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

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Abstract

Forests are closely connected with the hydrological network that serves large ground- and surface waterbodies in the Baltic Sea (BS) catchment area. Protection of the Baltic Sea catchment relies on the protection of inland waters because the majority of nitrogen (N) and phosphorous (P) in the Baltic Sea comes via riverine outflow. The loads of substances are strongly controlled by biogeochemical processes, which, in turn, are affected not only by climate and human management practice but also by activities of semi-aquatic mammals such as the Eurasian beaver (*Castor fiber* L.). The Eurasian beaver was exterminated in vast areas of the Baltic Sea Region (BSR) during the 19th century. Beaver population densities, especially in the south-eastern BSR countries, have reached levels that cause substantial damage to forestry. 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). The recent increase in beaver range and population size in the Baltic Sea Region (BSR) could be the potential to counteract ongoing eutrophication but might also pose challenges to freshwater ecosystems. From a management perspective, beavers have been classified as “keystone species”. The effects are a result of the beavers’ building and damming activities as well as

their foraging. 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. Data for this study were collected using a questionnaire sent to national beaver experts in the BSR countries: Sweden, Finland, Estonia, Latvia, Lithuania, Poland and North-western Russia in April-July 2016. 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, and 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.

In the context of water protection, the beaver damage management is reflected insufficiently in scientific publications of WAMBAF countries. Existing beaver tools and demonstration areas in BSR countries reveal beaver benefits insufficiently, through focusing on recreation and education purposes including wildlife observation, relaxation in nature, fishing and other recreational and educational activities in the forest. Most legal acts do not emphasize the beaver *per se* sufficiently, with the exception of hunting acts that determine the terms of beaver hunting. The most developed area is guidelines on beaver damage caused to forests and the monitoring of beaver ponds; however, the quantitative criteria of damage assessment are missing. There is a clear need for an integrated approach towards beaver population management that will include quantitative, qualitative and territorial methods.

Keywords: Beaver, WAMBAF, water, forest, chemistry, loads, environmental impact, damage, management

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1. INTRODUCTION

Beaver status in Baltic Sea Region countries and water protection

One third of the European territory is covered by forests (210 million ha) (EEA 2015). Forests are closely connected to the hydrological networks that serve large ground- and surface waterbodies in the Baltic Sea (BS) catchment area (1 720 270 km^2) (HELCOM 2004, GIWA 2005, EEA 2008) (Figure 1). The BS catchment area is almost four times larger than the BS itself. It is characterized by low water exchange rate (retention time of 30 years); therefore, the Baltic Sea is highly vulnerable to human impact. Protection of the BS catchment is based on the protection of inland waters as the majority of nitrogen (N) and phosphorus (P) in the Baltic Sea comes via riverine outflow. In the whole catchment area of the BS, measures are taken to reduce land-based pollution. These activities are largely linked with the implementation of the European Union (EU) Directives

(e.g. the Water Framework Directive, the Urban Waste Water Treatment Directive, and the Nitrate Directive) or with realization of obligations arising from the Helsinki Commission (HELCOM) declarations.

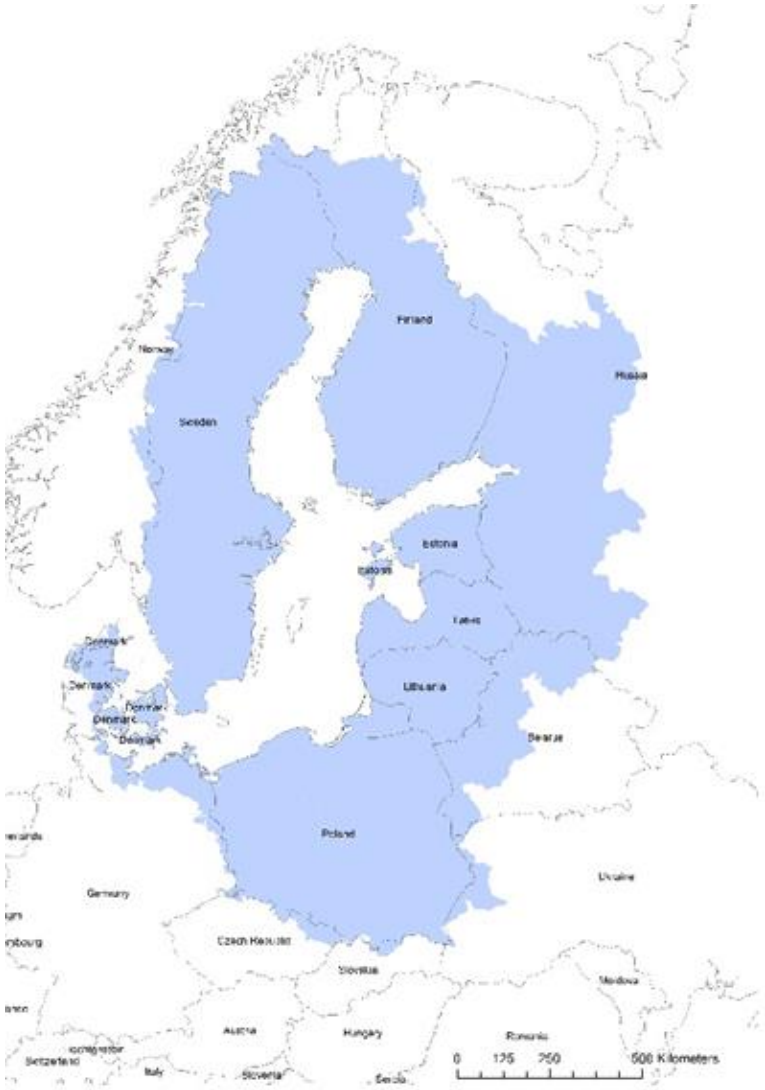


Figure 1. Map and countries of the Baltic Sea catchment (HELCOM)

External nutrient loading comes from the catchment area around the sea and from wet deposition. The main loads from forests, as nitrogen (N) and phosphorus (P) compounds, have been considered to be of particular importance as their excess causes water quality deterioration and adverse changes in marine ecosystem functioning. The background load from forest areas is

estimated to be 19% for total N and 16% for total P of the total load to the BS (HELCOM 2011). Loads of substances are strongly controlled by biogeochemical processes in natural and managed ecosystems. These loads, in turn, are affected not only by climate, land use and human management practices but also by activities of semi-aquatic mammals such as the Eurasian beaver (*Castor fiber* L.). The Eurasian beaver was exterminated in vast areas of the BSR during the 19th century. Beavers had extensive distribution in the northern hemisphere until the early 1800s, after which intensive hunting reduced both their range-size and population densities. It has subsequently recovered over much of its former range. In Finland, however, the North American beaver (*Castor canadensis* Kuhl.) was introduced in 1937, from where it dispersed to the Republic of Karelia and Leningrad Region (northwest Russia) (Figure 2). *C. canadensis* population in northwest Russia is today regarded as stable.

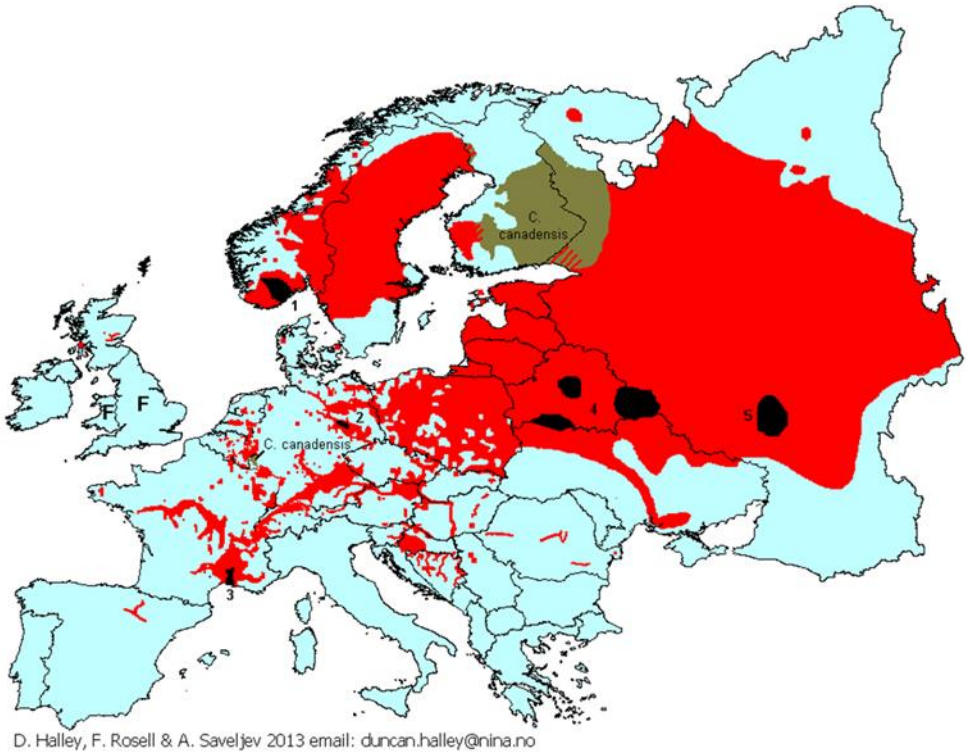


Figure 2. Distribution of the Beaver Species *Castor fiber* L. (**red** colour) and *Castor canadensis* Kuhl. (**green** colour) in Europe, 21stc. (© Halley, R. - Halley *et al*. 2012)

It is well-known that animals need spatially and temporally varying habitats that contain sufficient food supply and shelter. The Eurasian beaver, once widely distributed in the BSR, has

been affected by human activities for centuries. Humans have adapted the environment for their needs from prehistoric times. Beaver populations are impacted directly by hunting/trapping, and also indirectly through forestry activities. Forest logging changes drainage patterns and reduce the carrying capacity of once stable stream systems. Silvicultural practices that eliminate or shorten the deciduous shrub and tree stage of the forest regeneration cycle also have negative impacts on beaver populations. Continuing human-induced landscape transformation results in habitat loss, increased isolation between landscape fragments and new disturbance types that challenge beaver populations. 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. The long-established reintroduction of the Eurasian beaver has given rise to widespread and serious concerns due to increase in conflicts between the species and landholders and landowners in WAMBAF countries. In Europe, the Eurasian beaver is most abundant. Conservation measures are ongoing to prevent the population declining again, and the species is now in the category of Least Concern (IUNC 2016). In 2006 the minimum estimate of beaver population in Europe was 639 000. In Lithuania alone, the minimum number of beavers is estimated to be 85 879 and the maximum is 121 025 individuals (Ulevičius 2008; Kesminas *et al*. 2013) at the more than 48 000 estimated beaver sites. Beaver numbers continue to increase in Latvia (Busher, Dzięciolowski 2012; Halley *et al*. 2012), Estonia, Finland, Sweden (Halley *et al*. 2012), Poland (Miller 2005, Borowski 2013) and in the North Western Federal District of Russia (Halley *et al*. 2012) (Table 1).

