SWEDEN RIVERS

Title		**ReBorN LIFE / Ecostreams for LIFE**	
Organization		County Boards of Norrbotten and Västerbotten	
Start	**End**	**ReBorN LIFE**	**Ecostreams for LIFE**
		July 2016 / March 2022	January 2021 / December 2026
Length		Variable	
River typology		Meandering	
Q mean		Variable depending on the river and season (Q mean: between 16-67 m^3/s)	
Target species/habitat		Atlantic salmon, brown trout, freshwater pearl mussel, otter	
Contact		Johanna Hagglund johanna.hagglund@lansstyrelsen.se	

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LOCATION & CONTEXT

Within ReBorN (Restoration of boreal Nordic rivers) LIFE project six river systems were restored in the north of Sweden, in the counties of Norrbotten and Västerbotten.

The project areas were the following rivers: Kalixälven, Råneälven, Byskeälven, Piteälven, Åbyälven and Lögdeälven (Fig. 1 and 2).

Within the Ecostreams for LIFE project 6 rivers are being restored: Ammerån, Rörströmsälven and Åreälven (in Jamtland county), Ore (in Västerbotten) and Mo (in Västernorrland) Rivers.

Figure 1. Location of the rivers

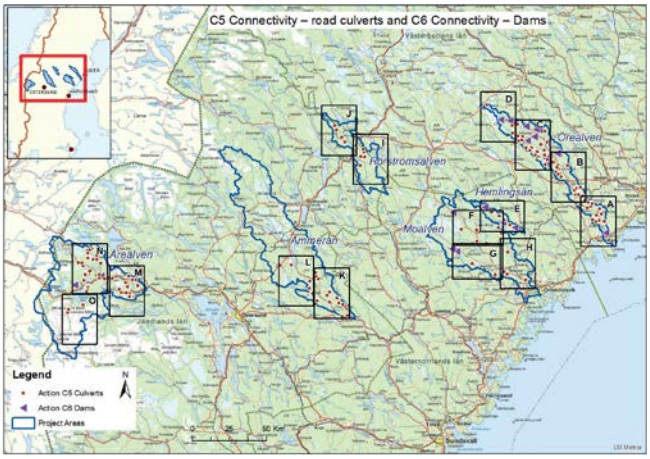

Figure 2. Location of the restoration sites of ReBorN LIFE project (left) and Ecostreams for LIFE (right)

Rivers in Sweden have been long altered to facilitate timber floating, watercourses served as a transportation rout for timber logs. Rivers were straightened and boulders removed from the riverbeds, which has changed the geomorphology, hydraulics and water velocity in the affected streams and in consequence has decrease aquatic habitats. The clearings made during the timber floating were done with all from hand power, horsepower, winches, bulldozers to dynamite. Due to the extensive efforts clearing the watercourses - similar efforts is needed to restore them (Fig. 3).

Figure 3. Works of clearance of boulders from the riverbed for timber floating

Spawning, nursery and feeding areas for fish were destroyed, whereas, water velocity increased, making less favorable ecosystem for aquatic organisms. Not only fish was affected, but also freshwater pearl mussel and plant species. In Figure 4 we can compared a cleared reach with an untouchable one. This pressure is one of the main reasons of not achieving the good or excellent status of the water bodies of the Bothnian Bay Water district.

Both ReBorN and Ecostreams for LIFE share the same pressures. In the last one, they add the presence of dams and road culverts that cut the longitudinal continuity, as well as forestry works, with siltation, erosion and transport of nutrients and heavy metals.

Figure 4. On the left cleared reach, on the right untouched reach

PRESSURES & IMPACTS
1) Timber floating 2) Straightening 3) Sediment starvation and habitats decrease 4) Dams and road culverts 5) Forestry works: siltation, erosion, transport of nutrients and heavy metals

OBJECTIVES

The objectives of the ReBorN project are:

- Recover the river natural dynamics, freely meandering pattern, increase the length of the watercourse and reduce slope, increase the water sustaining ability of surrounding lands, prevents floods and reduce droughts.
- Reconstruction of spawning grounds.
- Increase migrating fish for reproduction.
- Improve habitats for target species, Atlantic salmon, freshwater pearl mussel and otter and increase biodiversity both in the water and on the lands around the rivers.
- Create four educational demonstration sites about restoration and how the forestry takes good consideration to water environments during forest practices.
- Fish recovery will benefit the sport fishing tourism and I mprove ecotourism along the rivers.

