Good practices for management of beavers and beaver ponds in the Baltic Sea Region

Lithuanian beaver dam. Photo Alius Ulevičius.

Göran Sjöberg, Alius Ulevičius and Olgirda Belova

Preface

This report was produced within the WAMBAF-project (Water Management in Baltic Forests) (activity period from 1 March, 2016 to 28 Feb., 2019), which was initiated to tackle problems concerning forestry activities in relation to water quality. The project is financed by EU Interreg Baltic Sea Region programme. Special emphasis is placed on surface water quality, and export of nutrients, suspended solids and toxic substances such as methyl mercury. WAMBAF focuses on three main topics: riparian forests, forest drainage and beaver population / dam management.

The purpose of the good practices report is to suggest a number of useful management practices and methods according to experiences made in the participating and other countries that may be suited for beaver management and improving water quality in the Baltic area.

We hope to present options for beaver population management, to serve as inspiration for developing national, regional and local management, as well as national legislation and guidelines, within the Baltic Sea region. However, before implementing any of the measures proposed, make sure that the measure complies with national legislation, forest certification standards etc.

The general approach in this document is to manage a dense, already re-established, beaver population, as is the general case today in the Baltic Sea Region. This is therefore different from other books and documents which deal with the introduction and restoration process where there will be need for other considerations.

This document is based on information presented in the handbook "Beaver as a renewable resource", produced by the WAMBAF project. In the handbook there is an extensive list of references. The handbook was written by a group of participants in the project: Olgirda Belova, Karin Eklöf, Frauke Ecke, Leena Finér, Linnea Jägrud, Kaarina Kauhala, Nikolai Laanetu, Zane Lībiete, Elve Lode, Jānis Ozoliņš, Alexander Porokhov, Göran Sjöberg, Daniel Thorell, Alius Ulevičius, and Michał Wróbel.

WAMBAF Beaver handbook – Beaver as a renewable resource
https://www.skogsstyrelsen.se/en/wambaf/beaver-dams/

Good practices for ditch-network maintenance and management of riparian forests prepared within the WAMBAF-project are available on:

WAMBAF – Good Practices for Ditch Network Maintenance to Protect Water Quality in the Baltic Sea Region https://www.skogsstyrelsen.se/en/wambaf/drainage/

Good practices for forest buffers to promote good surface water quality in the Baltic Sea region — A handbook https://www.skogsstyrelsen.se/en/wambaf/riparian-forests/

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Summary

The main aim of the measures proposed in this report is to counteract or reduce excess export of nitrogen (N), phosphorus (P), suspended solids and mercury (Hg) to surface water due to forest management and harvesting.

Beaver was once abundant throughout the Baltic Sea Region (BSR). Intensive hunting and capture, together with changes in human land use, led to the total extinction of the species in the watersheds of the Baltic Sea basin. In the late 19th and early 20th century there was realization about the need for measures for preserving and re-establishing the beaver. Reintroduction, further translocations, natural spread together with species protection and regulated hunt has led to a strong growth in beaver populations and high densities in the BSR. Beaver populations are now considered to have reached densities causing substantial damage levels, e.g. in the south eastern BS countries.

There is presently a lack of:
- Knowledge, guidelines and tools to assess which type of beaver dams have the best capacity to decrease the amounts of nutrients and hazardous substances in waters
- Organization structures and incentives to manage the distribution of beavers in a sustainable way

The novelty in the WAMBAF project is to clarify the beaver role in water quality, not only implementing and the nutrient load reduction targets of the HELCOM Baltic Sea Action Plan but also enabling to determine species management plans. We suggest the use of an adaptive management method. This is a decision process that promotes flexible decision-making. It includes a situation analysis, setting of objectives, developing a model, and selecting and implementing management actions. Stakeholders should be involved in setting objectives for beaver management. When the system had been monitored and the actions assessed, the model may be further developed.

Management of beaver populations may include a number of actions. These include information and education for stakeholders, mitigation and prevention of beaver damage, but also relocation of beavers and removal of dams. Where permitted, hunting and trapping of beavers are the main methods for controlling beaver populations. Depending on the local / regional /national beaver situation, current legislation and policies, and the opinion among dominating stakeholders one or several of the management actions will be selected.

Management and harvesting strategies and methods should differ between two groups of beaver sites (see below under “Beaver management within the Baltic Sea Region”):
- *Allowable sites* are important for the local biodiversity, causing no or negligible damage, are potential centres for beaver distribution, important to maintain the local beaver populations, and are key landscape components of woodlands or belong to protected areas. These sites have to be maintained to persist as long as possible, applying minimal harvesting within limits of annual increment.
- *Unallowable sites* risk causing damage or conflict situations in the near future, contain low habitat and food supply for beavers. These sites are managed to be fully removed with subsequent prevention from repeated habituation of beavers.

A beaver dam tool has been developed which aims to classify beaver sites to these categories.

Interactions with the other WAMBAF themes, riparian forests and drainage systems are also presented.

Finally, national situations are described as well as the different beaver management systems present within the Baltic Sea Region.

Contents

Terminology

Beaver: The Eurasian Beaver (*idem* European beaver) (*Castor fiber* Linnaeus, 1758), belonging to the order Rodentia, family Castoridae, is the largest rodent in Eurasia. A closely related species, the North American beaver (*Castor canadensis* Kuhl, 1820), is native to North America, Canada, and parts of northern Mexico. In this document, "beaver" signifies Eurasian beaver if not stated otherwise.

Beaver dam: A structure that is built by beavers to rise water level to protect against predators and that, by stabilising the water level of a pond, provides easy and safe access to food during warm and cold seasons.

Beaver dam tool (sin. beaver site tool, beaver wetland tool)**:** a standard procedure developed by WAMBAF that aims to classify beaver sites to *allowable* and *unallowable,* and diversify management actions in a beaver population. See Appendix 1.

Beaver site: An area occupied by a beaver family, or a pair, or a single beaver. It contains part of a water body and adjacent land with signs of beaver activity (dams, ponds, trails, cuttings, etc.).

Beaver site centre: The beaver lodge or main burrow occupied by the alfa couple, or the main dam where there is no lodge, or the location of the main burrow is problematic. A cache of branches helps to locate the beaver site centre in late autumn. This is an important definition for distinguishing and mapping beaver sites, especially in densely inhabited territories.

Beaver damage: The flooding caused by beaver dams can results in extensive forest damage. When the flooding occurs next to infrastructure, it can cause widespread damage by washing out tracks and roads. Beavers also cut down various species of trees for both food and the building of dams and lodges. Beavers can destroy infrastructure by digging burrows.

Beaver impoundment (= Beaver pond): A body of water that is created by building a beaver dam. Beaver dams interrupt the fluvial water flow.

Ecosystem engineer: A species, or individual, which physically alters the surrounding habitat. Beavers are called "ecosystem engineers" because they physically alter habitats by cutting down trees, building dams, digging burrows and canals and building lodges.

Keystone species: A species that has a disproportionately large effect on its environment relative to its abundance. Beavers have been classified as "keystone species".

Further explanations are given in this document:

Belova, O. et al. 2017. Beaver Population Management in the Baltic Sea Region - A Review of Current Knowledge, Methods and Areas for Development. Final document of WP2. 27.02.2017. https://www.skogsstyrelsen.se/globalassets/om-oss/wambaf/beaver-tool-short-document.pdf

Aims and scope

The main aim of the measures proposed in this report is to counteract or reduce excess export of nitrogen (N), phosphorus (P), suspended solids and mercury (Hg) to surface water due to forest management and harvesting.