Table 1. Beaver (*Castor fiber* L.) abundance in WAMBAF countries

Country	Beaver number, n	Notes
Sweden	130 000	
Finland	1 500 – 2 500	+ 10 000 *Castor canadensis* Kuhl.
Estonia	16 300 – 17 500	
Latvia	100 000 – 150 000	71 400 by official statistics
Lithuania	85 879 - 121 000*	
Poland	100 000	Statistical yearbook of the Republic of Poland, 2014
NW Russia	120 500	including 15 000 *C. canadensis* in Karelia Isthmus & Leningrad province**

* Minimum and maximum estimates by expert evaluation (*Kesminas et al. 2013; Ulevičius 2008; Kesminas, Verbickas 2000);* ** Data on North American beaver (Danilov and Fyodorov 2016, person. Comm.)

The partial protection of species e.g. in Poland (Polish Minister of the Environment 2011) contributed to the rapid population growth and further spreading to new areas, including ones close to human settlements, where they are likely to get exposed to anthropogenic pollutants (Flis 2013; ClientEarth 2016).

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. 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).

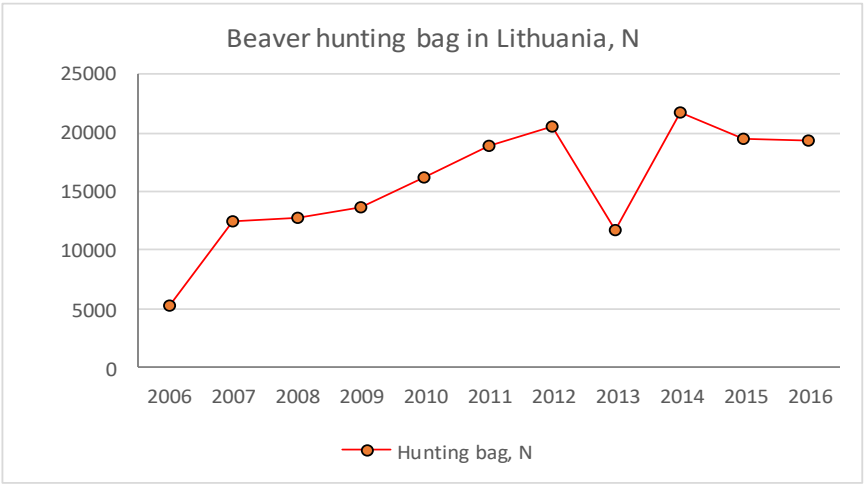
Table 2. Beaver harvesting (N of harvested beavers, animals) in the BSR countries

Country	Beaver hunting bag, N of animals			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	191	231	20/08 – 30/04	data on *C. fiber*
	5 300	6 700	4 200	20/08 - 30/04	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	
Northwestern Russia (Karelia)	238	165	150	01/10 - 28-29/02	*(St. Petersburg is not available)*

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

** Sources: Forest Statistics Yearbooks and Hunting statistics available at the *www* of the WAMBAF countries and via personal communications; Finnish data: personal communications 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.

In Sweden, beaver hunting is permitted within the whole distribution area without bag limit; however, the harvest is less than the growth in population. In Finland, hunting of *C. canadensis* is allowed without bag limit, but for *C. fiber* the licences on hunting are needed indicating the number of individuals to be harvested. The hunting is allowed here depending on the abundance of the local population and damage caused by animals to forest and agricultural land. Most damage is caused by the alien species, North American beaver (*Castor canadensis* Kuhl.) (Härkönen 1999; Parker *et al*. 2012; Report T-PVS/Inf (2014) 17). It was discovered that these two beaver species differ in the chromosome numbers (*C. fiber* = 48 and *C. canadensis* = 40), and negligibly in morphological features. The reproduction in *C. canadensis* is more effective than in *C. fiber* (the litter size 4.5 and only 2.5, respectively) (Nummi 2010; Parker *et al*. 2012; Vehkaoja *et al*. 2013, Vehkaoja 2014, 2016a, b). Since *C. canadensis* is the most numerous species in Finland, forest damage is mainly done by this species. In Estonia, Lithuania and Latvia, beaver hunting bag is not limited. The hunting is limited only by hunting season. In Russia, beaver harvesting is limited to two animals per hunter within one season and to one individual per day (Hunting Rules of the Russian Federation 2016). In Poland, the beaver is considered a partly protected species, and their hunting is allowed depending on the damage caused to landowners and forest owners/holders. An example of beaver quantitative management, Figure 3 is presented below.



a

b

Figure 3. Changes in beaver (*Castor fiber* L.) hunting bag: case studies in Lithuania (a) and Estonia (b) (*source: data of the national official statistics*)

Beavers as a keystone species in the forest ecosystem

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. Further, damming and digging by beavers contributes to streams recovering to their natural meandering state. Illuminated and warmed shallow water in the water bodies creates fertile conditions for the development of wetland communities with reeds. The increase in the water temperature and in the content of nitrogen and phosphorus compounds causes the development of phyto- and zooplankton (Call 1966; Nummi 1989; Hartun 1999, 2000; Lamsodis 2001; Valachovič 2000; Gorshkov 2004, 2007; Laanetu *et al*. 2011; Lamsodis and Ulevičius 2012a, b; Janiszewski *et al*. 2014; Lönnqvist 2014; other). The role of allochthonous inputs as a resource for aquatic biota is generally recognized. Vegetation decomposition results in a release of nutrients that form the base for a food web consisting of detritivores, such as chironomids and isopods (McDowell and Naiman 1986; Nummi 1989). Their increase is mediated further up in the trophic chain, and many vertebrate species including amphibians, fish, birds and mammals can benefit from this increase (Hägglund and Sjöberg 1999; Pollock et al 2003; Rosell *et al*. 2005; Nummi *et al*. 2011; Samas and Ulevičius 2015;

Glabischniget 2015; Virbickas et al. 2015; Vehkaoja 2014, 2016a, b; Malison et al. 2016; others). At once, it is important to consider that beaver presence is beneficial for e.g. salmonids in small incised streams (Pollock et al., 2012), while beaver dams may limit the total amount of floodplain habitat available for salmon rearing and could be detrimental to salmon populations in large alluvial rivers, e.g. in Kamchatka and USA (Malison et al. 2016). The higher variability in water depth, channel width, and temperature from dam-building activities, all indicators of the increased habitat complexity. This complexity provides fish a greater selection of locations at which to forage, rest, and avoid predation and high flow events, while reducing migration distances required to conduct these activities for multiple life-stages and positive responses of fish populations (Bouwes et al. 2016). The impacts of beavers need, however, to be assessed in a catchment and landscape context. While the effect of beavers on biodiversity is most likely beneficial in catchments poor in lake-like (lentic; standing water) systems, damming of stream-like (lotic; running water) sections by beavers might have a negative impact in catchments that are already rich in lentic systems. The high number of aquatic invertebrates in beaver flowages are attractive to rare and endangered species as insectivorous bats (Nummi *et al*. 2011). 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. Coppicing bank side vegetation by beavers could be considered as cost effective and sustainable (BACE 2016). Their activity increases the biodiversity value of wetlands by increasing the diversity and richness of communities of plants, insects, fish, amphibians, birds and mammals (Lunkas 2013; Lönnqvist 2014; Pollock *et al*. 2015; BACE 2016). Beavers are not only important for forest and water ecosystems and biodiversity but also for humans. In countries with low drinking water levels (e.g. Poland), beavers enhance retention of water and its self-purification (ClientEarth 2016). Their role could be considered as some contribution towards Blue Growth (Banaszak 2015; EUSBSR 2015).

