Beaver Population Management in the Baltic Sea Region - A Review of Current Knowledge, Methods and Areas for Development

1. Introduction

This document was prepared by members of the WAMBAF WP2 project to provide a summary of knowledge and methodology within the field of beaver damage management. It includes an analysis of the areas that still require development in the Baltic Sea Region. The review examines the advantages and disadvantages of actively managing beavers and their dams from the perspective of European (EU Water Framework Directive) and national legislation related to wildlife and its management. The demands and requirements of conservation regulations are also considered. The WAMBAF project joins together partners from Finland, Sweden, Poland, Latvia and Lithuania, along with associated organisations from Estonia and Russia.

Forests, which cover nearly 48 percent of the Baltic Sea Region (BSR), have a high ecological, economic and social value for countries in the region. Rivers and streams transport both nutrients and hazardous substances from forests to regional and coastal waters, resulting in eutrophication and pollution. Therefore, the management of riparian forests, maintenance of forest drainage systems, and distribution of beaver dams significantly impact water quality through controlling not only the flow of nutrients, but also hazardous substances (such as methyl mercury), which may be highly toxic and can adversely impact the biodiversity of water bodies and riparian forest ecosystems.

WAMBAF aims to find solutions that will counteract the negative effects of forestry activities on water quality. This project put special emphasis to water clarity (i.e. a physical characteristic of water defined by how clear or transparent water is), along with the export of nutrients and hazardous substances (e.g. mercury/methyl mercury). WAMBAF intends to promote the sustainable use of forest resources to those working within forestry and beaver damage management by providing knowledge, guidelines, methods and tools that will help minimise the leaching of nutrients and hazardous substances into coastal waters.

Beaver population densities, especially in the south-eastern BSR countries, have reached levels that cause substantial damage to forestry. Furthermore, a lack of knowledge, guidelines and tools severely limits assessments of which types of beaver dams are most effective at hindering or reducing the release of nutrients and hazardous substances to watercourses. It is also unclear which organizational structures and incentives would be ideal for the sustainable management of beaver distribution.

One of the main activities in the WAMBAF WP2 is the review of existing knowledge and methodology on beaver management and identification of needs for development. The WAMBAF WP2 has performed a review of the existing knowledge and methodologies to determine how beavers are currently being managed and to identify areas that require further development.

This review analysed the

a) existing scientific knowledge on how beaver damage and its management affects the leaching of nutrients and hazardous substances

b) knowledge regarding how efficient beaver dams are at controlling runoff water quality

c) current tools used for decision making on the potential destruction of beaver dams

d) current legislation (including environmental and nature conservation), regulations and guidelines on decisions concerning beaver dams, recreational services such as wildlife tourism and the sustainable use, further processing and marketing of beaver products (i.e. non-wood forest product of animal origin such as beaver meat, pelt and *castoreum*, an exudate from beaver castor sac, which is used in the perfume and food industries.

2. Definition of key terms

Beaver: the Eurasian Beaver (*idem* European beaver) (*Castor fiber* Linnaeus, 1758) (Fig. 1), 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.

North American beavers were introduced to eastern Finland in 1937 and have since then spread throughout the country and into Karelia in Russia. There were solitary instances of its introduction to reserves or zoos in Poland in the 1930s, in Austria between 1976-1990, and Germany and France in 1975.

Despite the similarity in appearance and behaviour of Eurasian and North American, they do not interbreed due to differences in the number of chromosomes (2N= 40 and 48, respectively) (Djoshkin, Safonov, 1972, Nolet, Rossel, 1998, Nummi, 2010). Beavers are a semi-aquatic species, and spend their life not only on land, but also in water. Beavers are true herbivores, feeding solely on plant foods (twigs, bark and leaves of trees, as well as stems and leaves of aquatic plants) (IUCN, 2016).

Fig. 1. The Eurasian Beaver *Castor fiber* L. (*Lithuania, © Romualdas Barauskas, NaturePhoto)*

Beaver dam: a structure that is built by beavers to protect against predators and that, by stabilising the water level of a pond, provides easy access to food during winter months (Fig. 2).

A minimum water level of 0.6 to 0.9 metres is required to keep the entrance to beaver lodges underwater. Beavers may not build dams, but instead live in bank burrows and lodges when lakes, rivers and large steams have sufficient water depth to provide access to food (Fig. 3 and 4).