Forests cover 48 % of the Baltic Sea (BS) catchment. Most forests are managed for timber and energy production and have high economic value. Rivers and streams transport nutrients and hazardous substances from forests to the regional and coastal waters causing eutrophication, pollution and decrease in biodiversity. HELCOM has estimated that the natural background load from forests comprise approx. 19 % of the total nitrogen and 16 % of the total phosphorus load to the BS. Maintenance of forest drainage systems, management of riparian forests, and the distribution of beaver dams are main drivers in the BS forests, which effect the inflow of nutrients and hazardous substances (e.g. methyl mercury), and affect the biodiversity of riparian ecosystems.

To date, water protection practices for maintenance of drainage systems and management of riparian forests and beaver populations have been developed and implemented nationally in the BS countries, resulting in different solutions and seldom using best available cost-effective practices. This transnational project will promote sustainable forestry and help to improve water quality in the whole BS Region.

Beaver populations are considered to have reached densities causing substantial damage levels, e.g. in the south eastern BS countries.

There is presently a lack of:

- Knowledge, guidelines and tools to assess which type of beaver dams have the best capacity to decrease the amounts of nutrients and hazardous substances in waters
- Organization structures and incentives to manage the distribution of beavers in a sustainable way

In the perspective of a changing climate, the role of forest waters is important in stabilizing runoff and water tables in periods of flooding and drought. Here, management of beavers and beaver dams may be crucial. Furthermore, the use of forests and the demand for forest products may increase in the future. However, the use of forests needs to be sustainable, not only economically but also ecologically and socially. Moreover, impacts on water quality, biodiversity and climate change as well as regarding popular access and recreational use should be considered. The recommendations given in this report acknowledge this complex setting.

In regions with high population density, such as large parts of the Baltic Sea Region (BSR), beavers are often perceived as a problem species when they inhabit landscapes which are either urban or dominated by forestry and agriculture. Situations of spatial overlap have a potential to develop into conflicts, and then a reaction will be to find rapid solutions to the problem. If these situations instead are predicted in advance, solutions may be found in time. In order to facilitate coexistence between society and beavers, proactive planning will therefore be useful.

In order to improve practices and learn from management actions, the process of adaptive wildlife management has often been applied, and should be useful also for management of beaver populations and beaver dams. This method implies a rigorous stepwise process including monitoring and assessment. Stakeholder engagement is also important for the success of adaptive management.

This best practice document is designed for use in the training courses and in the communication with the target groups of the WAMBAF project and with the purpose to facilitate implementation in all BSR countries. The document is accompanied by other resources in a "Toolbox for management of beaver populations" as follows:

- A Baltic beaver handbook "Beaver as a renewable resource", with general information on beaver populations and management needs, as well as country specific legislation and policies. The handbook will contribute to transnational learning on beaver management and use, be a resource for national policy development in respective BSR countries and provide incentives for sustainable management of beaver populations.
- A decision support tool for classification of beaver dams. The tools helps to decide which beaver dams should be removed. If done in a proper way, while preserving dams improving water quality through retention of sediments, the discharge of the hazardous methyl mercury will decrease. This tool can be an important resource for harmonization of environmental status in the BSR.
- A film about beavers in the Baltic Sea Region and how humans and beavers can co-exist.
- Beaver dam demonstration sites in several of the countries participating in the WAMBAF project.

The combined toolbox serves as a material for revised legislation aiming at reducing leakage of nutrients and hazardous substances, for instance by changing the management of beaver populations and beaver dams. It will serve as a science-based support for management of beaver dams, resulting in minimised leakage of nutrients and hazardous substances (e.g. mercury). The main output is up for use in all areas in Baltic Sea countries where there are abundant beaver populations such as central and northern Sweden, eastern Finland, Estonia, Latvia, Lithuania, NW Russia and Poland.

The novelty is to clarify the beaver role in water quality not only implementing the Water Framework Directive, the Habitat Directive, the Marine Strategy Framework Directive and the nutrient load reduction targets of the HELCOM Baltic Sea Action Plan but also enabling to determine species management plans.

FAO: The global outlook for forest products. http://www.fao.org/docrep/w4345e/w4345e06.htm

Introduction

- Extinction of the Eurasian beaver. Beaver was abundant throughout the Baltic Sea Region from early postglacial times, and an important game animal since the Palaeolithic period and on. Intensive hunting and capture, together with changes in human land use, led to the total extinction of the species in the watersheds of the Baltic Sea basin (see Table 1), even if beavers still occurred within the borders in some of today's countries – Russia and Germany.

Table 1. Chronology and abundance of beaver occurrence in the WAMBAF project area. Timeline mainly according to Halley et al 2012 and Belova et al. 2017.

Country/Region	Year of extinction	Year of first reintroduction	Population number 2015 (approx.)	Area of country / region (km^2)	Density – ind. / 100 km^2
Sweden	1871	1922	130 000	447 435	29
Finland	1868	1935	12 000*	338 449	4
Estonia	1841	1957*****	12 000	45 226	27
Latvia	1870's	1927	125 000	64 573	194
Lithuania	1938	1947	102 000	65 286	156
NW Region, Russia	Around 1868, possibly 1920's***	Leningrad province 1952** Vologda province 1949**** Pskov province 1951*****	160 000**	1 677 900	10
Poland	1844	1948	100 000	312 679	32

* Including 10 000 North American beavers

** Including ca 15 000 North American beavers

***Danilov et al (2011). *C. fiber* spread into Karelia 1967; *C. canadensis* spread into Karelia from Finland already 1961

****Zavyalov (2011)

***** Chapter 5; Simultaneously spread from Russia

– Reintroduction. In the late 19th and early 20th century there was a spread of conservation ideals in general, and a realization about the need for measures for preserving and re-establishing the beaver. Beavers from the remaining populations in Europe were used for re-introduction in the Baltic Sea region (Table 1).

– Successful reestablishment. Reintroduction, further translocations, natural spread together with species protection and regulated hunt has led to strong growth in beaver populations and high densities in the BSR. The species' number in the region today is well over 600 000 (Table 1). Beavers are also increasingly becoming a part of urban wildlife, which creates both assets and drawbacks.

– Density of beaver populations. The density is moderate to high in the countries of the region (Table 1). In some areas beavers are still increasing their distribution and abundance. In the larger countries, as Russia, Sweden, Finland and Poland, there is considerable variation in distribution, depending on variable landscapes and incomplete recolonization by beavers. In some parts, there is an active effort to keep populations at a target limit.

– Comparison with other macro-regions. Beavers survived after the 19th century in small areas of Norway and France, and today's Germany, Belarus, Ukraine and Russia. The species is now occurring in most countries of the European mainland, and also in Great Britain. Abundance is highest in the Northern and Eastern parts, where reintroduction started early. In southernmost Europe, such as the southern part of the Iberian Peninsula, as well as Italy, and Greece and its neighbouring countries, however, there is no occurrence of beaver.

– North American beaver. The American beaver species is also present in the BSR, in parts of Finland and in the Russian Republic of Karelia. The species was introduced to Finland at a time when the species status of beavers was not clearly established. North American beaver was introduced alongside with Eurasian beaver, and today the former is more abundant and has a larger distribution area. Hunting is more restricted in Finland for the Eurasian species. North American beaver has also spread into Russia where it now occurs close to the Eurasian species. Research is ongoing in Karelia to establish which species will eventually prevail. The two species are very similar in appearance and ecology but are not reported to hybridize.