The objectives of the Ecostreams for LIFE project are the same, adding the recovery of longitudinal continuity and reconnection of lateral waterways.

Some of the remains from the timber floating era have a high cultural-historical value and need to be preserved. The project has taken this into account by saving valuable environments, as some riverbank stabilization structures.

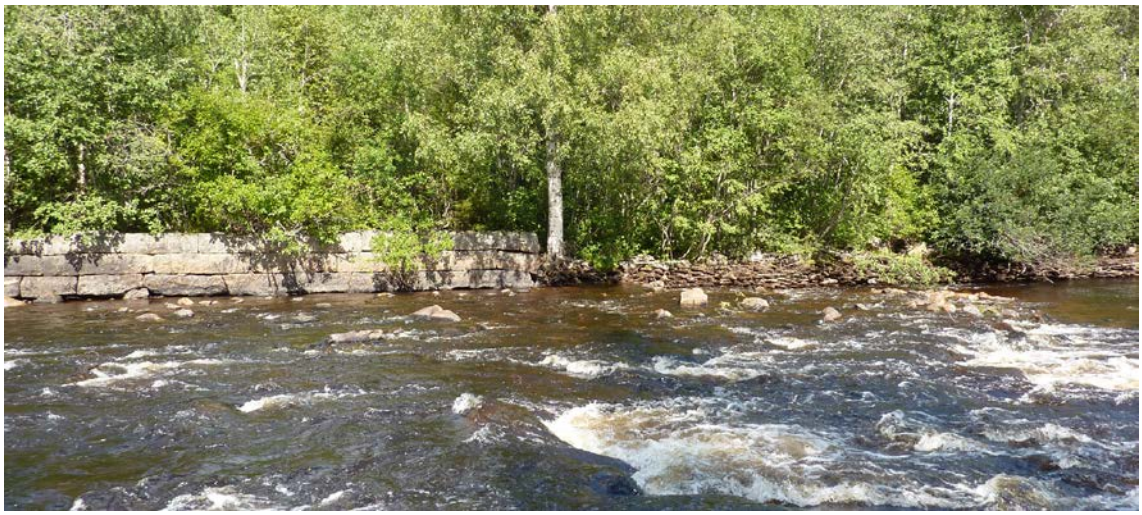

Figure 4. Example of remains from the timber floating era. Structures on the banks, stone pier (left) and riverbank stabilization structure (right). Source: Laymans report

Target species/habitats	**Atlantic salmon, brown trout, freshwater pearl mussel, otter** **The habitats targeted are Fennoscandian natural rivers and water courses of plain to montane levels**

The different species of fishes will be directly benefit from the restored habitats, whereas the freshwater pearl mussel population will be indirect. The survival of mussel larvae depends on the successful reproduction of brown trout and Atlantic salmon as the mussel larvae live as parasites on the gills of juvenile salmon and trout during the first year of their life cycle. Hence, efforts that have a positive impact on the reproduction of salmon and trout will also have a positive impact on freshwater pearl mussel recruitment (Perä, 2022).

RESTORATION ACTIONS

1) GIVING BACK BOULDERS TO THE RIVER BED

The reintroduction of gravel and boulders is done with mechanical excavators (Fig. 5). Those boulders are taken from the lateral accumulations on the sides when clearance was done. Sometimes gravel has been flushed away and new gravel needs to be added to the area if there is no any in the surroundings.

Figure 5. Returning blocks to the riverbed. Source: Ecostreams for LIFE

2) CREATION OF SPAWNING GROUNDS FOR FISH SPECIES

Parallely to the mechanical works reintroducing the boulders spawning grounds are created for the fish. Both by machines and by using hand tools that consist on the loosening the packed river bottom, the later method called Hartijoki (Fig. 6). This manual work relocating sediment is also used in small watercourse where big machines can harm the river.

Figure 6. Two persons moving a boulder during hand-method of creation of spawning grounds

3) REMOVAL OF BARRIERS

199 road culverts will be replaced and 22 dams removed, creating 845 kms of free flowing within Ecostreams LIFE project.