Beavers start construction by diverting the stream to reduce the pressure of water flow. Branches and logs are then driven into the mud of the stream shore to form a base, followed by sticks, bark (from deciduous trees), rocks, mud, grass, leaves, plants, and anything else available, which are used to build the superstructure.

The average height of a dam is 1.8 metres, with an average water depth of 1.2 to 1.8 metres under the dam.' (Pollock et al. 2003; Burchsted and Daniels, 2014; Virbickas et al. 2015). The dam is often one metre or more thick. The length depends on the stream width, but averages about 4.5 m long.

The type of dam and how it is built varies depending on the speed and width of running water. These dam structures significantly modify the water environment and affect the structure and functioning of an ecosystem, which makes beavers a keystone species (see below).

Beavers are active mainly at night and are prolific builders, carrying mud and stones with their fore-paws and timber between their teeth. Beavers can rebuild primary dams overnight, but may not defend secondary dams as vigorously. The maintenance of dams and lodges is primarily performed in the autumn.

Fig. 2. A beaver dam in a drainage ditch (*Latvia, © Jānis Ozoliņš)*

Fig. 3. A beaver lodge in a deep section of a forest pond (*Lithuania, ©Olgirda Belova)*

Fig. 4. A drainage ditch inhabited by beavers (*Lithuania, ©Olgirda Belova*)

Beaver site: an area occupied by beavers (single, couple or family) that covers any part of the water body and adjacent land with signs of beaver activity (dams, ponds, paths, cuttings, etc.) (Figs. 5 and 6).

Beaver sites can be considered as either perspective (acceptable) or non-perspective (non-acceptable) based on the balance between their positive and negative environmental contributions. Negative contributions include damage caused to the forest and a significant risk of leakage of hazardous substances, among others. Positive contributions include decreased runoff velocity, an increase in water carrying capacity, the addition of wet areas to the forest landscape and an increase in biodiversity.

Perspective beaver sites are often old-aged and can be important for the local and landscape biodiversity. They can also serve as potential centres for beaver distribution. Non-perspective beaver sites, on the other hand, are usually newly established in habitats sensitive to damage (e.g. spruce stands, vicinity of roads) or if there is a high risk of damage, which leads beaver-human conflicts. Moreover, these sites are limited in access to food, water, and space.

Fig. 5. A forest affected by beaver dams, Brattfors, Umeå (*Sweden, © Göran Sjöberg)*

Fig. 6. The arterial path of a beaver (*Lithuania, © Olgirda Belova)*

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 (Fig. 7).

Fig. 7. A forest road that has flooded due to a nearby beaver dam (*Lithuania, ©Olgirda Belova)*

The flash flood that results from a beaver dam bursting can overwhelm culverts. Part of the problem with beaver damage is related to time and perception. The undermining of a roadway or the drowning of some trees becomes visible shortly after a beaver inhabits an area.

However, there are other effects that take longer to notice. For example, beavers cut down various species of trees for both food and the building of dams and lodges, which may influence the biodiversity of the area on the long-term time scale (Fig. 8).

Trees in the flooded area die due to a lack of oxygen in the standing water.

Fig. 8. Beaver-felled birches, Röjvattsbäcken, Bjurholm (Sweden, *© Göran Sjöberg*)

Beaver impoundment (= Beaver pond): a body of water that is created by impoundment structures (Fig. 9) such as dams, dikes, and levees.

Beaver dams interrupt the fluvial water flow. The impoundment is then colonised by animals and plants that typically live in lakes rather than streams. In this way, beaver ponds have a cumulative effect in slowing the water flow through a catchment. By damming a stream, beavers create a pond where they can escape predation by remaining underwater for at least 15 minutes; however, at the same time they flood the bushes and trees that serve as their primary food source.

Fig. 9. Beaver pond with an old beaver lodge, Röjvattsbäcken, Bjurholm, Sweden (Sweden, *© Göran Sjöberg*)

Ecosystem engineer: a species, or individual, which physically alters their surrounding habitat. Beavers are called "ecosystem engineers" because they physically alter habitats by cutting down trees, building dams, digging canals and building lodges. In doing so, beavers change not only the running water morphology, which includes water regime and nutrient flows, but also influence the distribution and abundance of many other animals and plants (Jones et al. 1994, Wright et al. 2002).

