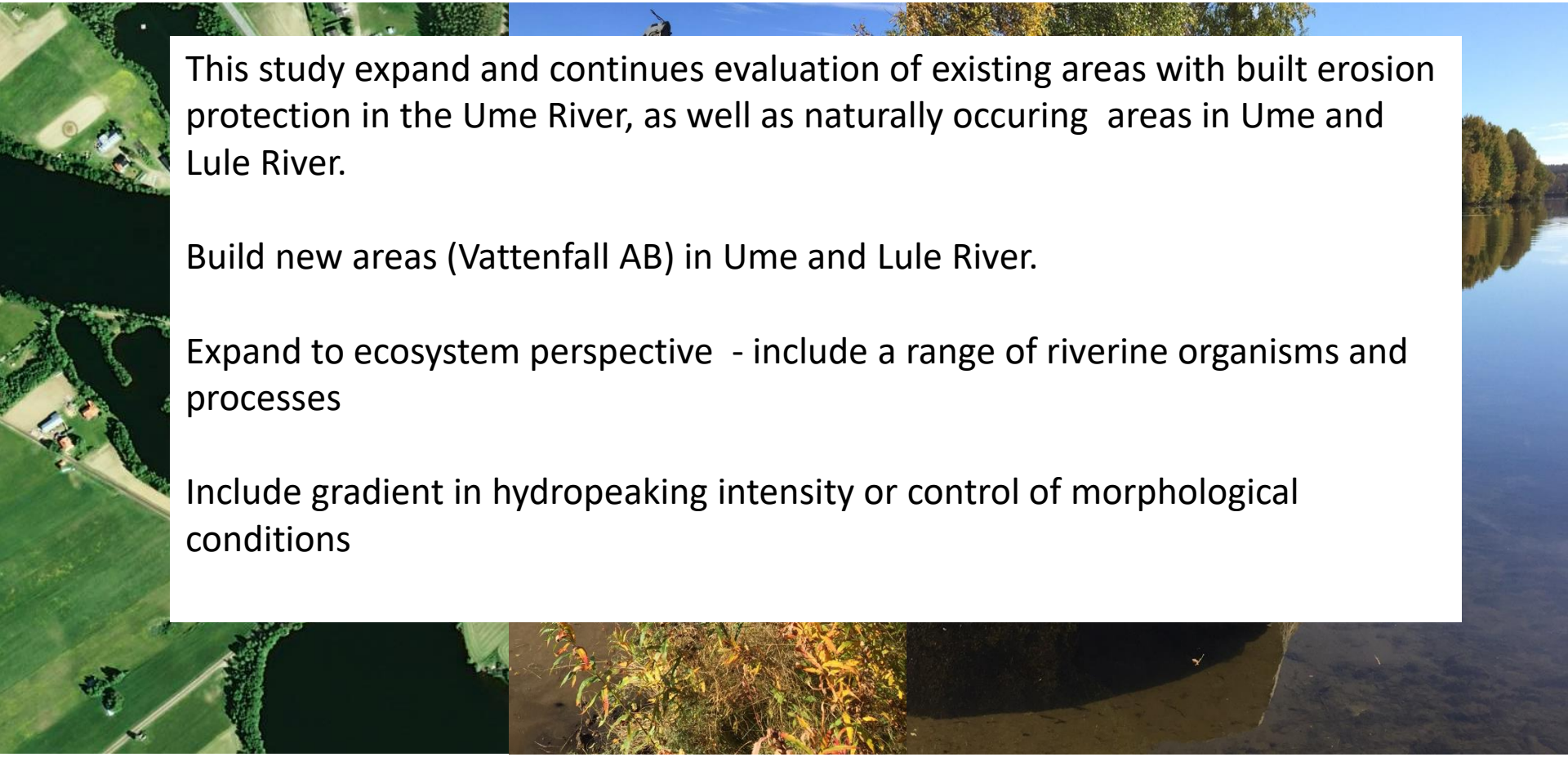
Without boulders

Effect of erosion protection





Restoration of riparian areas in hydropeaking reservoirs – Natural erosion protection to limit erosion and promote establishment of riparian vegetation



This study expand and continues evaluation of existing areas with built erosion protection in the Ume River, as well as naturally occuring areas in Ume and Lule River.

Build new areas (Vattenfall AB) in Ume and Lule River.

