

MERLIN



Beavers here and there, but
not everywhere

Beaver river engineering SE

www.project-merlin.eu

MEDIAN



Imprint

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1 For the Reader

This Regional Scalability Plan provides suggestions for maximizing the positive effects of beavers, and minimizing and mitigating the negative ones. Positive effects of beavers and especially beaver dams are for example enhanced biodiversity, recreational values and water quality. Negative effects are for example flooding-induced damages on infrastructure, forest stands and farmland.

Organisations that we hope can be helped by this document include County Administrative Boards of Sweden, Swedish Environmental Protection Agency, Swedish Agency for Marine and Water Management, Swedish Water Authorities, Swedish Forest Agency, municipalities, forest companies, forest owners' associations, hunting organisations, and Swedish Anglers Associations.

This document has been written by representatives of the Swedish University of Agricultural Sciences (SLU) and the Swedish Forest Agency (Skogsstyrelsen). At an early stage, feedback has been provided by the following organisations that are also part of the Swedish MERLIN reference group: County Administrative Board of Västerbotten, Sportfiskarna (NGO, Swedish Anglers Association), Sveaskog (forest enterprise), Södra (forest owner's association). However, for the content of this document the authors are fully responsible.

2 Focus of the Regional Scalability Plan

2.1 Regional characteristics

The Regional Scalability Plan targets whole of Sweden, a country overall dominated by forests, with agricultural landscapes being more prominent in the south where forest patches are interspersed in the landscape with riparian forests along waterbodies. Sweden is already experiencing climate change with warmer and wetter conditions and higher frequency of weather extremes.

This climate change induces e.g., range shifts of species, biodiversity loss, risk for floods and droughts, water quality degradation, risk for occurrence and spread of vector-borne and zoonotic pathogens and outbreak of spruce bark beetle and other pest infestations. Land-use management such as forestry has further decreased biodiversity and climate resilience in mainly even-aged monoculture productive forests. Sweden has a long history of draining water from forest and agricultural land by digging ditches. After Russia and Finland, Sweden is globally the country with the largest area of drained wetlands. This has caused less water to be stored in upland forests and agricultural land with increased risk for droughts and fires. This degradation of wetland habitats has also caused a dramatic loss in biodiversity.

Beavers have traditionally played a key environmental role in the Swedish forest landscape, a role that is now regained due to their recolonization following extirpation and subsequent reintroduction in 1922-1939. With the Regional Scalability Plan, we target whole of Sweden including areas where beavers are present today, and areas where they can potentially live in the future considering their potential extension of distribution range towards southernmost Sweden (Figure 1).