Keystone species: a species that has a disproportionately large effect on its environment relative to its abundance (Nuñez and Dimarco 2012, Cockman 2016). Beavers have been classified as “keystone species”. The effects are a result of the beavers’ building and damming activities as well as their foraging. Beavers have a profound effect on the aquatic, as well as terrestrial, species communities, and generally increase the biodiversity of both animals and plants (Rosell et al. 2005).

3. Beaver management and its role in the Baltic Sea Region - background, statistics and aims of beaver management, along with the current situation in different countries

The protection of the Baltic Sea (BS) catchment area is based on the protection of inland waters, as the majority of nitrogen and phosphorous reaches the BS via riverine outflow. In the whole catchment area of the BS, measures have been taken to reduce land-based pollution throughout the entire BS catchment area. Substance loads are strongly controlled by the biogeochemical processes of natural and managed ecosystems, which are, in turn, affected by the climate, land use and human management practices, as well as by the activities of semi-aquatic mammals such

as the Eurasian beaver (*Castor fiber* L.). In Finland and North-western Russia, the introduced North American beaver (*Castor canadensis* L.) dominates (Table 1, Fig. 10).

Table 1. Beaver (*Castor fiber* L.) abundance in WAMBAF countries (2012-2015, official statistics)

Country	Beaver number, n	Notes
Sweden	130 000	*estimation based on earlier surveys*
Finland	1 500 – 2 500	*plus 10 000 Castor canadensis* L.
Estonia	16 300 – 17 500	(*Halley et al. 2012)*
Latvia	100 000 – 150 000	
Lithuania	121 000	
Poland	100 000	*official statistics 2014*
NW Russia	120 500	including 15 000 *C. canadensis* in Karelia Rep. and Leningrad province*

* *Data on North American beaver (Danilov and Fyodorov pers. comm. 2016)*

The Eurasian beaver, once widely distributed in the BSR, has been affected by human activities for centuries. It is well-known that animals need spatially and temporally varying habitats that contain sufficient food supply and shelter. The beaver has recently made a remarkable recovery due to legal protection and targeted conservation measures, which include hunting restrictions, reintroductions and translocations, natural recolonization, land/water protection and habitat restoration.

However, the species is still under special protection across Europe according to a number of international legal acts, such as it is listed in the Annexes II and IVa as species of “Community interest” of the EC Habitat Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora) and in the Appendix III of the Bern Convention.