Beaver ponds accumulate large amount of sediments (Hammerson 1994; Gurnell 1998; Butler and Malanson 1995; John and Klein 2004; McCullough *et al*. 2004; Pollock *et al*. 2007, 2014; Rurek 2008; Green and Westbrook 2009; Lamsodis and Ulevičius 2012a, b; Kroes and Bason 2015; Stringer *et al*. 2015). Based on the decline in flow rate in the waterbody, drag and carrying energy of the flow decreases, and carried particles sink. Pond water, with a significantly reduced number of suspended solids and sediments, flows over the dam wall. According to Valachovič (2000),

plants, growing on the bottom and shores may filter captured suspended solids. Over time, the communities of anaerobic organisms formed on the bottom mineralize organic matter. Beaver ponds also capture parts of stems, branches, foliage, as well as anthropogenic waste. The water is enriched with nutrients from trees and shrubs dragged to the pond, as well as beaver excretions and the remains of feeding stores. As examples from studies in the Danube River catchment show, an adult beaver removes sediment from water, in an amount up to 700 kg per year (Valachovič 2000). During spring floods, the total volume of sediments could comprise near 800 tonnes per hectare accumulating 90% of sediments (e.g. Gorshkov 2004, 2011). These sediments can reach the depth of up to 2 m (Call 1966). There are some data in USA that show that beaver ponds could act as a sink for nitrogen, phosphorous, and carbon, as they retain and recycle greater concentrations of nutrients compared to the rest of the stream; however, the ponds do not appear to have downstream effects (Gibbs 2015). Depending on the age of the beaver pond, its ecological maturity, ditch morphology, and other factors related to the maintenance of drainage system properties, the pond can act as both a net sink for soil and woody debris and a source of elements that are transported downstream (Naiman *et al*. 1994; Como and Deegan 2015). It was recognized that beaver could be considered bioindicators of environmental pollution (Porochov 2005; Giżejewska 2015; Peterson and Schulte 2016). Beaver ponds are used for assessing environmental status and biogeographic changes in the environment, and ponds could act as water cleaning plants (Beaver Ponds 2015). The chemical composition of water accumulated in a beaver reservoir changes, increasing the nitrogen content, and nitrogen, phosphorus and carbcompounds are accumulated in anaerobic sediments. Heavy metals are removed and pollution of inflowing acids and bases is neutralized and stored in the bottom due to activities of microorganisms. In the beaver ponds, the hydrochemical conditions directly affect the accumulation of radionuclides, mainly in algae (Porochov 2006). Beavers create large volumes of deadwood and promote restoration in wetlands and riparian forests; moreover, coarse and fine woody debris is positive for deadwood-dependent species (Thompson *et al*. 2016). Beaver activity causes constant mixing of water and speeds up chemical processes and also changes the physical, and biological conditions in the surrounding terrestrial catchment (Valachovič 2000; Hartun 1999, 2000; Brykala *et al*. 2016). Some findings show that the differences in water velocity upstream and downstream of the man-made and the natural beaver dams are insignificant (Silliman 2007; Błędzki *et al*. 2011). Acidic waters in the coniferous sites may have stimulated more MeHg

production to downstream water bodies than in mixed woodland regions (Roy *et al*. 2009), while pH is of minor importance for methylation in Swedish systems (Levanoni *et al*. 2015, 2016). Due to the damming, changes occur in the soil and released nutrients are transported to the water bodies but further effect depends on the soil types (Naiman *et al*. 1988; Vehkaoja *et al*. 2015). It is important to consider soil conditions in beaver impact on forest water as in the absence of a clay layer, a beaver dam causes nearly 70% increase in groundwater discharge from the wetland pond (Feiner and Lowry 2015). Due to water accumulation in beaver ponds, the level of groundwater of surrounding land locally rises, which changes chemical composition and moisture of soil and species composition of soil fauna (Valachovič 2000). In Finland, the total damaged area reached 263 km^2 during 2004-2008 (Korhonen *et al*. 2013) but on average, damages occur locally and on small area, e.g. 2.2 ha (Härkönen 1999). It is question whether a) beaver dams affect water quality by acting as trickle barriers accumulating nutrients and hazardous substances; and b) accumulated bottom sediment behind the dams degrade downstream water quality. However, it is necessary to consider the state of beaver sites (inhabited or abandoned by beavers) as abandoned dams did not act as trickle filters (Como and Deegan 2015). Studying these factors would help to achieve sustainable management of beaver damage and properly assess their activities. It would be necessary to consider local habitat conditions, including topo-hydrological and soil parameters in beaver sites, which vary in the different countries 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 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 (i.e. number control via hunting) b) qualitative (i.e. sex and age control in the local populations considering species social structure as monogamic family and corresponding social and other behaviour) and c)

territorial (habitat) management (Belova 2006, 2008, 2012). The management strategy incorporates both technical assistance and direct control via physical exclusion, habitat management by water level manipulation, and population management through hunting/trapping. 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.

Before beginning any beaver control action, it should be assessed fairly and objectively whether beavers are really causing damage or creating hardship requiring control. The very presence of beavers might be regarded as a problem even though the beavers are causing no damage to forest. If damage is evident, prevention of damage or relocation of the animals is likely to be insufficient and removal of the dam might solve the problem (Boume 2001; Virchow *et al*. 2001; Belova 2012). However, removal of beaver dams stimulates the beavers' reconstructive (building) activity and animals re-build dams on the average within 24 hours (Belova 2012). Despite these activities, dam removal is widely used helping to protect forest and watersheds (as example Figure 4).

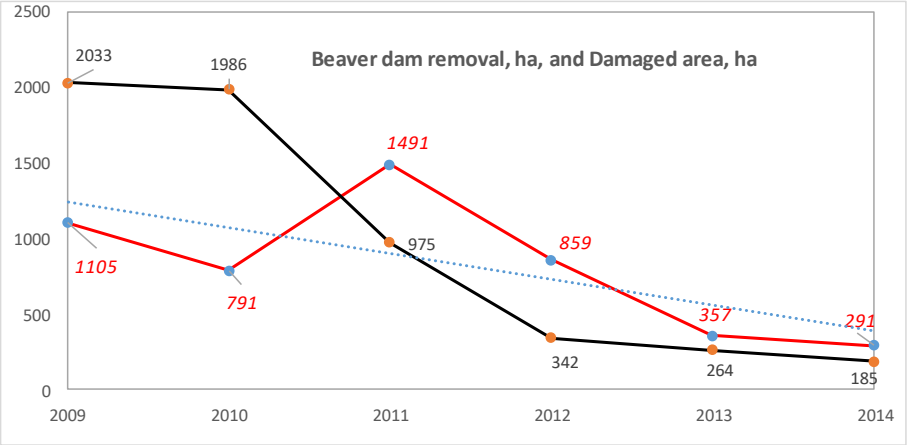


Figure 4. Example of the management of beaver dams: forest area of the removed non-perspective (red line; damage to forest) and remained perspective (black line; no damage/damage negligible) beaver dams, ha (blue dotted line is the trend of the damaged area) (*Source: Figure is based on the data obtained from the Department of Forest Sanitary Protection of the State Forest Service, Lithuania)*

The associated benefits of watershed restoration and potential for nature tourism may outweigh the cost of beaver-related damage under some conditions; however, potential conflict will have to be managed in some countries to allow for peaceful coexistence and mutual beneficence of beaver and man.

The aim of this study is to review and identify needs for the development of 1) existing scientific and other knowledge of the beaver effects on leaching of nutrients and hazardous

substances; 2) knowledge of the efficiency of current beaver management methods in controlling the runoff water quality; 3) existing tools used to plan water protection in beaver sites and 4) current legislation, regulations and guidelines regarding beaver management and water protection in different BSR countries.

2. MATERIAL AND METHODS

The review was performed in the BSR countries: Sweden, Finland, Estonia, Latvia, Lithuania, Poland and North-western Russia in April-July 2016. Data for the study were collected using questionnaires sent to national beaver experts. The information collected in the questionnaire is shown in the Attachment.

The studies on beaver damage caused to forest, forest protection against beaver, and species management issues were considered while other studies on beaver ecology, intraspecific and interspecific relationships, and behavioural features were not included when the effects of water protection methods were missing.

3. RESULTS

3.1. Scientific knowledge on beaver management and water protection

3.1.1. Overview of the number and type of studies in different countries

In the WAMBAF countries, most studies on beaver management and the impact of their dams on leaching of nutrients and hazardous substances, as well as knowledge of the efficiency of beaver dams in controlling the runoff water quality has not been prolific, as only a few publications were related to the leaching of nutrients (Sweden, Finland, Latvia, Lithuania and Russia), water level and quality and channel retention and changes in fluvial erosion (Poland), heavy metal content (Poland) and Hg Sweden) in water. Other studies relate to beaver as a bioindicator of environmental pollution (Poland, 0.09% publications), beaver damage and management (Finland, Lithuania, Latvia, Sweden and Poland), and the impact on vertebrate and invertebrate communities (Lithuania, Finland, Poland and Sweden). The majority of publications in WAMBAF countries are in English, some are available in national languages with abstracts in English while almost all Russian sources are available in Russian (Table 3). It shows that most publications in the native languages are available at the local level and less known at the international level.

Table 3. Number and type of publications in English and national languages on the beaver management and water protection in different countries

Country	Peer - reviewed scientific papers		Other scientific reports		Total number	Sources*
	English language	National language	English language	National language		
SE	6	x	x	X	6	
FI	4	0	0	0	4	
EE	0	0	0	1	1	*Jõgisalu, 2013-*
LV	0	1	0	0**	2	***one in Russian (Balodis 1990)*
LT	2	0	3	3	8	
PL	14	2	0	2	18	
N.RU	1	8	0	0	9	
In total	27	11	3	7	48	

* **FI:** Vehkaoja et al. 2015 *Biogeochemistry* 124: 405-415; Nummi 2011; Nummi, P. and Kuuluvainen, T. 2013. *Boreal Env. Res* 18 (Suppl. A): 13-24; Nummi, P. 1989. *Annales Zoologici Fennici* 26:43–52; Härkönen, S. 1999. *Silva Fennica* 33(4): 247–259; Vehkaoja, M. 2016a, Dissertationes Forestales 220. 32 pp.; Vehkaoja, M. 2014, 2016b.