– Beaver activities. Beavers perform many activities that have profound effects on aquatic and forest landscapes. They construct dams which will raise water levels, sometimes far upstream if the topography admits. For protection, they build permanent lodges close to the water, or dig caves into the river bank. Beavers also dig canals along the shorelines of the beaver impoundment to facilitate their movements. Beavers fell trees for their construction work and also for foraging. Trees and branches are stored in the impoundment as caches for their winter feeding.

- Beaver transformation of landscapes and ecosystems. Through damming and felling, beavers open up the forest canopy and create lying and standing dead wood. Beaver dams increase the wetted area of the forest landscape. Sunlight and heat will reach the water environment and, together with changes in the stream bed, this will change the microbial environment and the processes. The dams also slow down the stream velocity and create stretches of still water along streams thereby increasing stream habitat diversity. Dams will act as sediment traps and increase retention of carbon in lower stream orders of watersheds. The dynamics of nutrients and toxic compounds in beaver impoundments are complex and depend on the conditions.

By felling trees, adding organic material to the stream, and defecating, beavers increase the exchange between land and water environments. As herbivores, they are also exerting an influence on the species and age composition of woody plants, and also on herbal vegetation. When beavers move on and desert dams and lodges, various successional paths are possible depending on local conditions.

Due to the changes in the water environment, the species composition of aquatic animals such as fishes (if present), amphibians, and insects will change compared to a system without beavers. The opening up of the landscape and an increased insect abundance will facilitate for bats and wetland birds. Standing wood will serve as nesting resource for hole-nesting birds and other animals.

- Added values. The beaver occurrence in itself signifies a return to more pristine conditions of the aquatic landscape, such as promoted by e.g. the "Good ecological status" of the Water Framework Directive, and contributes to many levels of biodiversity both in land and water environments. In addition, beaver may today be seen as an asset in water management not least regarding effects of climate change such as increasing periods of extreme conditions of either draught or flooding.

Beaver may also be seen as a game resource which results in recreation value for hunters, but the species may be also used for production of meat, fur, *castoreum* and other products. A non-invasive

recreational use of beavers is beaver tourism such as “beaver safaris”, and beavers may serve educational purposes e.g. in ecology teaching of schools and children’s nature clubs.

- Perceived beaver–human conflicts. Beaver activities may cause economic drawbacks for land owners, e.g. in forest land by felling and drenching trees. For owners of smaller areas this may have serious consequences but larger companies and government agencies are normally less sensitive and may even count beaver occurrence as positive from an environmental perspective such as forestry certification. Beaver may also threaten forest roads e.g. by building dams in road culverts. In parks and other human environments beavers may fell large ornamental trees such as aspen, and even create risk for accidents. Human infrastructure such as man-made dams, barriers, electrical lines, roads and railroads are sometimes subject to damage by the digging by beavers.

The beavers’ effects on fish populations of differing species and sport fishing in the BSR are not well studied and may certainly differ much between local conditions and the fish species community. Worries for the status of migrating salmonid populations are common, even though trout and salmon has coexisted for millennia. It is also unclear which the effects are on freshwater pearl mussels.

– Beaver effects on water quality. Depending on local conditions, export of organic matter and nutrients from the beaver ponds to downstream may increase. Whether beaver ponds act as a source or a sink for nitrogen and phosphorus differs between study sites. If organic matter concentrations increase downstream of a beaver pond, total nitrogen and phosphorus concentrations may also increase. Nitrogen fixation within the pond and downstream can further cause the pond to act as a source of nitrogen. On the other hand, beaver wetlands as anoxic environments can be important denitrification sites.

Mercury in forest land is released into surface waters and may create health and environmental problems at least in parts of the BSR. This concerns in particular methylated mercury, since it is more available for uptake in the food chains. Methylation of mercury may under some conditions occur in environments created by beavers in particular where sediments are anaerobic. The processes of methylation and demethylation are complex and depend on microbial dynamics, but research results show that pioneer beaver systems increase the risk for methylation. In combination with the tendency of older dams to retain phosphorus, the lower risk for methylation there should favour the preservation of older and recolonized dams, in contrast with new, pioneer, dams.

Belova, O. et al. 2017. Beaver Population Management in the Baltic Sea Region - A Review of Current Knowledge, Methods and Areas for Development. Final document of WP2. 27.02.2017.

Campbell-Palmer, R. et al. 2016. The Eurasian Beaver Handbook: Ecology and Management of *Castor fiber.* Pelagic publishing, Exeter, UK. 202 p.

Danilov, P., Kanshiev, V. and Fyodorov, F. 2011. History of beavers in Eastern Fennoscandia from the Neolithic to the 21st century. In: Göran Sjöberg and John P. Ball (Eds.). The Return of the Beaver. Landscape-creative beaver activity in Northern Europe: a review of 50 years of restoration. Pensoft Publishers, Sofia-Moscow, Ch. 3, p. 27−38.

European Commission: Adapting the management of Water and Environmental Resources in response to Global Change http://ec.europa.eu/environment/water/adaptation/index_en.htm

European Commission: The EU Water Framework Directive - integrated river basin management for Europe http://ec.europa.eu/environment/water/water-framework/index_en.html

Halley. D., Rosell, F. and Saveljev, A. 2012. Population and Distribution of Eurasian Beaver (*Castor fiber* L.). Baltic Forestry 18(1): 168−175.

Levanoni, O., Bishop, K., Mckie, B. G., Hartman, G., Eklöf, K. and Ecke, F. 2015. Impact of Beaver Pond Colonization History on Methylmercury Concentrations in Surface Water. Environ. Sci. Technol. 49: 12679−12687.

Zavyalov, N.A. 2011. Settlement history, population dynamics and the ecology of beavers (*Castor fiber* L.) in the Darwin reserve. In: Göran Sjöberg and John P. Ball (Eds.). The Return of the Beaver. Landscape-creative beaver activity in Northern Europe: a review of 50 years of restoration. Pensoft Publishers, Sofia-Moscow, Ch. 7, p. 75−100.

Approaches for implementation of good practices in beaver management

- Adaptive management. We suggest the use of an adaptive management method. This is a decision process that promotes flexible decision-making. It leads to increased learning from management. However, to function properly it needs to be carefully designed and follow certain processes. A simplified picture of the steps in the process is presented below.