Expand to ecosystem perspective - include a range of riverine organisms and processes

Include gradient in hydropeaking intensity or control of morphological conditions


Sedimentation


Less ice erosion

The aim of the project is to develop morphological measures to enhance biodiversity in rivers with hydropeaking, that can feed into the NAP-process and fulfill WFD requirements without impacting hydropower production.

1. Evaluate to what degree areas with naturally occurring **erosion protection structures act as hotspots for biodiversity** and important ecological components in regulated rivers.

2. Explore if there a **threshold or dependence on the magnitude of hydropeaking impact** on the function of these biodiversity hotspots.

3. Test to evaluate **if we can create areas that function as natural erosion protection in rivers that are heavily impacted by hydropeaking** by placing near shore boulders in strategic places.

4. Explore and demonstrate how this measure can contribute to **WFD fulfillment** in terms of a positive effect on ecological potential.

5. Develop a **handbook** that presents measures that can rehabilitate and maintain biodiversity in regulated rivers without significant negative impact on hydropower production.

We will do this in four work packages (WP).

- WP1: explore the **relationship between naturally occurring erosion protection in the form of near shore boulders, hydropeaking intensity, and ecological quality factors** – broad ecosystem approach ⟹ **where** (hydropeaking intensity, morphology)**, for who** (include several organism groups)**, and how** (configuration and size of boulders)

- WP2: evaluate the effect on ecological quality factors in **three areas in the Ume River where erosion protection mimicking naturally occurring protection has been built** – broad ecosystem approach ⟹ can we **create** such areas? **where** (hydropeaking intensity, morphology)**, for who** (include several organism groups)**, and how** (configuration and size of boulders)

- WP3: build and evaluate **new areas with erosion protection**. – broad ecosystem approach. BACI-design (before – after – control – impact) ⟹ can we **create** such areas? **where** (hydropeaking intensity, morphology)**, for who** (include several organism groups)**, and how** (configuration and size of boulders)

- WP4: **produce a "handbook"** ⟹ aim is to expand the toolbox of environmental measures in regulated rivers.

The project will include sites in the regulated **Ume and Lule Rivers** as well as sites in the **unregulated Pite and Vindel Rivers**.

WP1: Paired design. 10-15 sites with **naturally occurring areas of boulders**, paired with 10-15 comparable sites **without any such structures** and 5-10 benchmark **sites in the unregulated rivers**. Sites in regulated rivers will be located in reaches that experience hydropeaking of varying intensity and will be matched by geographic location, hydropeaking intensity, slope, and substrate. Benchmark sites will be matched by geographic location, slope, and substrate.

WP2: Mainly a **CI design** (control, impact). Three river reaches (maybe additional site) in the Ume River that has been restored with boulders, compare with a subset of areas without erosion protection structures as well as the benchmark sites from WP1.

WP3: Build new erosion protection structures in 3-4 new sites located within the Ume and Lule Rivers impoundments belonging to hydropower plants owned by Vattenfall AB. **BACI-design** (before, after, control, impact)

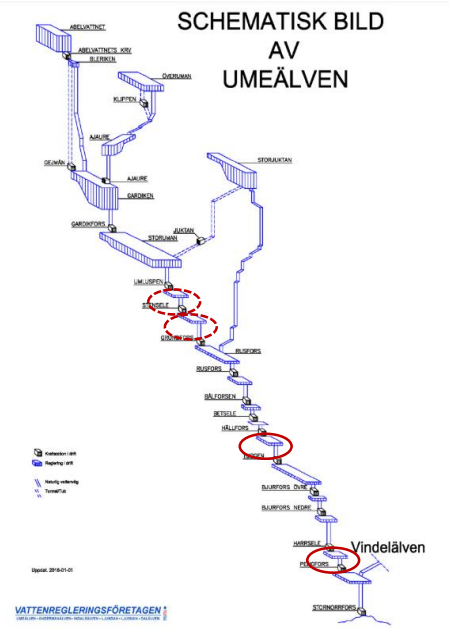
Ecological quality factors	Inventory technique	Samples per site
Riparian vegetation	0,25 m^2 plots in transects covering the regulation amplitude Drone photogrammetry	10-15 transects
Aquatic macrophytes	0,25 m^2 plots in transects down to compensation point	10-15 transects
Bentic fauna	Kick sampling, standardized methods	5 samples per site
Birds /bats	Sound boxes	Repeated recording on sites
Presence and decomposition rate of organic litter	Litter traps and decomposition bags with pre-weighted litter	10 traps and decomposition bags
Erosion and sedimentation rates	Erosion pins in transects and sediment traps (Astroturf mats) Drone photogrammetry	5 transects per site, 5 traps per site
Ice dynamics	Drone photogrammetry	Repeated flights over winter

Fish?