LV: Cimdins, P., Balodis, M. 1980. Mežsaimniecība un Mežrūpniecība 76: 40-43 (In Latvian);

LT: Lamsodis, R. 2001. In: Czech, A. & Schwab, G., Krakow 128-141; Belova, O. 2001. *Ibidem*: 176; Belova, O. 2006. Girionys, 34 pp. (in Lith.); Ulevičius, A. 2008 (in Lith.); Ruseckas, J. 2011. Girionys, p. 8-42 (in Lith.); Lamsodis, R. and Ulevičius, A. 2012a. In: Abstract Book Croatia, 108; Lamsodis, R. and Ulevičius, A. 2012b. *Zeitschrift für Geomorphologie* 54(6): 435-458; Belova, O. 2013. In: Aleinikovas, M. et al. (Eds.). LAMMC, Akademija, Kėdainių r., p. 51-54 (in Lith.); Belova, O. 2012. In: Abstract Book Croatia: 23.

PL: Kukuła, K., Bylak, A., Kukuła, E., Wojton, A. 2008. *Roczniki Bieszczadzkie* 16:375–388 (in Polish with Eng. Sum.); Kukuła, K, Bylak, A. 2010. *Arch. Pol. Fish*. 18: 33-43; Wróbel, M., Boczoń, A., Gawryś, R., Kowalska, A., Krysztofiak-Kaniewska, A. 2016. *Baltic Forestry* 22(1): 46-50; Boczoń, A., Wróbel, M., Syniaiev, V. 2009. *Journal of Water and Development* 1(13):313-327; Boczoń, A., Wróbel, M., Syniaiev, V. 2009. *Leśne Prace Badawcze (Forest Research Papers)* 70 (4): 363–371 (In Polish); Czerepko, J., Wróbel, M., Boczoń, A. 2009. *Journal of Water and Land Development* 1(13):249-262; Grygoruk, M. and Nowak, M. 2014. *Forests* 5: 2276-2288; Giriat, D., Gorczyca, E., Sobucki, M. 2016. *Science of the Total Environment* 544 (15 Feb.): 339–353; Giżejewska, A., Spodniewska, A., Barski, D., Fattebert, J. 2015. *Environmental Science and Pollution Research* 22(5): 3969–3975; Surma, M., Giżejewski, Z., Zieliński, H. 2015. *Ecotoxicology and Environmental Safety* 120: 436–444; Szpikowska, G., Szpikowski, J. 2012. *Monitoring Środowiska Przyrodniczego* 13: 95–102 (in Polish); Zalewski, K., Falandysz, J. Jadacka, M., Martysiak-Żurowska, D., Nitkiewicz, B. and Giżejewski, Z. 2012. *European Journal of Wildlife Research* 58: 655–660; Kamczyc, J., Bielachowicz, M. and Pers-Kamczyc. E. 2016. *Forestry Letters* 109: 7-10; Brykała, D., Gierszewski, P., Błaszkiewicz, M., Kordowski, J., Tyszkowski, S., Słowiński, M., Kaszubski, M. and Brauer, A. 2016. *Geophysical Research Abstracts* Vol. 18, EGU2016-5637-1. EGU; Czech, A. and Lisle, S. 2003. Oenisia 9, zugleich Kataloge der OÖ. *Landesmuseen Neue Serie* 2: 91-98; Peczula, W., and A. Szczurowska. 2013. *Knowledge and Management of Aquatic Ecosystem*s 410:67-79;

N.RU: Saveljev, A. P. and Safonov, V.G. 1999. In: Beaver Protection, Management, and Utilization in Europe and North America (Busher, P. E., Dzięciolowski, R. M. (Eds.), p. 17-24;

SE: Glabischnig, F. 2015. MSc Th., Uppsala, SLU, 45 pp. Available at: http://stud.epsilon.slu.se; Levanoni, O., Bishop, K., Mckie, B. G., Hartman, G., Eklöf, K. and Ecke, F. 2015. *Sci. Technol*. 49: 12679−12687; Levanoni, O., 2016, SLU, PhD Thesis; Hägglund, A., Sjöberg, G. 1999. *Forest Ecology and Management* 115: 259-266; Lönnqvist, J. 2014. MSC Thesis, SLU, Uppsala, 50 pp. Available at: http://stud.epsilon.slu.se/6919/11/lonnqvist_j_151019.pdf; Redin, A. and Sjöberg. G. 2013. *Šumarski list* 11–12 (CXXXVII): 597–607; Törnblom, J., Angelstam, P., Hartman, G., Henrikson, L. and Sjöberg. G. 2011. *Baltic Forestry* 17(1): 154-161; Sjöberg, G & Hägglund, Å. 2011. In: The Return of the Beaver. Landscape-creative beaver activity in Northern Europe: a review of 50 years of restoration. Pensoft Publishers, Sofia-Moscow, Ch. 20, p. 255-268.

The studies are performed mainly during the period 1991-2014. The oldest ones were accomplished in Latvia (1979) and Finland (1978 and 1989), and there were long-term studies (from 1978 to 2013) on the water chemistry in beaver ponds. More recent studies were done in Poland, Russia, Lithuania and Sweden. In most cases, the study periods are longer than 3 years. Some long-term studies were performed in Finland and Lithuania (1978-2012) and shorter one in Russia (1992-1997) (Table 4).

Considering study type, plots predominated over catchments, with less number of control area in most cases (Table 5). The changes in element concentrations or loads of the total N (TN) NH_4-N, NO3-N, C, the total P (TP) and suspended solids in the beaver ponds/dams were studied in most countries. For example, in Finland, DOC concentration increased during the first three beaver-impoundment years when compared to the pre-impoundment situation, and DO concentrations simultaneously decreased.

Table 4. The length of study periods in different countries

Country	Total N period	1-year period	1-2-year period	3-5-year period	>5-year period	Notes
SE	6	5	0	1	0	
FI	5	2	0	1	2	
EE	1	0	0	0	1	annual survey
LV	2	1		1		
LT	8	2		4	2	
PL	18	9	2	4	3	
RU	4	2	1		1	

Table 5. The total number of study catchments and plots, and number of the control catchments and plots on the beaver management and water protection in different countries

Country	Total N. of the catchments	N. of the control catchments	Total N. of the plots	N. of the control plots	Notes
SE	19	-	38	-	Studies applied an upstream-downstream approach*.
FI	61	22	50	3	
EE	338	3 162	0	0	hunting districts of all country
LV	0	0	6	6	
LT	9	8	62	63	long-term study
PL	35	2	414	0	400 plots for modelling
RU	14	1	17	0	

* N. of catchments based on Levanoni *et al*. 2015 and Hägglund & Sjöberg 1999 (only water chemistry studies are included here), N=12 and 24, respectively

In Sweden, the TOC and DOC concentrations do not differ between recolonized and newly established beaver sites (Levanoni *et al*. 2015, Levanoni 2016). However, only one study included Hg and MeHg (Table 6). A few studies encompassed concentrations/loads and runoff (Table 7); other water characteristics such as temperature, velocity, turbidity, colour (Sweden, Russia); sediment chemistry and other parameters, e.g. substrate stability and deadwood parameters (Sweden, Finland), fine and coarse woody debris (Sweden); species diversity (Poland, Sweden); benthic insects (Sweden) and other invertebrates (Poland); ichthyofauna (Sweden, Poland); amphibia (Finland); waterfowl, small mammals, invertebrates and vegetation (Finland, Lithuania, Sweden, Poland); beaver damage on forest depending on forest characteristics (Finland, Lithuania, Poland) and damage category (Finland, Lithuania); and benefits/negatives (hydrological, geomorphological, other) of beaver activities (Poland, Lithuania, Sweden, Finland). In Estonia, only the visible signs of beaver activity were recorded. In Russia, most studies (4) were performed on water contamination by radionuclides in beaver ponds (Table 8). In Lithuania, studies were performed on the morphological and hydrochemical changes in water chemistry in beaver ponds and how these nutrients migrate through a fluvial network (N=2); in dammed up drainage ditches (N=1), including beaver dam distribution in ditches (N=5); ground water level; changes in the water temperature and insolation; oil granulometric content; pond and ditch sediments; quantitative geomorphic effect resulting from beaver dams and their destruction; amount of material in dams and sediment; beaver effect on forest drying; ditch silting and forest hydrological conditions; relation between number of beaver site components and stand parameters; and movements and forest disturbance level.