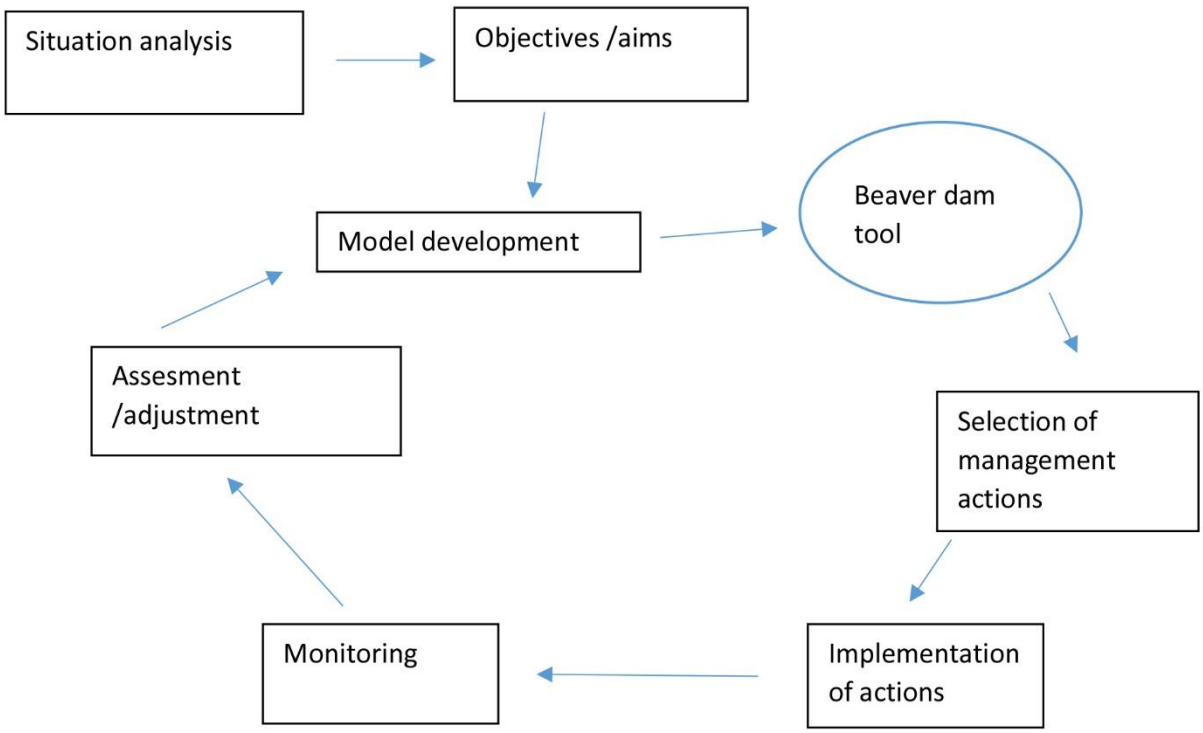
This approach can be adjusted in the face of uncertainties concerning ecological responses but also societal change. It is an iterative stepwise process starting with an analysis of the situation, and going through several steps where stakeholder engagement is important.

The first step is **a situation analysis**. In the first phase of this, the problem to be solved and the social–ecological context are defined.

In the second step, the stakeholders are involved, to make the analysis more realistic, and to include broader groups in society for solution of the problems. There are differing groups of stakeholders with differing perspectives – general public, landowners, hunters, sport fishers, conservationists, and urban developers. It will be important to involve several of these for an efficient planning process.

Stakeholders should be involved in **setting objectives / aims** for beaver management.

Simplified diagram over the process of adaptive beaver management – with a suggestion for the position of the use of the WAMBAF Beaver dam tool (see Appendix 1).



– Setting aims from national / regional / local general land management purposes. Aims for beaver management may be of different kinds.

- Obviously one important aim may be *population levels*, or population density. These may be adjusted up- or downwards over time.

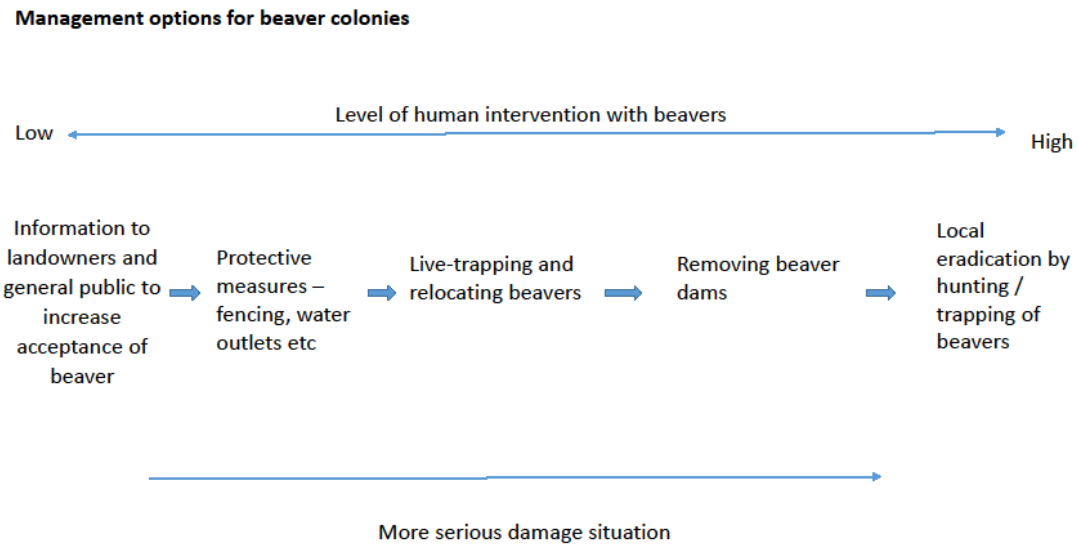
- Other possible aims may be on *economic impacts* – the extent of dammed areas of forest or agricultural land, or economic measurement of damage to land use or infrastructure.
- Optimizing *beneficial effects of beaver on various levels of biodiversity* may be a separate aim for management.
- In the WAMBAF project, *water quality* is emphasized. Depending on natural conditions, the most important measures may be methylated mercury, nitrogen or phosphorus, or some other toxic compounds or nutrients. The age of the dams may in some cases serve as a proxy for these conditions.
- Finally, the aims could be *social*, i.e. stakeholder appreciation of the beaver management situation.

Aims may be on various geographical levels. Regions or local areas may have different roles in beaver management. Conservation areas such as national parks, Natura 2000 areas and nature reserves usually have other policies than commercially used lands or human population centres.

All of these separate aims will require specific methods for measurement of different kind. So the choice of aims will dictate quite different processes for monitoring of management success.

- Development of a model. A model of the beaver system needs to be made in cooperation between managers and stakeholders, including economic, social and environmental effects. This step will clarify why management of beavers is needed. The second step in formulating a model is proposing management actions and describing how they are expected to fulfil the desired aims. The effects of the management actions need to be monitored. **For selection of a model and choice of management actions, WAMBAF has developed a Beaver dam tool (see Appendix 1).**

- Implementation of management actions. For beaver management there are many possible kinds of management actions, and they may be arranged on a scale of intensity or intervention with beavers. In the diagram below, options are listed from non-invasive (left) to hunting /trapping for local eradication (right). Depending on the damage situation, the latter may be less (left) or more (right) justified or desired by stakeholders.



Information and education. On the left-hand side one can list actions which are directed towards stakeholders, rather than directly to the beaver population. These actions may be cost-effective in some situations, especially they are applied at an early stage of population growth in a newly established beaver population. Some of these are:

- *Inform* landowners, hunters and other stakeholders about EU, national and regional legislation and policies. This is an important framework and sets the limits for other management actions of the population.
- *Educate* stakeholders about the role of beaver in the natural communities and ecosystems. This may create an understanding of the broader perspective of the role of beaver. The educational situation may also give feedback from experienced stakeholders to managers about the actual situation in beaver habitats.
- *Show* how to protect forest and agricultural land, infrastructure, and individual trees. There is a large number of techniques for protection of land, trees, crops and infrastructure. They need, however, to be carefully designed for each specific situation.
- *Increase* the value of beavers in the eyes of landowners and hunters. This may include watching beavers for touristic or educational purposes, or using beaver meat for cooking, beaver furs for dressing or *castoreum* for perfumes etc.
- *Help* to make decisions about beaver management and reaching management objectives including protection of water quality. The use of the WAMBAF Beaver Tool is promoted to achieve this purpose.