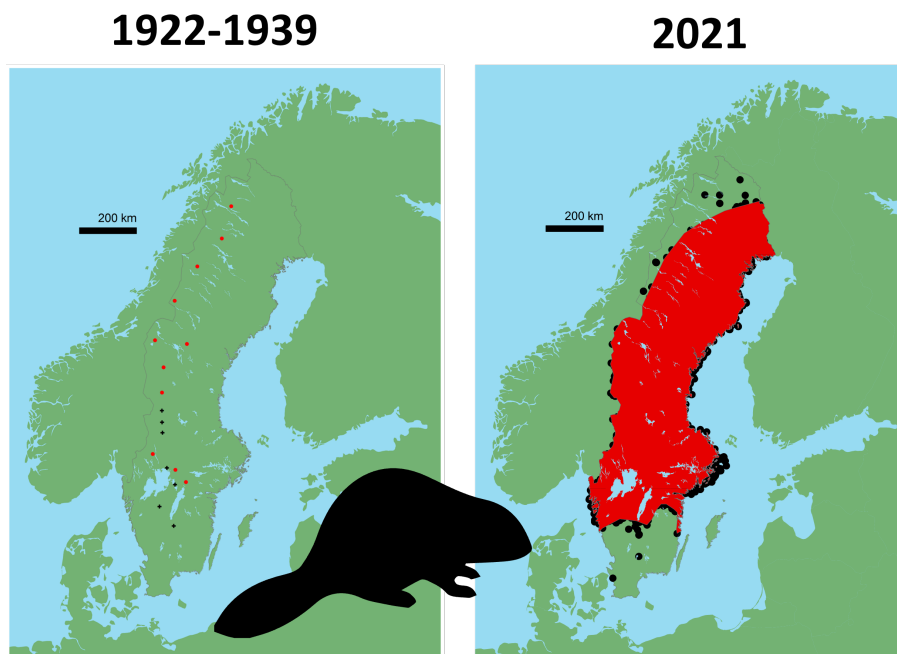


Figure 1. Map of Sweden showing the sites of reintroduction of Eurasian beavers in Sweden in 1922-1939 (left; red and black filled circles show sites of successful and unsuccessful reproduction, respectively) and their distribution range in 2021 (right, red polygon) with some observations (black filled circles) in especially in the northern- and southernmost parts of the country that might indicate a further extension of the distribution range.

2.2 Justification for the region

We include all of Sweden because beavers are present in most parts of the country and seem to further extend their distribution range (Figure 1). The nation-wide Regional Scalability Plan is further motivated by the actual restoration action being performed by beavers and is hence not associated with any costs for the actual restoration. Costs might however be associated with potential needs to mitigate or prevent unintended side-effects (e.g., flooding of infrastructure).

2.3 Linkages and synergies with other initiatives

The projects WAMBAF (2016-2019) and WAMBAF Tool Box (2019-2021) was focusing on beavers and beaver dams in the countries of the Baltic Sea Region. Experience and knowledge from these projects have been used when compiling this Regional Scalability Plan.

In the project Grip on Life, authorities, forest owner associations and NGOs work together to combine modern and active forestry while considering the values of wetlands. Results from MERLIN will contribute to the work done in Grip on Life.

The Swedish Forestry Agency has a long-term goal to rewet 100 000 hectares of ditched peat-covered forest land by the year 2045. Like beaver dams, this rewetting contributes to maintain water retention in the catchments. The main purpose of the assignment is to reduce emissions of greenhouse gases. We have documented and will analyze 15 re-wetted areas as part of MERLIN.

3 Stakeholders of the Regional Scalability Plan



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3.1 Description of the main stakeholders

Name	Description	Involvement
Swedish Forest Agency	The national authority in charge of forest-related issues, and partner of the MERLIN project.	Partner
County Administrative Boards	The County Administrative Boards are responsible for the game management of beavers. There are 21 County Administrative Boards in Sweden, and one of them (Västerbotten) is represented in the MERLIN reference group.	Reference group
Sveaskog	Sveaskog, a state-owned company, is the largest forest owner in Sweden. The company owns 14% of Sweden's forests. The core business of Sveaskog is to manage the forest, and provide timber, pulpwood, wood chips, biofuel, seedlings and forest services.	Reference group
Forest cooperatives	Swedish forest owners are working together to become a stronger part of the timber market. Sweden has three major forest cooperatives, and one of them is Södra, which is represented in the MERLIN reference group. About one third of Sweden's 310 000 private forest owners are members in a forest owner association.	Reference group
Sportfiskarna (Anglers association)	Sportfiskarna is a national organisation which represents the interests of recreational anglers in Sweden. Sportfiskarna organise about 63 000 members and 400 affiliated regional clubs. Beaver dams may have an impact on angling, which is why Sportfiskarna is represented in the MERLIN reference group.	Reference group
Svenska Jägareförbundet (Swedish Hunters Association)	In Sweden, there are almost 300 000 registered hunters, of which approximately 150 000 are members of the Swedish Hunters Association. The Swedish Hunters Association	

Name	Description	Involvement
	Association has not been involved in MERLIN so far, except for a few contacts on local level.	
Swedish Environmental Protection Agency	The public agency in Sweden that is responsible for environmental issues. The Agency's remit is threefold: Compiling knowledge and documentation, developing environmental policy, and implementing environmental policy. The agency has been informed about the MERLIN project and the Regional Scalability Plan.	Informed
Swedish Agency for Marine and Water Management	The responsible public agency tasked to protect, restore, and ensure sustainable use of freshwater resources and seas including fisheries management. The agency has been informed about the MERLIN project and the Regional Scalability Plan.	Informed
Swedish Water Authorities	The assignment of the water authorities is to implement the EU Water Framework Directive (WFD). Sweden is divided into five different water districts. In each water district one of the county administrative boards is appointed by the government to act as water district authority. The Swedish Water Authorities have not been involved in MERLIN so far.	
Municipalities	Sweden is divided into 290 municipalities. As landowners they sometimes need to manage conflicts with beaver dams. We have informed about 20 municipalities briefly about the MERLIN project.	Informed (a few)

This document is published by the Swedish University of Agricultural Sciences. However, there is currently no organisation that is responsible for its managing, maintenance or implementation.