Table 6. Number of studies of water chemistry in the beaver sites in different countries

Country	TOC	DOC	C	PO_4	TP	NO_3^-	NO_2^-	TN	DO	K	Mg	Ca	Na	SO_4^{2-}	MeHg	Hg	pH	Other/Notes
SE	1	1			2	2	2	2						1	1	1	4	FPOM, CPOM,
FI	0	3	0	0	4	0	0	3	2	0	0	0	0	0	0	0	2	water quality in dammed/undammed ponds
EE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
LV	0	0	0	2	2	2	2	2	2	0	0	0	0	0	0	0	0	
LT	0	0		2	1	1	1	0	0	0	0	0	0	0	0	0	0	BOD7 (2), NH_4-N, organic compounds; DIN
PL	0	0	0	1	1	1	0	0	1	1	1	1	1	1	0	0	2	heavy metals; Cl^-, NH_4^+; HCO_3^-; conductivity; alkalinity, chlorophyll-a
RU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Hg, Pb, Cd, Co, Zn, Cr, Cu, Ni, Fe, 137-Cs, 90-Sr (4); alkalinity

Table 7. Number of studies on concentrations/loads and runoff measurements in different countries

Country	Concentration	Both concentrations and loads	Runoff	Modelled runoff	notes
SE	1	0	1	0	av. annual runoff 9 l/km^2
FI	2				
EE	0	0	0	0	
LV	2	0	0	0	
LT			4	4	
PL	2	0	0	0	
RU	0	0	0	0	
Total	7	0	5	4	

Table 8. Number of studies on other water parameters and sediment chemistry or volume measurements and other parameters in different countries

Country	Sediment chemistry	Sedimentation volume	Water parameters	Other parameters
SE	0	1	0	woody debris, benthic insects, species diversity ichthyofauna richness
FI	0	0	0	beaver as disturbance; damage assessment
EE	0	0	0	vital signs only
LV	0	0	2	conductivity
LT	0	2	5	geomorphic effect; hydraulic calculations; soil and material of dams; impact on forest hydrologic conditions; water temperature, insolation
PL	0	2	6	water level, storage, accumulation of erosion products, flood deposition; temperature; colour; abundance & biovolume of phytoplankton; transparency
RU	0	2	3	turbidity, colour; water flow m^3/s, sediment flow, concentration, retention
Total	0	7	16	

3.1.2 Efficiency of beaver management and water protection methods

The most important output in water protection is indicated in Sweden (Levanoni *et al*. 2015, Levanoni 2016). The authors showed a net-increase (from upstream to downstream) in MeHg concentrations in streams of the pioneer beaver sites in comparison with sites after beavers have re-inhabited them. The MeHg effect was absent in the re-inhabited sites. Hence, from a management perspective, re-inhabited beaver systems, which will constitute the majority of beaver sites in the near future, don't pose an environmental concern related to MeHg. Hunting towards local extinction of

beavers would disrupt the natural recolonization by beavers and might pose a future environmental problem. The positive policy in beaver population management and water protection against MeHg contamination will be maintenance of natural development of beaver sites while the intensive hunting and removal of beaver dams interrupt the successional process and recolonization of abandoned beaver sites. The recommendations on beaver population management were suggested in Lithuania (Belova 2008, 2012). Following the common laws of population ecology, if the abundance of a certain unmanaged population exceeds the carrying capacity under favourable conditions, overpopulation causes not only a shortage of preferred suitable habitats but also the spread of contagious diseases. However, agents of these are not typically displayed. The non-intensive hunting/trapping of 15% annually stabilizes a local population; however, an increase in the damage caused to forest by beaver requires more intensive management (20% harvesting), and the share of juveniles should be near 50% of all harvested beavers (Belova 2008). Selective removal of beaver dams (simultaneously cleaning drainage ditches) helps to maintain the beaver population and reduce damage caused to forest. However, removal of dams does not hinder beavers from inhabiting these ones repeatedly (Lamsodis 2000; Belova 2006, 2013) as they are inclined to re-build a dam after its removal within 24 hours (11 hours under undisturbed conditions).

The role of beaver dams as a water filter was indicated in several scientific publications in WAMBAF countries (Lamsodis 2000; Ruseckas 2011; Raguotis 1974), and as a trickle filter (Castro *et al*. 2015; Como and Deegan 2015) in the non-WAMBAF countries. There is the high potential for denitrification within dams. Therefore, in streams with different hydrological conditions that promote more contact with dam sediments, dams may cause more of a trickling filter effect. Although the abandoned beaver dams have not trickle filter effects, the hydrological and biological conditions, which foster nutrient uptake, are influenced by the presence of dams and the ecosystem alterations caused by the engineering activities of beavers are associated with the ecosystem service of nutrient reduction (Como and Deegan 2015).

In Poland, K. Zalewski *et al*. (2012) and A. Giżejewska *et al*. (2015) have found heavy metal contamination in beavers away from significant industrial emission sources, and suggested to use this species as bioindicator of environment pollution. Benefits and mischiefs of beavers in forest ecosystems were determined in Finland (Nummi and Hahtola 2008; Nummi *et al*. 2011; Nummi and Kuuluvainen 2013; Vehkaoja 2014, 2016 a, b). The most important type of damage is flooding (50 %)

caused by the damming activity of beavers; therefore, commercial forestry should make more effective management plans for game management districts; however, beaver numbers increased sharply in areas where hunting bags increased too (Härkönen 1999). The efficiency of beaver management and water protection was not indicated in Estonia and Latvia. In Russia, the main study direction was water contamination by heavy metals and radionuclides in beaver ponds determining beaver as bioindicator (Leonova *et al*. 2002; Porochov 2003, 2005, 2006) and the role of beavers as a landscape former (Gorshkov 2004, 2007, 2011).

3.2. Tools and demonstration areas of beaver ponds/dams

The number of tools of beaver pond/dam management was three and that of demonstration areas three too (Table 9).

Table 9. Number of planning tools or demonstration areas for beaver management in the different countries

Country	Tools	Demo areas	Notes
SE	0	0	
FI	0	0	
EE	2	1	
LV	0	0	
LT	1	1	
PL	0	1	
RU	0	0	*no data*
Total	3	3	

Estonia and Lithuania have developed some planning tools, and Estonia, Lithuania and Poland have demonstration areas. These tools are free to use for non-commercial purposes. Tools are developed for national use and in national languages (Table 10) though Estonia's tool is also available in English.

The purpose and content of the existing demonstration areas/tools are mainly related to the management or demonstration of beaver activities in forests, with nothing on the impact of beaver activities to loads of different elements in a catchment scale (Table 11). The scale of the existing demonstration areas/tools differ from stream to the catchment (Table 12). The users of the tools and demonstration areas vary from the public to foresters, hunters or scientists and students of the three main levels (as BSc, MSc and PhD) (Table 13).

Table 10. Number and availability classes of beaver pond/dam demonstration areas/tools and publication language in the different countries

Country	Free		Commercial		Limited		Publication language	
	tool	demo	tool	demo	tool	demo	tool	demo
SE	0	0	0	0	0	0	0	0
FI	0	0	0	0	0	0	0	0
EE	2	1	0	0	0	0	EE/EN	EE
LV	0	0	0	0	0	0	0	0
LT	1	1	0	0	0	0	LT	LT
PL	0	0	0	0	0	1	0	PL
RU	0	0	0	0	0	0	0	0
Total	3	2				1		

Table 11. Purpose and elements/parameters of the tools/demo areas by countries

Country	Purpose and elements/parameters
SE	0
FI	0
EE	Tools: regulation of beaver population; protect forest against beaver flooding; only water inundation damage Demo area: for beaver vital activity; only on vital activity
LV	0
LT	Tools: management of perspective/non-perspective dams & beaver population; beaver effect on forest Demo area: beaver activity; no parameters
PL	Demo area: water management in forests; beaver's dam, riparian zone, forest drainage
RU	0

Table 12. Scale of the tools/demo areas by countries

Country	Scale
SE	0
FI	0
EE	Tools: ca 380 km^2, i.e. divided between 338 hunting districts; all drained state forests Demo area: three sites
LV	0
LT	Tools: stream, catchment; Demo area: stream
PL	Demo area: stream
RU	0

Table 13. Users of the tools/demo areas by countries

Country	Users
SE	0
FI	0
EE	Tools: hunters, RMK; Demo areas: education
LV	0
LT	Tools: scientists, students of three levels, foresters, conservationists Demo area: Žemaitija national park visitors
PL	Demo area: scientists, forest administrators
RU	0

3.3. Review of current legislation, certification systems and guidelines

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. The largest number of legal acts are in place in Sweden (Table 14); however, these acts are linked with beaver rather negligibly but still have to be considered in the management of game species and improving/maintaining water quality.

Table 14. Regulations for game management, including beaver, in legislation in different countries

Country	Legal act title and Date	Regulations for beaver
EU-level	WFD, The EU Water Framework Directive 2000/60/EC (23/10/2000)	not specified
	Directive 2008/105/EC, Environmental quality standards 6(/12/2008)	not specified
	EC Habitat Directive 92/43/EEC Annexes II, IVa (21/05/1992)	species of “Community interest”
	EC Habitat Directive 92/43/EEC Annex V (21/05/1992)	Derogation for beaver management from strict protection for Sweden, Finland, Latvia, Lithuania and Estonia.
	Bern Convention, Appendix III (01/06/1982)	Protective status
SE*	The Environmental Code [Miljöbalken]:(1998: 808), latest	Contains the fundamental environmental rules in Swedish legislation. Rules prohibiting the killing, injury or capture of

	update June 30 2016 (SFS 2016:786) – English translation: August 2000	wild animals or the taking of or causing of damage to their offspring and nests. Water operations, may only be undertaken if the benefits are greater than the costs and damage associated with them.
	The Game Act [*Jaktlagen*]: 1987 (1987:259), latest update 2014 (SFS 2014:698)	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 right to protect damage from wildlife, if such damage may not be counteracted otherwise. The government may give instructions on hunting seasons, licences, hunting permissions to prevent damage by wildlife. Prohibited hunting methods are defined.
	The Game Regulation [*Jaktförordningen*] 1987 (1987:905), latest update SFS 2016:125	Hunting seasons; equipment; permissions; reporting; examination or other conditions for use of equipment; order on hunting if wildlife cause damage; prohibited hunting methods are defined; specific seasons and areas for game species including beaver.
	The Species Protection Regulation [*Artskyddsförordningen*] 2007 (2007: 845), latest update 2014 (SFS 2014:1240)	Protection of wild animal and plant species including prohibition on season, damage of animal breeding sites and shelters. The list of species by the Habitat Directive include beaver.
	The Swedish Environmental Protection Boards' instructions and General advice on hunting and the State's Game [*Naturvårdsverkets föreskrifter och Allmänna råd om jakt och statens vilt*] 2002 (NFS 2002:18), latest update 2013 (NFS 2013:14)	Instructions and decisions on the advice based on the Game Regulation and the Arms Regulation. Semi-automatic bullet arms that have a clip capacity of not more than two cartridges (and may be loaded with one more cartridge in the cartridge position), bullet cartridges, body-gripping traps for beavers are defined. Special permit by Count Administrative Board is required for hunting with capturing device killing beaver.
FI	Hunting decree 666/1993 updated 11.4.2013	Aim is to increase the population of European beaver and reduce that of Canadian beaver. European beaver population remain in rather small area while Canadian spread over the country. Need to get the License for hunting on European beaver (Canadian beaver is unlicensed), hunting season during 20.8.-30.4. Beaver dam can be removed from 15 June to 19 September in the whole country and at the end of October in southern Finland. Time of beaver wintering and breeding.
EE	Hunting act, 01.03.2016	General regulations for regulation and use of game species.