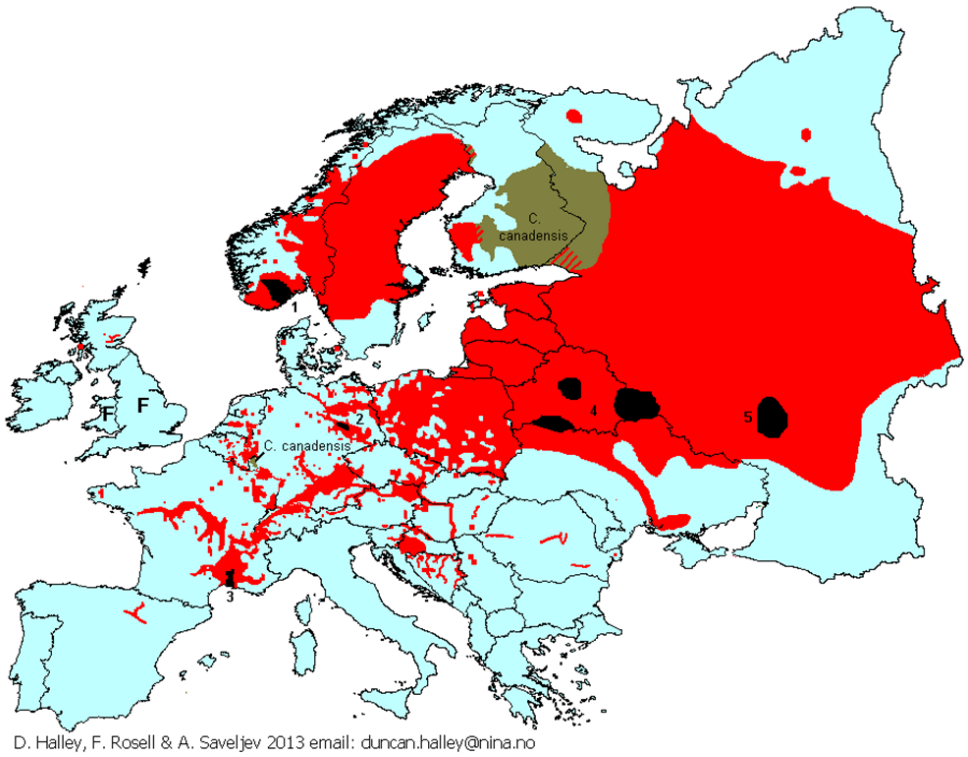

Fig. 10. Distribution of the Beaver species *Castor fiber* L. (red colour) and *Castor canadensis* L. (green colour) in Europe, 21st century (© Halley, D. - Halley *et al*. 2012)

Beaver harvesting is strictly controlled and, in general, limited in most BSR countries. Some countries have derogations from the strict beaver protection established in the Directive. Currently, beavers can be hunted and/or trapped as a game species throughout much of Eurasia, including the EU member states Sweden, Finland, Latvia, Lithuania and Estonia, which are listed in Annex V of the Directive (Table 2).

Table 2. Beaver harvesting in the BSR countries

Country	Beaver hunting bag, ind.**			Hunting season, dates	Additional comments***
	2015	2014	2013		
Sweden	12 928	8 448	8 210	01/10 – 10/05 (S) or 15/05 (N)	Viltdata.se
Finland	235 5 300	191 6 700	231 4 200	20/08 – 30/04 20/08 - 30/04	*data on C. fiber* *data on C. canadensis;*
Estonia	6 557	5 572	5 700	x/ – 15/04	
Latvia	24 248	31 376	24 711	15/07 – 15/04	
Lithuania	19 544	21 749	11 778	15/08 -15/04	
Poland*	*133/22%*	*93/24%*	*38/15%*	01/10 – 15/03	
Republic of Karelia, Russia	238	165	150	01/10 -28-29/02	

* *Note*: according to the EU legal acts, partially protected species can only be hunted in very specific cases and if there are no alternative methods; example from Podlaskie province (Northwestern region): *harvested/% of the given permits*

*** ind. –individuals (abbreviation)*

*** Sources: Forest Statistics Yearbooks and Hunting statistics available on the websites of the WAMBAF countries and via personal communications; Finnish data: personal communication (Dr. Sauli Härkönen, *Suomen riistakeskus*) and Hunting statistics available at the web site; Karelian data: personal communications (Dr. Fyodor Fyodorov and Dr. Alexander Saveljev) and Hunting Rules of the Russian Federation.

Beaver management is non-intensive in WAMBAF countries. For example, in Sweden, the harvest is less than the growth in population. Most studies of beaver impacts on watersheds focus on the relationship between beavers and other components of the forest and water biota. Moreover, in the context of ecosystem functioning and services, there are multiple benefits from beaver activities (e.g. recharging of drinking water aquifers, increase in the food supply for fish and other animals, increase in the salmon population, support of biodiversity, including diversity of threatened species, maintaining the flow of watersheds, repair of incised and damaged stream channels and watersheds, preservation of open space, decrease in soil erosion, removal of pollutants from surface and ground water).

It is important to consider the differences in beaver management between BSR countries as well as the goals that WAMBAF has set regarding beaver dam management when decisions about local beaver populations are made. The dual role of beaver dams, harming forestry but controlling the drainage system in Baltic forests, makes finding an optimal situation challenging.

4. Beaver damage management and water protection - how beavers impact waters and water protection methods and their efficiency

Certain landowners and forest managers consider beavers to be a problematic species since they cause damage to forests and adjacent agricultural lands. Their building of dams, digging of channels and felling of trees can result in the flooding of large areas. This significantly alters the characteristics and appearance of water bodies and modifies species composition. In constructing their own home, the beaver significantly affects the welfare of other plants and animals.

The beaver is classified as a keystone species because it enhances habitats, reduces down-stream flooding and silting runoff, and pollution in the major water courses. A proper trade-off between the advantages and disadvantages of beavers precedes the sustainable management of beaver populations and a reliable assessment of the environmental effects of their activities. It is necessary to consider local habitat conditions and landscapes.