- *Damage mitigation and prevention.* This includes all possible legal methods and instruments to reduce or escape negative impacts of beavers to the environment, habitats, structures, etc., without application of lethal/non-lethal removal of beavers. Damage mitigation methods could be applied also in allowable beaver sites where a compromise between positive and negative impact of beavers is needed (e.g. flooding of valuable plant communities, cutting of valuable trees, etc.). In unallowable beaver sites, preventive means against repeated habituation of beavers are recommended after removal of beavers, especially in areas with dense beaver population and shortage of suitable habitats for beavers. Methods of beaver damage mitigation and prevention can be classified to *water level management*, *fencing* and *habitat manipulations*.

- *Water level management.* Techniques for protection against damming include pipes, filters and wire cages. They include many technical means for regulation of water level (basically lowering) in the beaver-dammed areas and prevention means against blocking drainage facilities. The main idea in water level regulation is that beavers should not leave the area, i.e., the water level should not fall down too much. At the same time water levels should be kept low enough in order to protect land, roads, culverts and other infrastructure against damming. There are also devices to facilitate fish passage through beaver dams. If levels are too low, beavers will construct another dam or rebuild the same to ensure a proper water level for their safety. That is why removal of beaver dams usually does not lead to the desired result if additional preventive means (removal of beavers, fencing, habitat manipulations, etc.) are not applied. In many cases, lowering of the water level should not exceed 30–50 cm depending on relief conditions. Before planning of such means, it is always worthy to find out how deep the entrance is to the main beaver burrow. It must not be revealed after the water level regulation.

- *Fencing* is used to protect individual trees or prevent beaver from access to undesired areas. Usually a wire mesh is used. Poles may be made from metal or wood, but in the last case fresh and not debarked poles should be avoided. Special attention should be paid to how the underneath of a mesh

is attached to the ground. Is recommended to put the underneath part of the mesh into the ground ca. 20 cm., or attach a horizontal strip of mesh (50 cm width) on the surface of the ground from the outside of the enclosure in the fashion of the letter “L”. Other fencing techniques serve to protect single or groups of valuable trees against beaver felling in forests, parks or housing areas. Tree trunks are usually enveloped by mesh of about 1 m high. Mesh should be applied not tightly by leaving enough space between bark and mesh to allow tree trunk thicken.

Protective measures have been more widely used in North America. They have often been considered expensive and economically inefficient for the European needs. They may now, however, be gaining more terrain also in Europe as there are more calls for humans to coexist with beavers not least in urban areas. There is however a great deal of skill and experience needed to design well-functioning protection measures and it may take some time to build up this in separate countries.

- *Habitat manipulation*. This may be useful before the arrival of beavers, or as additional means after removal of beavers. It is especially applicable in drainage channels. Regular mowing of slopes of a channel prevents it from overgrowing by shrubs (*Salix* et al.) that are preferable food for beavers. It is also recommended to remove *Salix* and aspen shrubs and trees along channels and to leave species that are less attractive to beavers (spruce, grey alder).

- *Relocation.* In periods where beaver populations have been unevenly distributed over the area of a region or a country, one solution for solving human – beaver conflicts has been to live-trap beaver families and relocate them to a new area with suitable beaver habitat but with lower population density and less risk for conflict with humans. Properly performed, this will allow spread of the beaver population to new areas.

Expertise is needed for a successful and humane handling; all beavers in a family group need to be captured and then transported safely to the new location. It is however not certain that the location will remain beaver-free since new beavers from adjacent groups may colonize, and then the procedure will need to be repeated. To avoid this, coordinated efforts need to be made over larger areas.

- *Dam removal.* Another method to counter the effects of the beavers’ construction activities is to remove the dam, or several dams, often with machines or explosives (where these are permitted). This measure is of course strictly regulated in national legislation and policies. If it is executed too late in the season, in a region with harsh climate, beavers may not have time to move to a new location and build up a food cache before winter sets in which may lead to starvation.

The efficiency is limited if the beavers stay in the area since the can repair or replace the dam in short time. The method will work best if beavers are relocated or culled in connection with the removal of the dam(s).

Relocations into beaver-free areas is rarely applicable for the Baltic Region since overall beaver population density is high.

- *Hunting / trapping.* This is the main tool to control beaver population growth and remove nuisance beavers from unallowable beaver sites. Shooting the beavers or using killing traps is the ultimate management method. This is also strictly regulated in national law and requires a high hunting skill and ethical methods. According to hunting ethics, the hunted/trapped beavers should then be used for various purposes such as food and handcraft. In some areas there are traditions for such use, while they have been forgotten in others. One aim of the WAMBAF project is to spread knowledge about

the utilisation of beaver products. This knowledge may also stimulate a sustainable management of beavers.

If the aim of the hunting/trapping of beavers is to eliminate or reduce the population in a locality, there needs to be a persistent hunting activity over time and in a larger area since new beavers otherwise will move in and there may be a compensatory population growth.

Management and harvesting (in countries where harvesting is allowed) strategies and methods should differ between these two groups of beaver sites (see below under "Beaver management within the Baltic Sea Region"):

- *allowable* beaver sites have to be maintained to persist as long as possible, applying minimal harvesting within limits of annual increment;

- *unallowable* beaver sites are managed to be fully removed with subsequent prevention from repeated habituation of beavers;

- in *allowable* beaver sites hunting limits should not exceed annual increment, whereas in *unallowable* sites full harvesting is recommended;

- in *allowable* beaver sites "silent" and non destructive-to-habitat methods (hunting from hides and legal Conibear traps) are recommended;

- in *unallowable* beaver sites all legal methods, including beaver dam demolition and using trained dogs to drive out beavers from burrows, can be allowed.

- Implementation

Depending on the local / regional /national beaver situation, current legislation and policies, and the opinion among dominating stakeholders one or several of the management actions will be selected. If several actions are chosen it will be important to make it possible to evaluate the response of the separate actions.

- Monitoring

Sensu lato monitoring aims to estimate status and dynamics of beaver population (abundance, habitat distribution, scale of damage).

Sensu stricto monitoring is limited to inventory of beaver sites, see *Population density.*

Scrupulous monitoring will be needed in order to evaluate the model and the management actions. The advantage with the adaptive approach is to learn from results of the performed management actions.

Population density. If the aim is to reduce density or abundance, or to achieve a specific population target, the monitoring should concern the number of beavers – usually expressed as the number of family groups (multiplied by the estimated average size of each group). Methods to obtain this data are as follows:

- aerial (or remote-sensing-based) counts, or

- land-based counts.

A trained observer can tell an active from an inactive beaver locality using e.g. aerial photos. A combination may preferably be used for validation. In specifying and mapping of beaver sites, it is important to consider beaver site centre (see Terminology), especially in the densely inhabited territories. Estimation of family size will need to be land-based. A cheaper method, however with lower precision, is the use of hunters' or foresters' observations over time, as a basis for an index showing the direction and magnitude of population change.

For a land-based beaver census which aims to estimate beaver number in a population or an administrative unit, the number of sites is multiplied by 4 (mean number of beavers per site) to get the beaver number estimate. This statistical method works adequately for large extensive areas. However, for small local territories significant departure from the indicator 4 is highly possible. Thus, it is recommended to divide all beaver sites into three groups: a) weak sites (indicator is 1.5), b) moderate sites (indicator is 4), and c) strong sites (indicator is 7).

Criteria for weakness/strength of beaver sites (See Terminology):

1. A **weak beaver site** is inhabited by 1–2 beavers (mean 1.5). Tree and shrub cuttings in autumn are concentrated in one or two places, one or two beaver trails going from water to cutting places; usually one beaver dam, and no branch cache.