	List of game monitoring data and regulation for data collection, and authorised institution for monitoring arrangement [*Jahiulukite seireandmete loetelu ja kogumise kord ning seiret korraldama volitatud asutus*] 16.01.2016	Monitoring of game species and principles of its arrangement.
LV	Hunting Law [*Medību likums*] updated 02.12.2015	Determination of the right to hunt and procedure to obtain this right; territories, where hunting is allowed; prohibited means of hunting.
	Hunting Regulations, Regulations by the Cabinet of Ministers No. 421 - updated 22.07.2014	Determination of the special regulation of the management: open season, reporting to surveillance authorities, use of the traps. http://likumi.lv/doc.php?id=267976
	Animal Protection Law 11.07.2014	Animal categorisation by their use http://likumi.lv/doc.php?id=14940
	Law on the Protection of Species and Biotopes 01.01.2016	Division of the protected species into particularly protected and those with restricted use http://likumi.lv/doc.php?id=3941
	Regulations on the List of Particularly Protected Species and Protected Species with Restricted Use, Regulations by the Cabinet of Ministers No. 396, 31.07.2004	Beaver is not included in the current list which is not in conformity with EU regulations.
LT	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	Approval of the method of beaver population management depending on the damage caused by beaver to forests. The management of non-perspective dams, which have to be removed on the ground of the decision of Regional Environment Protection Department by application from foresters or other holders.
	The Law of Hunting No. IX-966 20.06.2002; updated XII-372 18.06.2013	The Order of compensation of damage caused by beaver to lands and hydrotechnical facilities. The order of population regulation based on damage caused by game to land and forest holdings. Decision on removal of beaver is based on application from holder of hunting ground unit, landowners, forest owners, water or other holders.
	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	The Order of game hunting. Determination of changes in hunting season for separate game species including beaver; types of hunting, hunting course, definition of beaver sites etc.

PL	Regulation of 6 October 2014 On the protection of species of animals (Dz. U. No. Pos. 1348) [Rozporządzenie Ministra Środowiska z dnia 6 października 2014 r. w sprawie ochrony gatunkowej zwierząt (Dz. U. Nr poz. 1348)	Partial protection of species; the possibility of hunting depending on the abundance of the local population.
	Regulation of The Minister of Environment of 10.04.2001. Defining the list of game species and determine hunting seasons for these species (Dz. U. No. 43, item. 488) [Rozporządzenie Ministra Środowiska z dnia 10 kwietnia 2001 r. w sprawie ustalenia listy gatunków łownych oraz określenia okresów polowań na te zwierzęta (Dz. U. Nr 43, poz. 488, z późn. zm.)	Beaver hunting is forbidden.
RU	Order on approval of norms of permissible use of game resources and norms of their permissible numbers (No. 138 of 30.04.2010)	Approval of 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
	Hunting Regulations in Russian Federation (2010) updated 04.09.2014 No 383; 2016	Approval of 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/destroying of the beaver dams is prohibited excluding arrangement of traps. Use of game resources independent on hunting season could be allowed for the research purposes; hunting is prohibited on the area less than 200 m up to the settlements/homesteads

* SE: English translation by Göran Sjöberg, SLU

Most legal acts are approved earlier but updated recently. Special guidelines for beaver management and monitoring have been adopted in some WAMBAF countries: Lithuania (2003), Poland (2004) and partly Sweden (as it was adopted for some counties only, - personal communication, G. Sjöberg 2016); however, neither guidelines nor scientific publications sufficiently discuss how beavers impact water quality. The annual monitoring of beaver ponds is performed in Latvia from 2001 (LVM, Latvia's State Forests) and in Estonia. As an example, the quantitative

management (the assessment of number) of beaver populations is based on the specific regulations in Lithuania (Žin. 1997, No. 108-2726; 2001, No. 110-3988; Žin. 2008-04-12, No. 42-1562; Žin. 2000, No. 53-1540; 2002, No. 97-4308; Žin. 2002, No. 97-4309; 2009, No. 42-1626). According to the regulations, the removal of beaver dams depends on the level of the damage to forest (i.e. named as perspective beaver sites, where damage is negligible or in the absence of damage and habitat conditions meet species-specific requirements); and non-perspective sites, where damage occurs and inundation of forest/land is evident including damage not only to stands or plantations but, moreover, to forest roads and other communication or power lines or if beaver dams are situated in the ecologically and culturally valuable watersheds). The list of such watersheds is governmentally approved (Žin. 2004, Nr. 137-4995). Landowners, forest owners, forest holders and users of a hunting ground unit have the right to remove beaver dams in the non-perspective beaver sites using manual and mechanic means during the entire year. Such practice requires the regular survey by foresters, hunters and other holders of forest/land. It is necessary to develop the action of dam removal determining the criteria for the practical use (Table 15).

Table 15. Regulations related to beaver management in certification systems in different countries

Country	Certificate title and date	Regulations related to beaver management.
SE*	Swedish FSC Standard for Forest Certification including SLIMF indicators (2010)	The principles and criteria for the development of a national, suitable forest management standard including principles on environmental impact in the context of biodiversity protection, landscape ecology perspective in their planning. Management procedures have to promote continuously forested, if possible stratified, transition zones conditioned by topographical, hydrological and ecological features along watercourses and open water areas considering aquatic habitats when forest land is set aside for nature conservation purposes.
	Svensk PEFC Skogsstandard – PEFC SWE 002:3 (2012)	The objective for Swedish forest standard is to develop a sustainable forestry with good balance between production, environment and social/cultural interests including environmental standards (management procedures to protect soil and water, edges/protective zones, lakes and streams, broadleaved and mixed stands.
FI	PEFC (10.8.2015)	Beavers are not mentioned.
	FSC - NEPCon Interim Standard for Assessing Forest Management in Estonia, FSCTM/ASI (19.12.2014)	Beavers are not mentioned.

EE	Documents certifying hunting rights, 01.03.2016	Hunting act https://www.riigiteataja.ee/akt/121112014025?leiaKehtiv
LV	FSC 19.12.2014	Old beaver ponds, flood-lands, wetlands in natural watercourses characterized by dead trees and/or by vegetation characteristics of wet sites shall remain intact. This does not apply to the drainage systems.
	PEFC (28.4.2010)	Planning, maintenance and construction of forest infrastructure (incl. drainage systems) to preserve natural environment and functions of watercourses and waterbodies.
LT	FSC, 17.06.2002	FSC principles and criteria based on the national legislation, international declarations and agreements including CITES, ILO, ITTA, and Convention on Biodiversity. Forest management target activity on effective multifunctional use of forests aiming to warrant economic vitality and wide environmental and social function spectrum. Monitoring and assessment including criteria on need of scientific research and data collection of the state and changes in flora and fauna.
	PEFC	Promotes sustainable forest survey and use of forest resources, protection of forest protective functions, healthy and vital ecosystems and biodiversity. Beavers per se are not mentioned.
PL	FSC, 20.01.2014	Forest managers are aware of the obligation to protect the species by the official list of protected animals actually occurring in the forest. Beavers are protected but are not mentioned in the document.
	PEFC, 18.02.2005	Writing general. Forest management seeks to preserve, protect and enhance forest biodiversity at the genetic, species, ecosystem. Beavers not mentioned in the document.
RU	Assessment of Conservation values, Impact, Sensitivity and Added value of streams NPK+	Assessment for Blue target class including species under interest as beaver.