4 Green deal goals

A sustainable beaver distribution affects many of the green deal goals. Here we have divided the green deal goals in primary and secondary goals. The primary goal that beavers may contribute to is biodiversity net gain. Beavers are ecosystem engineers and their activity in the landscape may increase biodiversity. Beavers thereby provide huge opportunities to "refill" the local and regional species pools of endangered species by the nature-based solutions. The secondary green deal goals; climate regulation, flood and drought resilience, health and well-being, zero pollution, Farm2Fork - sustainable food systems and inclusivity, are additional goals that may be effected by beavers.

4.1 SMART Green Deals relevant for the region: primary goals

By building dams, beavers contribute to landscape heterogeneity. These dams can transform a stream into series of small slow-flowing water ponds or running-water swamps. These are environments that may improve biodiversity. We thereby argue that all beaver dams which contribute to a high biodiversity, without significant negative impact on infrastructure, forest production or agriculture should be kept.

4.2 SMART Green Deals relevant for the region: secondary goals

Although the main green deal goals that beavers contribute to are biodiversity net gain, beavers may contribute to many other green deal goals as well.

Flood and drought goals: Beaver dams may buffer floods by regulating environmental flow and keeping water higher up in the catchment during periods of high precipitation and hence contribute to flood reduction further down in the catchment. However, the flood reduction most probably depends on where the beaver dams are built and the age of the beaver dams (how compact the dam constructions are). The question on whether beaver dams contribute to raise the groundwater level and hence mitigate drought risk in the surroundings of dams is more uncertain. There are some studies on wetland restoration and wetland creation that could be compared to beaver dam establishment, but in general, there is a lack of empirical data evaluating ground water levels. Whether ground water levels outside the dam itself will be affected or not most probable depends on the soil type in the surrounding land.

Health and wellbeing goals: Beavers could contribute to human health and well-being in several ways. Beavers may facilitate people to come out in the nature. If beaver dams contribute to a higher biodiversity and open water surfaces, this might attract recreational visitors. In Sweden, beaver safaris are organized, activities that contribute to people enjoying being out in the forest and to educate them in the topic of beavers as a nature-based solution.

There might be a risk that beavers create environments that hold animals that can act as hyperreservoirs and vectors for various diseases, for example mosquitoes, ticks, bats, and rodents. It may also be that beavers themselves can act as vectors. However, high beaver-induced biodiversity likely mitigates the risk of vector-borne and zoonotic pathogens via for example increased predation on vectors and reservoirs.

Knowledge goals: To decrease the knowledge gaps on how beavers affect various aspects such as hydrology, water quality, greenhouse gases, risk of vector-borne and zoonotic pathogens, and landscape heterogeneity, more empirical data is needed. The MERLIN case study will produce empirical data from a variety of beaver systems that can be scaled up to a landscape scale.

Zero-pollution goals: Stream water entering the beaver dam will slow down allowing particles to embed in the sediments. However, beaver dams may also increase some unwanted elements in the water. By flooding terrestrial land, organic carbon, metals, and nutrients could mobilize from soil to water. Beaver dams, especially younger ones, have been found to act as a hotspot for the formation of methylmercury, which is a bioavailable and toxic form of mercury. However, if scaling up to a landscape scale, the effect of beaver dams may not be negatively affected as methylmercury may demethylate in downstream waters.

Sustainable food system goals: Biomagnification of Hg in aquatic food webs may pose risks for elevated dietary Hg intake with toxic effects of Hg in top predators, including humans. Increased browning of surface waters, that may either increase or decrease by beavers, may be a problem for the long-term drinking water supply in Sweden. This is critical because Sweden's drinking water production relies heavily on surface water resources. However, at a landscape scale, beaver dams will probably not be a significant source of organic matter loads to water treatment plants. A sustainable hunting of beavers could contribute to the use of beavers as a natural resource by using both meat, fur and castoreum.