As beaver ponds significantly alter habitats, it is important to include topo-hydrological and soil parameters in evaluations of how beavers affect the environment. The BSR countries currently differ in regards to knowledge of how water quality (including nutrient composition) changes in the upper and lower zones of ponded water bodies, as well as how beaver ponds influence downstream nutrient compositions.

The management of beaver populations and their damage has multiple aims

- to provide a sustainable beaver population for both hunting and human recreation in areas where it is acceptable
- to utilise the beavers' ecosystem services to improve biodiversity and water management
- to decrease the level of damage that beavers' engineering and foraging activities cause to forests
- to manage water quality in terms of nutrients and hazardous substances

The management includes three basic and inseparable approaches:

a) Quantitative (control via hunting)

b) Qualitative (control of population sex and age structure)

c) Territorial (habitat) management.

The management strategy incorporates both technical assistance and direct control via physical exclusion, habitat management by water level manipulation, and population management through regulated hunting/trapping. The beaver hunting is non-intensive in WAMBAF countries.

However, non-intensive management may result in compensatory reproduction and further population growth. Therefore, the specific peculiarities of beaver behaviour and ecology should be considered, e.g. slow 3-year rotation or a lack of suitable habitats, in management plans. Usually, a beaver family consists of a pair of adults-parents and one or two generations of offspring. Young beavers do not breed even if they are able to. Only the dominant pair mates, and produces one litter per year. In the late spring, two-year-old juveniles will leave the family (such dispersal allows the family to avoid increased food and inbreeding pressure) and start breeding during the next year; this comprises the 3-year rotation cycle mentioned above.

The prohibition or strong limitation of beaver hunting will not necessarily allow local populations to achieve an optimal structure and permissible abundance.

The protection of roads, as well as man-made dams, levees, ditches and drainage systems conferred by strict beaver management would improve human health and safety. On the other hand, the associated benefits of watershed restoration, having the beaver as a game species, and the potential for nature tourism would likely outweigh the costs of beaver-related damage. However, potential conflicts will have to be managed in some countries to allow for the well-functioning coexistence and mutual beneficence of beaver and man.

5. Planning and demonstration of beaver damage management in forest water bodies - description of the tools and demonstration sites

Practises and regulations for beaver management in the context of water protection in forests have been developed and implemented independently in the different BSR countries, resulting in different solutions for cost-effective management measures.

Demonstration areas and water protection planning tools serve to facilitate the management of beaver activities in forests. However, none of the tools available include the impacts of beaver activities on the loads of different elements on a catchment scale. The scale of the demonstration areas/tools range from stream to catchment in WAMBAF countries. The users of the tools and existing demonstration areas include the public, foresters and hunters, scientists and students of 3 main levels (BSc, MSc and PhD).

An analysis of the existing knowledge, tools and demonstration areas relating to beaver issues shows that the benefits from beavers are not used sufficiently for recreational and educational means, such as hunting/trapping, the use of beaver products, wildlife observation, relaxation in nature, and fishing, in the BSR countries. There is a clear need for an integrated approach towards beaver population management that will include quantitative, qualitative and territorial methods.

6. Legislation, certification and guidelines for beaver management and water protection - an overview of the current situation in different countries

The BSR countries, with the exception of Russia, are members of the EU and have, in this way, adopted common legislation, such as the Water Framework Directive (2000/60/EC), the directive of Environmental Quality Standards (2008/105/EC), EC Habitat Directive (Council Directive 92/43/EEC) and Bern Convention, into their national legislation. However, the BSR countries have different goals when it comes to game management.

An analysis of legislation and guidelines shows that selective removal of beaver dams (with the simultaneous cleaning of drainage ditches) could help the sustainable management of the beaver population and reduce damage caused to forests. It should be noted that the removal of dams does not prevent beavers from repeatedly inhabiting the area.

Special guidelines for beaver management and monitoring have been adopted in some WAMBAF countries (Lithuania, Sweden, Poland, and Estonia); however, neither guidelines nor scientific publications sufficiently discuss how beavers impact water quality. Moreover, only a few studies have investigated how beaver activities in forests affect the loads of hazardous substances in water. This question is still open and will require clarification as well as knowledge sharing between the WAMBAF countries.

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