*SE: English translation by Göran Sjöberg, SLU

Guidelines “Beaver and measures against their damage” were adopted in some counties in Sweden. There are certain possibilities by the game legislation to remove beaver dams due to the damage caused by beavers. The permission of such activity is granted by County Administrative Board allowing landowners, road managers and others to keep the beaver activity under surveillance during the whole year, and in particular during September. In localities with great beaver damage, it

is recommended to hunt in the general hunting season for beaver from October 1 to May 10/15. During offseason hunting, landowners and hunters can destroy beaver dams without permission. During summer, no actions may be taken against inhabited beaver lodges. Removal of the dams and lodges is related to the other legal act as the Game Regulation (§29). The preventive measures are defined. In Finland, guidelines (Metsähallituksen ympäristöopas 2011), indicate the use of beaver ponds in constructing wetlands for retaining suspended solids and nutrients. Populated dams can be removed from June 15 to September 30 to prevent forest damages; however, if damages are noticed too late, dams should be remained untouched. Recommendation of management of dams are defined: dams should be not removed because of re-building activity of beaves (beavers usually rebuild the dam and, in the worst case, move to a new site causing new forest damages). In Latvia, the annual survey (monitoring) is done categorizing all beaver sites as 1) have to be managed (preserved) and 2) to be removed, that corresponds with the regulations on beaver populations in the above mentioned countries. In Estonia, monitoring of the beaver population is done by the Action Plan for the protection and management of the European beaver (*Castor fiber* L.) in Estonia (Laanetu 2001). The regulation of beaver populations is based on their effect on watersheds in the various hunting districts, namely: I – beaver sites are allowed (damage occurs rarely) and beaver hunting is allowed within hunting season, II – beaver is under constant control (beaver sites are allowed if damage do not exceeds the permissible limit), and animals should be trapped up to the level, at which significant damage to protected habitats does not occur (medium-size water courses, and outflows of drainage systems, forests); III – beaver sites are not allowed (not recommended) and beavers must be trapped. As an exception, beaver hunting and trapping is allowed in the closed season, and permits need to be approved by the Environmental Board. In Poland, the beaver is a partially protected species according to the recent (2014) governmental act, and the removal of beaver dams is allowed in certain areas depending on the damage caused by the beaver to the forest (Table 16)

Table 16. Guidelines related to the beaver management in different countries

Country	Guide title and date	Regulations related to beaver management
SE*	Handbook for the Species Protection Regulation, Part 1 – protection and dispensations [*Handbok för artskyddsförordningen, Del 1 – fridlysning och dispenser*] 2009	Facilitation of the activity of County Administrative Boards with protection cases and cases concerning commercial activities, i.e. preparation, trade, and demonstration. The application of The Game Act, the Game Regulation and international directives is indicated. Wildlife should not be disturbed or pursued other than during hunting. The prohibition

		is impeded for landowners in case of damage to their holdings. Use of wildlife in their breeding/shelter habitats is defined. Beaver is not mentioned specifically.
	The Swedish Environmental Protection Boards' instructions and General advice on hunting and the State's Game [*Naturvårdsverkets föreskrifter och Allmänna råd om jakt och statens vilt*] 2002 (NFS 2002:18), latest update 2013 (NFS 2013:14)	Instructions and decisions of the Environmental Protection Board on the following advice based on the Game Regulation and the Arms Regulation. General advice – Capture devices – permission to use body-gripping trap for capture of beaver should be given restrictively and in first hand concern hunt in areas where permission has been given to destroy the lodge or dam construction of the beaver.
	Beaver and measures against their damage [*Bäver och åtgärder mot dess skador*] Accessed 19 07 2016	Information and advice from the County Administrative Board of Västernorrland County to landowners. Permissions by the game legislation to destroy beaver dams because of beaver damage but considering the need to keep the beavers' activity under surveillance during the whole year, in particular during September. Costly acute actions are not needed if beavers are able to build and dam the streams in absence of disturbance. Recommendation to use the general hunting season for beaver: October 1 – May 15 in localities with great activity and troublesome damage. Landowner/hunters have right to manage beaver dams without special permissions if beaver caused damage during the period May 1–August 31. No actions may be taken against inhabited beaver lodges. Link to application form for removing beaver dams
	Nature consideration at final felling [*Naturhänsyn vid slutavverkning*] 2013. Brochure by the company SCA Skog AB on nature consideration.	Instructions to forestry planners and felling entrepreneurs (Beaver dams are generally allowed to remain unless they are perceived as a threat to forest roads. Decisions about removal are taken by the company's district officers).
	The art of growing forests - Holmen's path to sustainable forest management: 2015. Book issued by the forestry company Holmen Skog AB.	Description of the fundamental principles behind Holmen's approach to silviculture. Maintenance of different types of forest environments must be fostered. Holmen's document Miljö- och energipolicy (Environmental and energy policy) (The company has no general rule for handling beaver dams and they are treated differently from case to case, depending on the site and whether they influence the vicinity e.g. contribute to the value of nature or flood a forest road).
FI	Metsähallituksen ympäristöopas, 2011	Beaver ponds can be use as constructed wetlands for retaining suspended solids and nutrients. Populated dam can be removed between 15.6.-30.9., preventing forest damages; if damages usually are noticed too late, dams should be remained untouched. Recommendation of management of dams: dams should be not removed because of re- building activity of

		beaves (beaver usually builds the new dam and, in the worst case, moves to a new site causing new forest damages).
EE	Action plan for the protection and management of the European beaver (*Castor fiber* L.) in Estonia, 2001*	Monitoring of beaver population: Regulation of beaver population in the certain hunting districts by beaver impact to watersheds: I – Beaver habitation allowed (beaver damage occurs rarely), - beaver hunting is allowed during hunting season depending on increment, II – Beaver is under constant control (beaver habitation is allowed in case of damage greater than the permissible limit), - the animals 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) ; III – Beaver habitation is not allowed/not recommended – beavers must be trapped. In exceptional cases, beaver hunting and trapping is allowed outside the hunting season, permit should be approved by Environmental Board. (*Laanetu, N. 2001. Action plan for the protection and management of the European beaver (Castor fiber L.) in Estonia. [translation: M. Jüssi], Tartu.*
LV	Guidelines for monitoring of beaver areas in the state forests	Monitoring: annual survey of beaver sites dividing all beaver sites into 2 groups: 1) to be managed (preserved); 2) to be removed.
LT	Sustainable development strategy of Lithuania, Oder No. 1160 of 11.09.2003 [Lietuvos darnaus vystymosi strategija (LRV nutarimas Nr. 1160, 2003 m. rugsėjo 11 d.)	Recommendation of quantitative and qualitative criteria and parameters related to the use of forest resources. Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles; Maintenance of forest ecosystem health and vitality; Maintenance and encouragement of productive functions of forests (wood and non-wood) and Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems; Maintenance, conservation and appropriate enhancement of protective functions in forest management (notably soil and water).
PL	The Act on Destruction of beaver there requires permission of the Regional Director for Environmental Protection or the General Director for Environmental Protection. 16.04.2004 Nature Conservation (Dz. U. of 2015r., poz. 1651)	Possibility of destruction of beaver's dam is determined. 1) The actions to be implemented within the framework of projects likely significant effects on the environment 2) the removal of dams should be done in cases of inundation in accordance with the permit issued pursuant to Art. 56 sec. 1, 2 or 2b, or decree, issued on the basis of art. 56a.
RU	*not available*	*not available*

*SE: English translation by Göran Sjöberg, SLU

4. DISCUSSION

Need for research, tool development and legislation

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. Simultaneously, the beaver is classified as keystone species that significantly modifies habitats and influences not only the interaction between species in biotic communities but also changes abiotic conditions of water. Beavers, therefore, play a crucial role in biodiversity. 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.

Analysis of existing knowledge, tools and demonstration (demo) areas, related to beaver issue in BS countries, shows that, however, beaver benefits are not used sufficiently for recreational and educational purposes, including wildlife observation, relaxation in nature, fishing and other recreational activities in the forest. There is a need for an integrated approach in beaver population management including quantitative, qualitative and territorial management.

However, beaver management is non-intensive in WAMBAF countries. One of the reasons could be its status as a species under special protection across Europe. However, non-intensive management may result in compensatory reproduction and further population growth (Belova 2008, 2013) as it occurs in populations of other mammalian species (Ricklefs 1999). 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. When game population is not managed, it tends to grow to an extent which leads to an impoverishment of their vital resources. If predator numbers are low or in their absence, and effect of other natural disturbance-factors is negligible, hunting/trapping could help to restore ecological equilibrium.

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 (Lamsodis 2000; Belova 2006, 2013) as they rebuild a dam after its removal within 24 hours (in 11 hours under undisturbed conditions). 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.

5. CONCLUSIONS

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. Most legal acts do not emphasize the beaver *per se* sufficiently, with the exception of hunting acts that determine the terms of beaver hunting. Beavers are mentioned in the general wildlife legislation where compensation for damage caused by beaver to holdings of land/forest owners is determined. The most developed area is guidelines on beaver damage caused to forests and the monitoring of beaver ponds; however, the quantitative criteria of damage assessment

are missing. There is a clear need for an integrated approach towards beaver population management that will include quantitative, qualitative and territorial methods.

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WAMBAF: http://www.skogsstyrelsen.se/en/AUTHORITY/International-activities/WAMBAF/[1]

APPENDIX No. 1

The Questionnaire collected information:

1) **the studies reported in relevant scientific publications** and **other information** of beaver management and the impact of their dams on leaching of nutrients and hazardous substances and knowledge of the efficiency of beaver dams in controlling the runoff water quality including the following variables: report type (peer-reviewed or other scientific reports); country (country or countries where the study areas/plots are situated); language (language of the report); study method (field experiment, modelling or combination of both ones); study type (the scale of study: plot or catchment or beaver dam); total number of areas/plots/dams (total number of areas/plots/dams in the study); number of control areas/plots/dams (number of control areas/plots/dams or other control areas/plots/dams included in the study); treatments (list operations which impacts were studied with beaver dams); study period (study periods: years before; and years after treatment); elements and other parameters (elements and parameters studied); concentrations, loads or both reported; runoff (how runoff was determined: measured, modelled, both measured and modelled or not determined); efficiency (explanation of the efficiency of the water protection); literature reference (number of the reference providing complete bibliographic information of the reference at the bottom of the computational tools); and a PDF of the reference as an attachment; other remarks (space for other remarks, i.e. information on the control areas/plots/dams included in the study); indication whether the same site was used in another referred study;

2) **the current tools and demonstration areas for planning management** of beaver dams for water protection including the following variables: name of the tool/demo area; country or counties where the tool is used or demo area situated; organization (organization who developed and updates the tool/demo area); availability (free, commercial product, access limited); language (user language); platform of the tool/demo area (indication of the platform of the tool or demo area e.g. computer programme, cellular phone application, GIS-tool, flow-chart, virtual demo area, beaver dam, etc.); determination of load (indication of whether the load, e.g. kg/ha/, a) estimation is included: yes or no); purpose of the tool/demo area (description of the purpose of the tool or demo area); elements and other parameters (indication of elements and parameters are presented in the tool or demo area); scale (indication of the scale of the tool or demo area, e.g. stream, catchment, dam); users of the tool/demo area (identification of the main users of the tool/demo area, e.g. scientists, forest and environmental

administrators, forest and environmental managers); literature reference (number of the reference providing complete bibliographic information including the www-page at the bottom of the Table), and a PDF of the reference as an attachment: other remarks (remarks relevant in the perspective of water protection or practicality of the tool/demo area);

3) **the legislation, regulations and guidelines** regarding beaver management and water protection, including following variables: country, name and number of the law, certification system or guideline; date of the validation of the law, certification system or guideline, specific regulations for beaver management, language of the law, certification system or guideline is available; literature reference (link to literature reference or the www-page, attaching a PDF of the reference if feasible; other relevant comments.