Sustainable energy goals: Bioenergy from forests is an important energy system in Sweden. Beavers may both increase the forest resilience to climate change but also cause flood of productive forests. However, we do not expect that beavers have a significant effect on bioenergy in a larger landscape scale.

Climate regulation goals: Related to the climate regulation goals, beavers may contribute in both directions. Dams, of various kind including beaver dams, may promote methane formation and emission. Especially young beaver dams are thereby likely a source of GHG emissions, an effect that however will cease with age. Also, in a larger landscape perspective, we expect beaver dams not to be a significant source of methane or other GHG. Instead, by contributing with a high heterogeneity in the landscape, beavers may mitigate some of the challenges following climate change, such as droughts, local floods, and pest infestations.

Inclusivity goals: We argue that local hunters should also in the future have the right to hunt and use beavers as a resource. At the same time, we aim for a sustainable beaver population that could contribute with ecosystem services. To reach this goal, we need to reach out to landowners and inform them about the nature-based solutions that beavers may contribute to. More knowledge about how beavers may mitigate droughts, floods, forest growth resilience and biodiversity, could make landowners more positive to beavers on their land. By reaching out to hunters to inform them about the benefits and risks of beavers, those actors could help in managing beavers sustainably. Multiple stakeholders are affected by beaver dams and should be included in education and outreach activities.

5 From general goals to actions

Given the relevant Green Deal Goals we here provide specific actions towards achieving the goals. This includes guidance on how to fill gaps in knowledge and informing stakeholders.

5.1 Climate Goal

Action 1: Monitor GHG emissions in beaver systems of different age, in different ecoregions and on different soil types.

5.2 Biodiversity Goal

Action 1: Promote the existing beaver tool and make it more user-friendly, possibly as a webapp.

Action 2: Compile and promote best possible practices for how to remove beaver dams, or reduce their negative effects without compromising other goals.

5.3 Inclusivity goal

Action 1: Keep updated on plans that would change the right to hunt beavers, and act if needed.

5.4 Zero-pollution goal

Action 1: Inform about the role of young and old beaver dams as sources and sinks, respectively, of methyl mercury.

5.5 Flood and drought goals

Action 1: Inform about the positive effects of beaver dams on flooding and drought mitigation.

Action 2: Promote the building of artificial beaver dams (“leaky dams”) in areas that suffer from flooding and/or droughts and that beavers have not recolonized, yet.

5.6 Health and wellbeing goals

Action 1: Monitor the effects of beavers as reservoirs and beaver dams as vector habitat on public health.

Action 2: Inform about the positive effects of ecosystems with high ecological integrity for human well-being.

Action 3: Inform about the important role of biodiversity for mitigating disease risk from zoonoses, i.e., infectious diseases spread by animals.

5.7 Sustainable food system goals

Action 1: Promote the WAMBAF beaver handbook “Beaver as a renewable resource” that provides hands-on guidance on hunting of beavers as a sustainable food source including recipes.

Action 2: Inform about the value of this goal in scenarios beavers need to be removed but could still be used as a resource.

5.8 Knowledge goals

Action 1: Inform about the importance of beavers in the Swedish forest landscape as promoters of biodiversity and ecosystem services while also highlighting potential adverse effects that however can be managed.

Action 2: Produce a film that informs about the contribution of beavers to ecosystem functioning and the multitude of ecosystem services that beavers provide, while also considering potential adverse effects and how to manage and mitigate these.

Action 3: Create a national beaver network with task to provide a platform for exchange of knowledge and best practice.

5.9 Sustainable energy goals

Action 1: Inform about the rather minor role beaver has on the sustainable energy goal.

5.10 Identify the responsible stakeholders and their roles

There is a need to clarify which Swedish authority, or other organisation, should be responsible for beavers.