4) RESTORATION OF WETLANDS

In the Öreälven, Ammerån and Moälven watersheds, areas of intensively drained wetlands occur. In this action ditches in four wet woodland areas will be plugged to restore the pre-draining hydrological situation. Plugging will be carried out by placing bundles (diameter ca. 60 cm) of young willow trees in the ditches, perpendicular to the flow. The bundles will successively be filled with natural material (silt, peat). An excavator is used to install the plugs. In total, 18 kilometers of ditches will be plugged and the wetlands can re-achieve their potentials. Expected results:

- The inflow of suspended and dissolved matter into streams will be reduced

- Stream siltation will decrease

- Habitat for fish eggs and aquatic invertebrates including pearl mussels, will improve in the interstitial space in the stream gravel

- Pearl mussel populations will increase due improved habitat

- Egg survival and zoobenthos densities will increase in smaller streams

5) REINTRODUCTION OF LARGE WOODEN DEBRIS FOR MICROSCAPANIA SPECIES

Trees will be put down or taken dead and transported to suitable bankside sites along the rivers. In total, trees or logs will be deployed at 34 sites, with on average 10 trees per site. The trees or logs will be put close to the ground and secured. The logs will be in aggregation, which facilitates dispersal between logs and act to keep the wood moist. Pine, spruce and aspen trees will be preferred, and the trunk diameter will be at least 20 cm in the thickest part. Suitable places to for the dead wood aggregates are in the outside of bends of the rivers, along wide slow flowing stretches and in periodically flooded side channels. Trees will preferably be placed in the upper part of the zone that is wetted at peak flow. Logs from timber floating installations that are removed as part of the river restoration (1: Giving back boulders to river bed) actions will be reused to create suitable habitats for scapania mosses in a similar manner as described above.

The wood must be wetted regularly, at least once in a few years, but should otherwise stay moist. The mosses colonize wood that has been dead for a few years and has lost the barch.

This action will be performed in Öreälven, Moälven and Ammerån.

6) REINTRODUCTION OF FRESHWATER PEARL MUSSEL

To propagate viable juvenile pearl mussels for further augmentation or reintroduction we will use best practice methods. All augmentation will be based on the eDNA screening of population distribution (identification of possible broodstock) as well as analyses of the genetic diversity and differentiation of populations and broodstock mussels to secure the genetic integrity and evolutionary potential of the species, e.g. to avoid genetic bottlenecks. Host fish (trout or salmon) studies will also be carried out.

Population augmentation will be implemented using multiple approaches: **A**. release of infested host fish will be conducted every year: Gravid mussels and host fish will be collected in the late summer and held in small flow through containers until the fish get infested. **B**. Captive breeding will produce large numbers of offspring to enhance distribution and critical abundances of mussels in the restored streams. Mussel larvae will be collected from gravid mussels, and the previously identified host fish will be inoculated and kept at the fish hatchery, where the rearing of juvenile mussels is carried out.

MONITORING

There are some monitoring results from the ReBorN project. To monitor the measures, several surveys has been done on, for example, freshwater pearl mussel, fish population, otter (*Lutra lutra*), geomorphology etc.

Monitoring of geomorphology and hydraulics

Rivers geomorphology in Sweden, and Scandinavia, is driven by two specific factors: a) the mix of sediment granulometry coming from glacial deposits, and b) the land uplift that divides the catchments in two parts, above and below the former highest-coastline (FHC), now around 250 m above sea level. Above glacial deposits dominate with mostly coarser sediment, below finer detailc sediment, land that has been underneath sea level.

The monitoring consisted in surveying channel geometry (cross-sections, longitudinal profile and channel edges) and flow velocities with the objective of determining geomorphic complexity. It has been conducted in the Lödge River catchment, in the mainsteam and its tributaries. 8 monitoring sites were selected in both mainsteam and tributaries, and distributed above and below FHC. The survey was conducted before restoration and 2 times after restoration, 1 year and 3 years after. The results clearly show that the river stretches got wider after the restoration, had a more meandering course and have become more heterogeneous, i.e. more varied (Layman report).

The change on rewetted areas was monitored with drones, 109 hectares increase of aquatic habitats (Fig. 7).