Sample form Finland is indicates below:

Questionnaire:

WP 2

Tables for collecting information for Activity 2.3

Dead-line for delivering the Tables is 15.5.2016

The activity 2.3 will review and identify needs for development in a) existing scientific and other knowledge of the impacts of beaver damage and its management on leaching of nutrients and hazardous substances, b) knowledge of the efficiency of beaver dams in controlling the runoff water quality, c) current tools used for making decisions about the potential destruction of beaver dams, and d) current legislation (including environmental and nature conservation), regulations and guidelines when making decisions about beaver dams and the sustainable use. All these activities will cover all participating Baltic Sea countries. The partners involved will be active in the collection of the information and identification of the needs for development. Most of the material needed for the review will be collected from scientific and other papers and documents available on internet and in

libraries accessible by the partners or is provided by the experts working in WAMBAF. For collecting information three Tables have been prepared.

Table 1. The aims of this Table is to collect all relevant published and other information of the impacts of beaver dams and their management on leaching of nutrients and hazardous substances and knowledge of the efficiency of beaver dams in controlling the runoff water quality. One line in table 1 will be filled for each study (article) relevant for Baltic Sea countries

Names of persons who gave the information: Sirpa Piirainen

Organizations: Luke

Date: 23.8.2016

Report type (PR/OS)	Country (FI; EE, LT, LV, PL, RU, SE)	Langua-ge	Study method (field/ model/ combi)	Study type (plot; catchment)	Total number of areas/ plots/ dams	Number of control areas/plots/dams	Treatments	Study period (before; after)	Elements and other parameters	Conc./ loads/ both	Runoff	Efficiency	Literature reference	Other remarks
PR	FI	Eng.	field	catchment/ lake	37 lakes	22 non-dammed lakes	dammed lakes vs. undammed lakes	1978-2012	TP, TN, DOC, DO, pH	Conc.	not	not relevant	1	compare water quality in dammed and non-dammed lakes
PR	FI	Eng.	model	catchment	0	0	analysis of beaver as disturbance factor in forests	2013	beaver as disturbance agent; patch-scale and landscape-scale effect	not	not	negative and positive role	2 (indicated below)	

PR	FI	Eng.	model	catchment	0	0	simulation: beaver effect on ducks, invertebrates and vegetation	1989	beaver - vegetation-invertebrates-vertebrates	not	not	positive role	3 (indicated below)	
PR	FI	Eng.	Comb.	plots	50	3	forest damage assessment	1994-1997	damage by forest category, dominant tree species, forest site type, peatland forest category, damage type, duration and severity	not	not	assessment of damage to forest	4 (indicated below)	
PR	FI	Eng.	Comb.	catchment	2		water chemistry, deadwood; amphibia	1978–2013; 2014; 2010	pH, DOC, DO, TP, TN, deadwood parameters	Conc	not	positive role	5	

RT=report type**:** peer-reviewed international (PR) or other scientific reports (OS); **Country**=country/countries where the study areas situated; **Language**=language of the report e.g. English, Swedish...; **Study method**= which methods were used: field experiment, modelling or combination of both; **Study type =** indicate the scale of study: plot or catchment or beaver dam; **Total number of areas/plots/dams=**total number of areas/plots/dams in the study; N**umber of control areas/plots/dams=**number of control areas/plots/dams or other control areas/plots/dams included in the study (please explain in the remarks); **Treatments**= list operations which impacts were studied with beaver dams; **Study period**=study periods: years before; and years after treatment; **Elements and other parameters**=indicate which elements and parameters were studied; **Conc./loads/both**=indicate whether concentrations, loads or both were reported; **Runoff**=indicate how runoff was determined: measured, modelled, both measured and modelled or not determined; **Efficiency**= explain the efficiency of the water protection; **Literature reference**=number of the reference, please provide full information about the reference at the bottom of the Table, and a pdf of the reference as an attachment; **Other remarks**=space for other remarks, i.e. information about control areas/plots/dams included in the study. Indicate also whether the same site is used in another referred study.

1	Vehkaoja et al. 2015 Biogeochemistry 124: 405-415

2	Nummi, P. and Kuuluvainen, T. 2013. Forest disturbance by an ecosystem engineer: beaver in boreal forest landscapes. *Boreal Environment Research* 18 (Suppl. A): 13-24.
3	Nummi, P. 1989. Simulated effects of the beaver on vegetation, invertebrates and ducks. Annales Zoologici Fennici 26:43–52
4	Härkönen, S. 1999. Forest damage caused by the Canadian beaver (Castor canadensis) in South Savo, Finland. Silva Fennica 33(4): 247–259.
5	Vehkaoja, M. 2016. Beaver in the drainage basin: an ecosystem engineer restores wetlands in the boreal landscape. Dissertationes Forestales 220. 32 pp.

Table 2. The aim of this Table is to collect information about the current tools and demonstration areas for planning management of beaver dams for water protection. One line will be filled for each tool or demonstration area relevant for the Baltic Sea countries

Names of persons who gave the information: Sirpa Piirainen

Organizations: Luke

Date: 23.8.2016

Name	Country (FI; EE, LT, LV, PL, RU, SE)	Organization	Availability (free/ commercial/ limited)	Language	Platform of the tool /demo area (computer/ cellular/GIS/ virtual…)	Determination of loads (yes/no)	Purpose of the too/ demo area	Elements and other parameters	Scale	Users of the tool/demo area	Literature reference	Other remarks
Tools												
	no tools											
Demonstration areas												
	no demo areas											

Name=name of the tool/demo area; **Country=** country or counties where the tool is used or demo area situated; **Organization**=organization who developed and updates the tool/demo area; **Availability**=free, commercial product, access limited; **Language**=user language e.g. English, Swedish…; **Platform of the tool/demo area:** indicate the platform of the tool or demo area e.g. computer programme, cellular phone application, GIS-tool, flow-chart, virtual demo area, beaver dam... etc.; **Determination of load** =indicate whether the load (e.g. kg/ha/a) estimation is included: yes or no; **Purpose of the tool/demo area:** describe the purpose of the tool or demo area; **Elements and other parameters**=indicate which elements and parameters are presented in the tool or demo area; **Scale**= indicate what is the scale of the tool or demo area: e.g. stream, catchment, dam…; **Users of the tool/demo area=** identify the main users of the tool/demo area: e.g. scientists, forest and environmental administrators, forest and environmental managers…; **Literature reference**= number of the reference, please provide full information about the reference including the www-page at the bottom of the Table 2, and a pdf of the reference as an attachment; **Other remarks**=other remarks which are relevant in the perspective of water protection or practicality of the tool/demo area.

Table 3. The aim of this Table is to collect information about current legislation (including environmental and nature conservation), certification systems and guidelines regarding management of beavers and beaver dams. One line in the Table will be filled for each law, certification system and guideline valid on 15.4.2016 in the Baltic Sea countries

Names of persons who gave the information: Sirpa Piirainen

Organizations: Luke

Date: 23.8.2016

Country (FI, EE, LT, LV, PL, RU, SE)	Name	Date	General regulations for management	Special regulations for management	Language	Literature reference	Other remarks
Legislation (legislation relevant for beavers and beaver dams)							

FI	Hunting decree 666/1993	updated 11.4.2013	License is needed for hunting European beaver, hunting of Canadian beaver is free, hunting time during 20.8.-30.4.	Populated dam can be broken between 15.6.-15.9. all in country and in the end of October in southern Finland	Finnish and English		1. Idea of the days is that beavers had "home" during winter and during breeding time. 2. Aim of regulation is to increase population of European beaver and decrease that of Canadian one. European beaver population existed only in rather small area in Finland, but Canadians are populated over the country.
Certification system							
FI							beavers are not mentioned
Guidelines							
FI	Metsähallituksen ympäristöopas	2011	Beaver bonds can be use as constructed wetlands for retaining suspended solids and nutrients	Populated dam can be broken between 15.6.-30.9. for preventing forest damages, but as damages usually are noticed too late, dams should be leave untouched	Finnish		Dams are not recommend to broke as beaver usually makes new one and in the worst case also to a new place which can cause new forest damages

CO=country; **Name**=full name and number of the law, certification system or guideline; **Date**=when the law, certification system or guideline is imposed; **General regulations for management**=describe the general regulations included regarding beavers; **Specific regulations for managements**= describe the specific regulations included regarding beavers; **Language**=in which languages the law, certification system or guideline is available; **Literature** reference=link to literature reference or the www-page, and attach a pdf of the reference if feasible; **Other remarks=** other relevant comments.