6 Timeline

Activity	Period (2-yr interval)			Period (5-yr interval)		Period (10 yr-interval)
	2024-26	2027-28	2029-30	2030-2035	2035-2040	2040-2050
6.1 GHG	Compile recommendations & information material	Disseminate	Disseminate	Reassess	Compile recommendations & information material & Disseminate	Reassess
6.2.1 Beaver tool	Digitalize	Promote	Promote	Reassess		
6.2.2 Removal and building of beaver dams	1. Dam removal, 2. Dam building, 3. Compile recommendations & information material	Disseminate	Disseminate	Reassess	Compile recommendations & information material & Disseminate	Reassess
6.3 Inclusivity - Hunting	Act if needed	Act if needed	Act if needed	Reassess	Act if needed	Reassess
6.4 Methyl mercury	Compile recommendations & information material	Disseminate	Disseminate	Reassess	Compile recommendations & information material & Disseminate	Reassess
6.5 Flood & drought	Compile recommendations & information material	Disseminate	Disseminate	Reassess	Compile recommendations & information material & Disseminate	Reassess
6.6 Health	Monitor	Monitor & evaluate	Monitor, evaluate & Disseminate	Reassess, monitor, evaluate & Disseminate	Monitor, evaluate & Disseminate	Monitor, evaluate & Disseminate
6.7 Food	Disseminate	Disseminate	Disseminate	Reassess, Disseminate	Disseminate	Disseminate
6.8 Knowledge	Compile recommendations & information material, create national beaver network	Update information material and disseminate	Update information material and disseminate	Reassess knowledge status, update information material and disseminate	Reassess knowledge status, update information material and disseminate	Reassess knowledge status, update information material and disseminate
6.9 Energy	Compile recommendations & information material	Disseminate	Disseminate	Reassess		

7 Budget

The expenses for implementing this plan concerns mainly personnel for:

- Coordination of activities and keeping track on implementation of the plan.
- Developing and preparing communication material about beavers, e.g., PowerPoints, texts on websites, films.
- Promoting and dissemination of communication material on beavers, including for example webinars, contacts with stakeholders, excursions, social media, publicity in media.

A rough estimation of the costs for the above-mentioned costs is:

Activity	Expenses	Type
6.1	50 000 EUR	Film & information material
6.2.1	20 000 EUR	Digitize Beaver tool
6.2.2	500-5 000 EUR 2000-5 000 EUR See 6.1 for film	Dam removal (cost per dam) Dam building (cost per dam) Film & information material
6.3	-	-
6.4	See 6.1	Film & information material
6.5	See 6.1	Film & information material
6.6	Difficult to assess	
6.7 6.8	See 6.1	Film & information material
6.9	See 6.1	Film & information material

8 Uncertainties and assumptions/ boundary conditions

The geographic boundary used in this Regional Scalability Plan is Sweden. Some of the beaver dam effects will influence the local environment, in a positive or negative direction. Here we have discussed these local effects, but also upscaling to a larger landscape scale.

The assumption that we base this report on is that the beaver population will continue to expand into new regions in Sweden, but also that beaver population density will increase, as long as the population is not managed by hunting or restricted by food resources.

The main uncertainty is suggested to be the potential risks of beaver ponds such as elevated methane emission and methylmercury formation, as well as risks of vector-borne and zoonotic diseases. The uncertainty embraces the initial effects, but we know even less about how long-lived these effects are. In addition to the uncertainty in a temporal perspective, there is also uncertainty regarding how significant these effects are at a landscape scale.

Relevant materials

Information on the natural history of beavers in Sweden, their distribution, ecology, impact as ecosystem engineer including biodiversity and biogeochemistry, rules for hunting and trapping as well as damage mitigation measures can be found in the handbook “Beaver as a renewable resource” published by the Interreg Baltic Sea Region Project WAMBAF, and is available on the

WAMBAF webpage. In addition, a decision support and assessment tool for balancing beneficial and detrimental effects of beaver dams, is available on the same webpage: www.skogsstyrelsen.se/en/wambaf/beaver-dams/

A new webpage in Swedish on beaver aspects provides information about their important role as ecosystem engineers, their history and practical advice on how to manage negative effects of beavers and beaver dams: www.bavrar.se.

Grip on Life has produced reports, brochures, books, films about forestry and water: www.skogsstyrelsen.se/griponlife

Re-wetting of peatland is described on the webpage of the Swedish Forest Agency:

<https://www.skogsstyrelsen.se/miljo-och-klimat/skog-och-klimat/atervatning-av-torvmark/>