2. A **moderate beaver site** is inhabited by 3–5 beavers (mean 4). Tree and shrub cuttings in autumn are concentrated in 3–5 places with the same number of beaver trails. Beaver lodge (if present) usually big and intensively maintained by beavers; usually more than one beaver dam, the main dam is significantly larger than others; presence of branch cache.

3. A **strong beaver site** is inhabited by more than 5 beavers (mean 7). Numerous cuttings of trees and shrubs, and a lot of beaver trails in autumn. Sometimes more than one beaver lodge – a big main lodge and one or more smaller lodges, or several branch caches may be the case.

Samplers of beaver monitoring data may be local stake holders, e.g. hunting ground units or landowners. Experts are involved in subsequent data processing and analysis. Regularity of beaver monitoring may be once a year, or at least once in three years (three years is the approximate duration of a beaver generation). *Economy.* In order to judge effects on economy, various expertise is needed. To evaluate aerial extent of beaver impoundments, again time-series of remote-sensing data will be needed, and GIS-trained persons to make measurements. To judge actual costs of damage from damming or tree-felling, more complicated remote-sensing technology, or careful field work, will be needed, in combination with knowledge of forest (or agricultural) economy. For costs of infrastructure damage from beavers, surveys may need to be made to companies and / or municipal authorities. Separate statistics for beaver damage will most likely not be available.

Biodiversity. Although there is a general agreement among ecologists and most managers that beavers contribute to several levels of biodiversity, the actual effects may vary depending on local conditions, and the importance of this in a certain region as well, depending on the need for improvement, or the purpose of land management in a given area. On land set aside for conservation purpose, beavers will normally be an asset, if their activities do not conflict with other specific aims such as certain invertebrate, fish or bird populations. In a landscape where structural, processional, faunal or floral biodiversity along streams is already high, the extra value of beaver activities will not be as high as in a more monotonous landscape.

Habitat diversity – stream characteristics or vegetation structure - may be monitored using remote sensing technology ore drones. For more careful measurements such as stream velocity or canal depth field measurements will be needed.

For species diversity actual inventory of plants or sampling of invertebrates, electrofishing, or monitoring of birds and other vertebrates, coupled with taxonomic expertise, will be needed to determine species abundance and/or or diversity indices. In some areas monitoring of certain species of conservation interest – wood-peckers, amphibians, trout, pearl mussels etc. – will motivate special monitoring programs.

Water quality. This is a core task for the WAMBAF project and we suggest monitoring of nutrients and toxic substances (also in biological material) to be included in the process of planning beaver management. Sampling and particularly handling and analysing of samples is a difficult and costly procedure. Therefore, thorough planning and detailed instruction of the work is needed to ensure cost-efficiency and reliable data. It is also important to consider timing of sampling over the year to ensure that samples may be compared between years.

Stakeholder opinion. In order to monitor stakeholder attitudes and opinions regarding the beaver situation in a specific area, various techniques may be used. All of these, however, need expertise familiar with the assumptions and specific preconditions for their use and analysis of data. For a general picture of opinions, a questionnaire may be sent out to different target groups and analysed if there is sufficient response from these. For a deeper understanding of stakeholder reactions, more semi-structured interviews may be performed, or focus-groups used. The analysis of these may then be used to collect additional feed-back. Stakeholders will represent different interests in society so it is valuable to include different groups to get a broad range of perspectives.

Assessment and adjustment. After analysis of monitoring data of whatever kind, the management actions and also the underlying model may need to be adjusted. This needs to be made together by managers and stakeholders. The process may need to continue to ensure that the aims continue to be fulfilled. New situations may emerge, either in beaver populations, climate or other conditions, in technology of monitoring, or in human society, and these may also require adjustment of management.

- Interactions with the other WAMBAF themes

- *Riparian forests.* This is the main habitat of beavers and they will transform them while adding some values but at the same time creating what may be perceived as problems. For management of riparian forests, beaver may generally be considered an asset, if the objective is to optimize biodiversity. Implementation of policies for riparian forests need to be flexible enough to allow for the activities of beaver, which are not quite predictable. Beavers may fell forest buffers that have been left after forestry activities, in particular if the species left standing are palatable ones.
- *Drainage systems.* The activities of beavers directly counteract the objectives of forest drainage activities which is to increase runoff from forest soil and wetlands. Beavers strive to impound streams and wetlands and keep the water level high and stable. This implies that it will be necessary to make priorities for a given area or watershed. Should beavers be allowed to restore the ecosystem or should drainage systems be protected? Preferably, this should be decided in advance of an actual conflict situation so that is immediately clear for managers and stakeholders what action, if any, will be taken.

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Beaver management within the Baltic Sea Region

Full names and dates of legislative acts etc. are found in Appendix 2.

Country/Region	Purpose of national beaver management	Target for national beaver management	Methods for beaver management	Present population status
Sweden	Generally, to provide a sustainable population; more specifically the landowners' benefit.	None. No monitoring of the beaver population.	Hunting, dam removal. Certain killing traps, after special permission.	Database for voluntary reporting of localities of observations. No official standpoint on beaver numbers but it is placed in category of 'least concern'. It is not a controversial species.
Finland	Partial protection of Eurasian beaver in relation to North American. North American beaver should be prevented to spread into range of Eurasian beaver in Finland, and into Sweden.	None. Beaver numbers are monitored by hunters' organizations.	Shooting. License required for hunting of Eurasian but not for North American beaver.	North American beaver – considered too high. Eurasian beaver is listed as 'near threatened'.
NW Region, Russia	Limiting damage to forestry and agriculture.	No exact figures.	Trapping.	Beavers in Russia have almost completely reconstructed their previous habitat. Numbers of both species today considered too high in NW region. Harvest needs to increase.
Estonia	To keep the beaver abundance within permitted limits, in accordance with the needs of	Optimal abundance from 10 000 to 11 000 individuals, according to the Action Plan for	Trapping (mainly state lands) and shooting (private lands); Expanded period in beaver-damaged sites.	Abundance is presently brought down to optimal numbers.

	species protection and the impact of beaver activity on environment and economy.	Protection and Use of Beaver.	Removal of dams.	
Latvia	Favourable conservation of beaver, and protection of drainage systems and other resources. Also providing hunting opportunities.	Ambition to bring down population numbers.	Trapping and shooting. Hunting clubs contracted to protect drainage systems om state forest company land. Special management strategy for Riga city beavers, with use of protection for trees and other measures.	According to official estimates, population was brought down form maximum 90 000 to 58 000 individuals. Actual figures may be much higher.
Lithuania	Provide a sustainable beaver population; Limiting damage.	About 40 000 – 50 000 individuals.	Determination of "allowable" and "unallowable" dams. Trapping and shooting.	Much too high (over 100 000) – should be reduced with at least 50 %.
Poland	Protecting the beaver population, but also avoiding excessive damage for landowners.	None. National inventories during 2006–2007.	After special permission, shooting, livetrapping with relocation, or destruction of dams and burrows. Also, protective measures for forests, fields, and infrastructure.	No national exemption from species protection in EU Habitat directive. Population numbers appear to stabilize at relatively high level.

– EU-level

The Bern Convention (ratified 01/06/1982) gave the beaver protective status (Appendix III) in EU. Beaver is included into the lists of EC Habitat Directive 92/43/EEC: Annexes II, IVa (21/05/1992) species of "Community interest EC Habitat Directive 92/43/EEC, and Annex V (21/05/1992) derogation for beaver management from strict protection for Sweden, Finland, Latvia, Lithuania and Estonia.