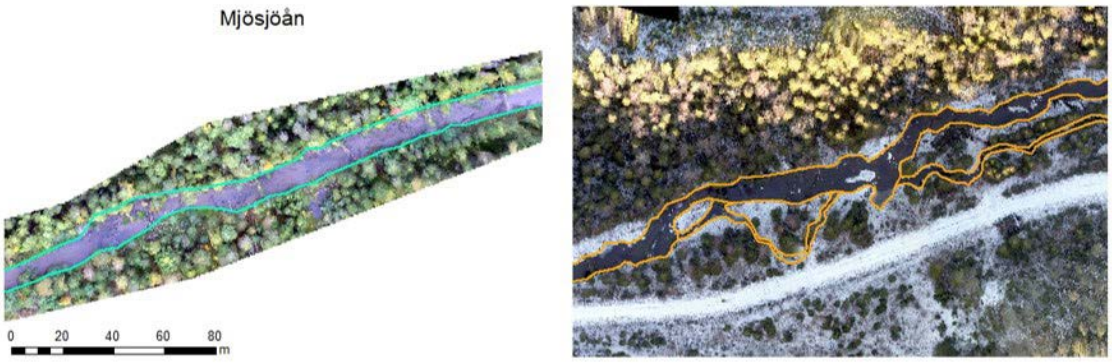

Figure 7. Monitoring of rewetted areas

Monitoring of spawning grounds

The function of the spawning grounds has been followed up by documenting spawning fish from land and with the help of water binoculars, it is possible to see if the gravel has been excavated by a fish.

The biological monitoring of fish, freshwater pearl mussel and otter is part of regional monitoring programmes, some of them related to WFD, other to environmental administration, with several years of continuity.

As in the After life report is said Perä (2022): "*In total, 44 water bodies have been restored in the ReBorN project. In the water districts of the Bothnian Bay and the Bothnian Sea, the classification of the parameters of hydromorphology was done in May of 2019. Restoration work done after (2019-2021) has not been taken into account in the classification in cycle 3. When cycle 4 is done, we will compile the data and assess the outcome of the restoration work on the water bodies applying the classification of the Water Framework Directive.*

16 water bodies had their hydromorphological parameters improved by the actions in the ReBorN project. However, even when the restoration has been a part of the assessment a reclassification is not guaranteed, six of those did not improve their ecological status since there were still other parameters that were worse than good".

ACHIEVEMENTS

ReBorN project: finished in March 2022,

- 243 km of streams restored
- 14,679 spawning beds created, 48% of them have been used by spawning fish
- 109 hectares restored water habitat
- 4 demonstration sites established
- Improve habitat for target species Atlantic salmon, freshwater pearl mussel and otter
- Dissemination of the project: 121 meetings with 9640 participants

Ecostreams for LIFE is in course, the achievements up to now are:

- 21 km of streams restored
- 162 spawning grounds created
- 41 road culverts removed
- 7 dams removed

BUDGET

The budget of the ReBorN project is 13,052,875 €. Funds coming from the LIFE project and the Swedish Agency for Marine and Water Management.

The budget of the Ecostreams for LIFE project is 16,693,347 €

SOCIAL IMPACT

Even though the Covid-19 pandemic more than 120 meetings, seminars, conference and excursions were done with landowners, students and general public (almost 10,000 persons)

to explain the restoration works, the importance of forestry with consideration to water environment and the history and damage of timber floating era.

Visitors from other agencies, other parts of Sweden, foreign governments have been also received.

Assessment and valuing of ecosystem services has been also conducted at the end of the ReBorN project. After restoration "*a valuable ecosystem service that is found in restored watercourses is that high water flows are subdued and the water velocity decreases. When watercourses flow more slowly through the landscape, the effects of extreme drought are moderated as more water can be filtered down to the groundwater. With a slower pace, natural water purification becomes more efficient. And as a result - we get more pure water*" (Layman report).

SIMILARITIES WITH DORDOGNE RIVER

- Fish species habitat and migration recovery.
- Sediment continuity and addition.

WEBSITES

ReBorN LIFE

https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=5864&docType=pdf

https://www.rebornlife.org/

https://en.rebornlife.org/_files/ugd/a179e9_0497f6cf93eb49948888c5877156ef47.pdf

Ecostreams for LIFE

https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=7695

https://www.ecostreamsforlife.com/

https://www.instagram.com/ecostreamsforlife/

BIBLIOGRAPHY

Perä, S. 2022. *After LIFE report ReBorN Restoration of boreal nordic rivers. A LIFE project which restored watercourses heavily affected from the timber floating era*. 19 p.

Videos:

https://www.youtube.com/watch?v=WaOhFC4lW7s