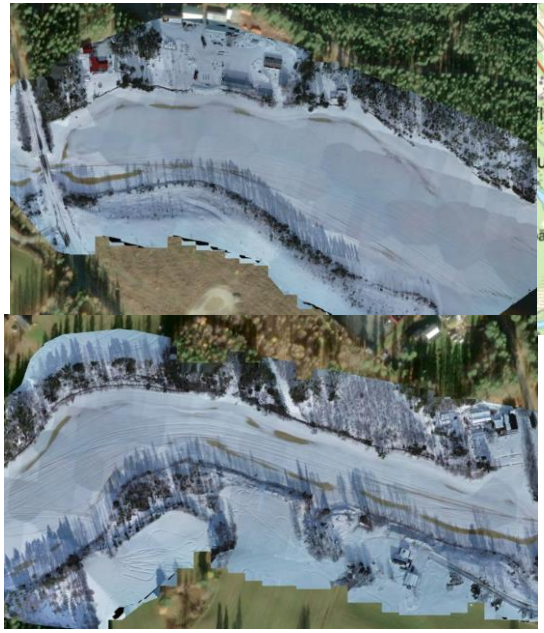
Restoration sites

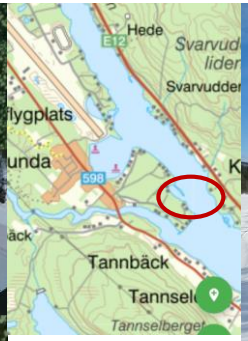
Selection of sites in May 2024 – UMU, SLU and Vattenfall AB

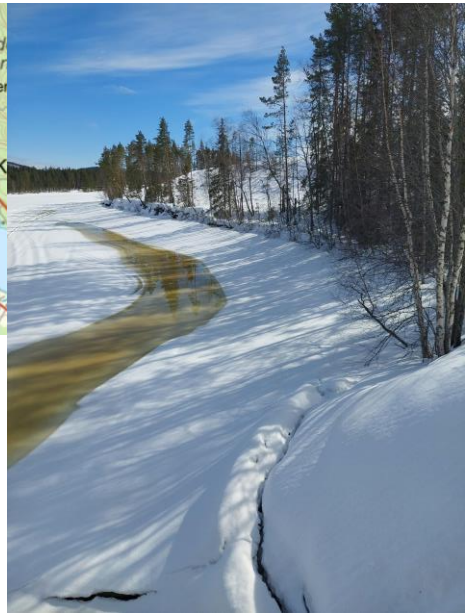
Ume River: Tuggen, Pengfors, (Grundfors, Stensele)
Lule River: Laxede, Vittjärv, Porsi, (Harsprånget, Ligga)

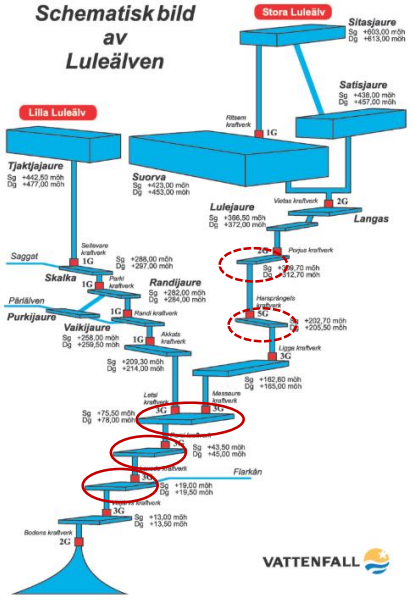


Figur 1. Schematisk bild av Umeälven med kraftverk och dammar. Figur gjord av Vattenregleringsföretagen (http://www.vattenreglering.se/wp-content/uploads/2016/05/UVF_schematisk_bild.pdf)









Figur 1. Schematisk bild över kraftverk och regleringsdammar i Luleälven. Källa: Vattenfall


Thank you!