– Sweden

The Game Act concerns wildlife conservation, the right to hunting, and the pursuit of hunting within Swedish territory and matters in connection with this. Wildlife must not be disturbed or pursued other than during hunting. Landowners have the right to protect property from wildlife damage, if such damage may not be counteracted otherwise. The hunting period is stated in the Swedish Game Regulation, from October 1 to May 10 or 15 (depending on county). For hunting, bullet rifles of certain calibres are permitted, and the hunt follows general legislation for small-game hunting in Sweden. Killing traps of certain types are permitted under special conditions. Decisions about harvesting is up to the hunting-right owner, normally the landowner. There is no active management of beaver populations. Beaver dams are generally allowed by forestry companies to remain unless they are perceived as a threat to forest roads. Decisions about removal are taken by the companies' district officers. Removal of beaver dams is permitted during summertime. Permission for removal may be sought for other periods but is not always granted. The use of explosives are rarely permitted. No actions may be taken against inhabited beaver lodges. Felled beavers are reported voluntarily by the hunters to the Swedish Association for Hunting and Wildlife Management and the game statistics are publicly available. The annual hunting bag is estimated at ca 8 000 individuals. There is no compensation for damage made by beavers.

– Finland

The Hunting Decree aims to increase the population of the Eurasian beaver and reduce that of the North American. The European beaver population remains in a rather small area while the North American beaver has spread over the country.The hunting season for beavers is from August 20 to April 30. A hunting license is demanded for the hunt of Eurasian beaver. For the hunting season 2017/2018, the quota is 350. The hunting bag was 242 in the hunting season 2016/2017. Hunting is allowed in all municipalities of the province of Satakunta, and in some municipalities in the provinces of Etelä-Pohjanmaa, Pohjanmaa and Pirkanmaa. In other areas, hunting of some individuals which cause a lot of damage may be licensed. A license is not required to hunt North American beavers, but the hunting season is the same as for Eurasian beavers. The hunting bag of North American beavers is about 5 000 individuals. Removing dams is allowed from 16 June to 15 September or 30 October, depending on the area, but permission from the landowner is needed. In other times of the year permission is demanded also from The Finnish Wildlife Agency. A forestry environment guide recommends that dams should be not removed because of re-building activity of beavers. Beavers usually build a new dam and, in the worst case, move to a new site causing new forest damage.

– NW Russia

An order on approval of norms of permissible use of game resources and norms of their permissible numbers approves the norms on beaver hunting: 50 % of the local population number on 1 April based on the state monitoring of game resources and their habitats.
The Hunting Regulations in the Russian Federation approve the hunting season for game species, hunter responsibilities, order of hunting and selection of hunting method, prohibited hunting methods, transportation, hunting limits on the protected areas, requirements of the certain game species including beaver. During the hunting, removal/destruction of the beaver dams is prohibited (except for arrangement of traps).
In Russia the main harvesting method is using killing traps.

The numbers of beavers in Russia generally, and in the northwest region, are considered to have been restored to historical levels.
An increased trapping is now needed to protect agriculture and forestry.
The outcome of the competition between North American and Eurasian beavers is difficult to predict.
There is no specific measure to protect Eurasian beavers in North-West Russia.

– Estonia

The Hunting Act contains general regulations for regulation and use of game species.
The list of game monitoring data and regulation for data collection, and authorised institution for monitoring arrangement defines monitoring of game species and principles of its arrangement.
The *Action Plan for Protection and Use of Beaver* requires to keep the beaver abundance within permitted limits. This implies a quality assessment of the beaver habitats and planning of the beaver occurrence in accordance with the needs of species protection and the impact of beaver activity on environment and economy. Beaver habitats are defined in three categories of protection and use:
1) water bodies, where the beavers are allowed (the environmental impact of beaver activity is positive) - beaver hunting is allowed during hunting season depending on increment of population,

2) water bodies, where the beaver activity is kept under control (water bodies where there are species-rich communities and high-value tree stands, or high recreational values) - beavers should be trapped to the level at which there is no significant damage to protected habitats (medium-size water courses, and outflows of drainage systems, forests), and

3) water bodies, where the occurrence of beavers is not allowed (where the beaver activity causes great economic loss or undesirable effects on environment and key habitats) – all beavers must be trapped.

In Estonia various methods for harvesting are permitted but killing traps is the most common. Shooting, sometimes after capture by dogs or net, is also used, and in addition bow and arrow. According to the Estonian Hunting Rules and the Hunting Act, beavers may be hunted: 1) from August 1 March 15, with hunting trap, scoop-net, or certain hunting dogs; 2) from October 1 to April 15 with all type of hunting dogs; 3) ambush and stalking hunt with certain dogs from August 1 to April 15. Hunting may be combined with removal of dams. The hunting bag size is not limited.
In the cases of beaver-damaged sites, beaver hunt is permitted the year around as ambush and stalking hunt with certain dogs, with the permission of the Environmental Board.

– Latvia

Guidelines for monitoring of beaver areas in the state forests are developed. Monitoring means annual survey of beaver sites dividing all beaver sites into 2 groups:
1) to be managed (preserved);
2) to be removed.

The Hunting Law determines the right to hunt and procedure to obtain this right as well as territories, where hunting is allowed, and prohibited means of hunting. The Hunting Regulations determine the special regulation of the management: open season, reporting to surveillance authorities, use of the traps. Several methods are permitted for harvesting: Sit-and-wait-shooting, killing traps and chasing by dogs. Hunters have to report the numbers of hunted beavers to the local authority of the State Forest

Service. Beavers can be hunted regardless of estate size. There are no restrictions in cull numbers, but there is a closed season from 16th April till 14th July.

Beaver is the most frequent animal taken by hunters in order to reduce economic damage. The government is not responsible for the damage done by the beavers because the landowners have sufficiently wide options to control their numbers.

The company "Latvia's State Forests" has an agreement system with the hunter clubs. The company maintains and renovates historical forest drainage systems as well as provides recreation and hunting services. Major part of the woodlands is leased for hunting to the local hunter clubs. If a renovated drainage system is present in a hunting ground, the hunters have to sign a written agreement about beaver management to prevent ditches from damming. Guidelines for monitoring of beaver areas in the state forests are developed. Monitoring means annual survey of beaver sites dividing all beaver sites into 2 groups: 1) to be managed (preserved); 2) to be removed.
Beaver numbers need to be balanced for both positive and negative effects on biodiversity and species protection (trout and pearl mussels vs carnivores).

– Lithuania

The Law of Hunting contains general regulations for control and use of game species. The Hunting Rules on the Territory of the Republic of Lithuania define the order of game hunting and determine the changes in hunting season for separate game species including beaver, hunting methods, hunting course, definition of beaver sites, etc. Permissible methods are hunting and trapping using admissible Conibear traps. The beaver hunting is limited by the hunting season only which continues from August 1 to April 15. The reported national hunting bag reaches today near 20 000 individuals. Other means of beaver management used are live-trapping and relocation, dam removal and habitat management by water level manipulation. Trained dogs are also used to drive out animals from burrows in combination with draining of beaver ponds.

A special post-legislative order approves the method of beaver population management depending on the damage caused by beaver to forests. By this order, the management of population is based on the determination of allowable and unallowable beaver sites. The latter dams have to be removed on the ground of the decision of Regional Environment Protection Department by application from foresters or other holders. The order also includes the way of compensation of damage caused by beaver to lands and hydro-technical facilities.

Allowable sites are important for the local biodiversity, causing no or negligible damage, are potential centres for beaver distribution, important to maintain the local beaver populations, and are key landscape components of woodlands or belong to protected areas. There are, as a rule, old sites, and occupy large extensive wetland areas. Annual harvest should not exceed 15–20 %, and still hunting (1st August–15th April) and trapping (1st August–15th April) are recommended.

Unallowable sites risk causing damage or conflict situations today or in the near future, contain low habitat and food supply for beavers. Such sites have to be removed on the ground of the decision of the Regional Environment Protection Department by application from foresters, forest owners, or other holders. Here it is recommended to hunt all beavers using the legal hunting methods during the whole hunting season. About 50 % of beaver sites in Lithuania are regarded economically problematic in agriculture and forestry.

Guidelines for monitoring beaver sites aim to inventory beaver sites on hunting ground and protected areas every year. Classification of beaver sites to allowable and unallowable is included into above-mentioned guidelines since 2003. Decision whether a beaver site is allowable or not is based on simplified questionnaire, which is applicable to a non-skilled person (mainly hunters). However, items on beaver effect to water quality are not included.

– Poland

The beaver is partly protected according to a special regulation "On the protection of species of animals". The possibility of hunting depends on the abundance of the local beaver population. Another Regulation defines the list of game species and determines hunting seasons for these species. Beaver hunting is forbidden according to this regulation. There is also considerable protection in the Act of Nature Protection against a number of disturbance factors for beaver.

Hunting is only allowed depending on the damage caused to landowners and forest owners/holders. The procedure for obtaining a shooting permission includes an application filed by the land owner to the Regional Directorate for Environmental Protection. The Regional Director for Environmental Protection may authorize the shooting of individual animals, the transfer to another site, or the destruction of dams and burrows, unless alternative solutions are available. Shooting is performed by hunters from the Polish Hunting Association. Live-trapping and displacement of beavers is made from areas where they cause damage. Permission to use live traps can be issued when all other possibilities have been exhausted. Branches of the regional directorate for environmental protection keep statistics on beaver hunting and trapping. The Act on Destruction of Beaver dams determines the possibility of destruction of beaver dams. A permission from the Regional Director or the General Director for Environmental Protection is necessary also for such an action.

Landowners may claim compensation for beaver damage. Payments are around 4 M€ annually (2016).

To avoid damage such as flooding of land, digging leading to destruction of dykes etc., cutting of valuable trees, and feeding on crops, various protective measures are used. In some cases, though, fields are instead dedicated to the beavers.

– Conclusions

Beaver is increasingly seen as a problem species, except in Sweden, Finland and Poland where problems are only local. Estonia has a specific population target. In Estonia regions with differing management rules are designated, and in Lithuania dams are judged "allowable" or" unallowable". In Finland and Russia, the situation is more complicated with two species occurring which in Finland has led to species differentiation in hunting policies. In Poland, the EU Habitat Directive exemption for beaver, valid in the other EU countries in the Baltic region, still is in place. Therefore, beaver has another status considering species protection in Poland.

The use of technical devices to protect against the beavers' damming and tree felling is not commonly used in the Baltic Sea Region country, with some exception for Poland, and the city of Riga.

This section has been compiled using information in the Beaver handbook, Chapters 3, 6 & 9.

Appendix 1 - Beaver dam tool

Beaver dam tool (sin. beaver site tool, beaver wetland tool) aims to classify beaver sites to allowable and to unallowable. Saving the labour resources, classification of beaver sites using beaver dam tool is possible along with monitoring of beaver sites; however, involvement of more skilled experts into classification process is highly recommended. Allowable beaver sites:

- causing no damage or damage is minimal/easily managed,
- are important for local biodiversity,
- positively influence local hydrological conditions (retain surface runoff water, influence formation of swamps, fens and bogs), (most important from the WAMBAF perspective),
- are potential centres of beaver spread, i.e., important to maintain local beaver populations,
- are expressive elements of natural landscape, or key landscape elements in the woodland key habitats,
- are parts of a protected area (strict nature reserve, reserve, etc.) and beaver impact has no negative consequences to the Red List species,
- usually are old ones and occupy large extensive wetland areas (most important from the WAMBAF perspective).

Unallowable beaver sites:

- are those causing damage or high probability of a conflict situation exists in present or in the nearest future,
- containing low habitat supply for beavers (food, protection, space, etc.), usually are the newly established ones in the damage-sensitive or limited habitat supply.

From the WAMBAF project perspective, the focus on water quality and its influence to forest hydrological conditions prevail during classification of beaver sites. Usually the most hydrologically and ecologically positive beaver impacts appear after long habituation of beavers with consequent formation of so called „beaver wetlands“. Thus, many of old and extensive beaver wetlands should be regarded as allowable beaver sites (Table 1).

Table 1. Interference matrix between beaver activities in new and old beaver sites, WAMBAF preferences, habitat diversity and biodiversity using expert evaluation scores (-1 – negative, 0 – indifferent, 1 – positive impact) in the forest streams

Beaver activities	WAMBAF aspects					Formation of wetlands	Habitat diversity	Biodiversity	Total score
	Drainage function	Water quality SS,N,P	Methyl-Hg	Buffer zones	Riparian forest				
New beaver sites									
Damming	-1	1	-1	-1	-1	1	1	-1	-2
Burrowing	-1	-1	-1	-1	0	1	1	1	-1
Cutting	0	0	0	-1	-1	1	1	1	1

Total score - new	-2	0	-2	-3	-2	3	3	1	-2
Old beaver sites									
Damming	-1	1	1	1	-1	1	1	1	4
Burrowing	-1	0	0	0	0	1	1	1	2
Cutting	0	0	0	1	-1	1	1	1	3
Total score - old	-2	1	1	2	-2	3	3	3	9

Appendix 2 – Legislation and regulation concerning management of beaver and beaver dams

Country	Laws, Decrees and Acts	Rules and Regulations	Instructions, Orders, Lists etc
Sweden	Game Act: 1987 (1987:259), latest update 2014 (SFS 2014:698)	Game Regulation (1987 (1987:905), latest update SFS 2016:125). Species Protection Regulation (2007 (2007: 845), latest update 2014 (SFS 2014:1240))	The Swedish Environmental Protection Boards' instructions and General advice on hunting and the State's Game (2002 (NFS 2002:18), latest update 2013 (NFS 2013:14))
Finland	Hunting Decree 666/1993 (updated 11.4.2013)		Forestry environment guide [Metsähallituksen ympäristöopas, 2011]
Estonia	Hunting act, 01.03.2016		List of game monitoring data and regulation for data collection, and authorised institution for monitoring arrangement, 16.01.2016 The Action Plan for Protection and Use of Beaver
Latvia	Hunting Law (updated 02.12.2015)	Hunting Regulations (Regulations by the Cabinet of Ministers No. 421 - updated 22.07.2014)	
Lithuania	The Law of Hunting (No. IX-966; 20.06.2002; updated XII-372 18.06.2013)	The Hunting Rules on the Territory of the Republic of Lithuania (No. 258, 27.06.2000, updated 2011.11.12, No. 135-6429, 2015, 2014, 2013, 2016)	Order "Concerning change in the Order of LR Minister of Environment of 29 May 2003 No.265 "Beaver Population Regulation, No D1-378 11.05.2010
Russia		Hunting Regulations in Russian Federation (2010; updated 04.09.2014 No 383; 2016)	Order on approval of norms of permissible use of game resources and norms of their

			permissible numbers (No. 138 of 30.04.2010)
Poland	The Act on Destruction of beaver dams	Regulation of 6 October 2014 “On the protection of species of animals (Dz. U. No. Pos. 1348)” Regulation of The Minister of Environment of 10.04.2001	