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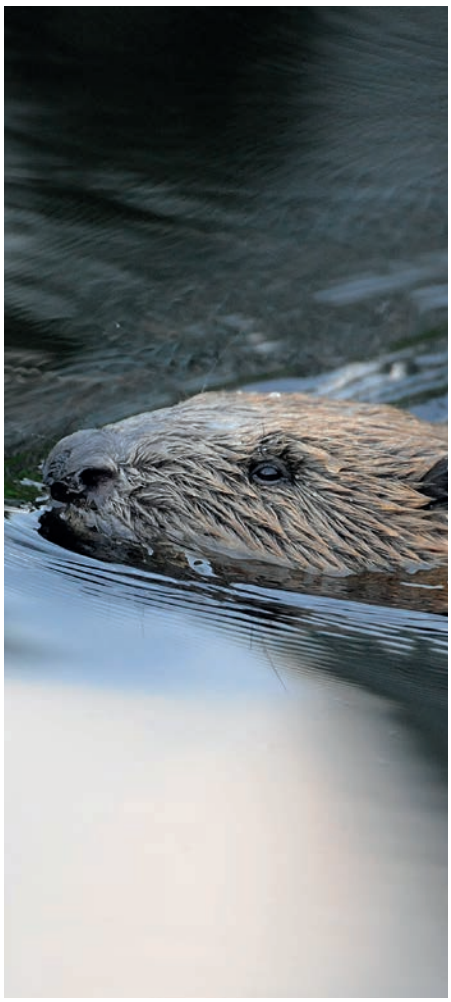
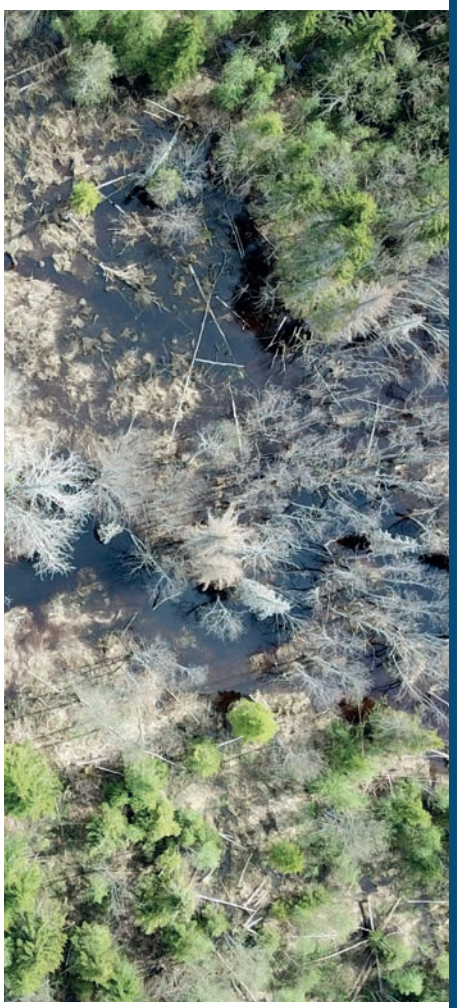
WAMBAF

Beaver as a renewable resource

A beaver dam handbook for the Baltic Sea Region





Editors: Göran Sjöberg and Olgirda Belova

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Cover photos: Joel Segersten (left and right) and Kenneth Johansson (center).

Photo: Mostphotos

Chapter 1: Foreword - The purpose of WAMBAF

Daniel Thorell and Linnea Jägrud
Project leaders

The project WAMBAF stands for Water Management in Baltic Forests. It was initiated to tackle problems concerning forestry activities in relation to water quality. The project was financed by the EU Interreg Baltic Sea Region programme and was carried out during the period 1 March 2016 – 28 February 2019.

Special emphasis was set on clear water, nutrient export and mercury. The project focused on three topics that have large impact of water quality: riparian forests, drainage and beaver activity.

Initially, WAMBAF mapped scientific knowledge, regulations, guidelines and tools in the Baltic Sea Region countries. Based on this background information the project produced different planning tools, this handbook and guidelines aiming to reduce the export of nutrients and methyl mercury from forests to streams, lakes and the Baltic Sea. Also, a number of demonstration areas were established in Sweden, Finland, Latvia, Lithuania and Poland, open to visit for forest owners, public and others.

You can find the tools, guidelines and films, as well as a map to the demonstration areas, on the WAMBAF website www.skogsstyrelsen.se/en/wambaf. Welcome to visit us! On the website or in a demonstration area.

The colour of the beavers' fur is often a dark brown (Russia). Photo: Alexander Porokhov

Chapter 2: General biology of beavers

Göran Sjöberg, Olgirda Belova and Michal Wróbel

The species

The beavers belong to the class mammals (Mammalia), the order rodents (Rodentia) and the beaver family (Castoridae). There are two beaver species existing today, both belonging to the genus *Castor*. The Eurasian beaver *Castor fiber* is native of Europe and Northern Asia, while the North American beaver *Castor canadensis* historically inhabited North America including Northern Mexico. *Castor fiber* was described by Carl Linnaeus in 1758, while *Castor canadensis* was described in 1820 by Heinrich Kuhl (Figure 2.1). The distinguishing features of each species are given in Table 2.1.

In 2005, the results of phylogenetic studies using mitochondrial cytochrome b gene were published. Eight populations have been identified corresponding to the populations surviving in separate refugia (Durka et al. 2005). The populations have been grouped into two Evolutionary Significant Units (Ducroz et al. 2005) with the western ESO comprised of populations from Norway, Germany and France.

Some of the data below is taken from sources on North American beaver since more research was made on that species, and many aspects are identical to Eurasian beaver.

Morphological features

Eurasian beavers, the largest rodents in Europe, weigh from 13 to 35 kg and are 73 to 135 cm in length (e.g. in Lithuania, from 15 to 26 kg and from 72 to 86 cm, respectively). Of this, body length is about 100 cm, and tail length 20–25 cm while the tail width is 11–17 cm (Czech 2010). The muzzle is blunt, ears are small, and the legs are short. As semi-aquatic animals, beavers are well-adapted for their life in the water. The beaver's body is massive and stocky, passing without a well-developed neck to a round head. Such body structure makes it easy to move in the water. In water, beavers can hold their breath for up to 15 minutes. Their cheeks close behind their incisors so they can grasp and drag branches underwater. Ear canals and nasal openings can be closed to keep water out. They have an inner transparent eyelid to allow underwater vision.

The beavers' teeth play an important role and exhibit specific adaptations in construction. With the help of the long and strong teeth, beavers can perform most of their vital functions: cutting trees and building dams. The front surface of the incisors is made of a very hard enamel that is dull orange in colour (Fig. 2.4). Since the back part of the tooth is not as hard, it wears off first, resulting in a chisel-like shape, which is perfect for felling trees and stripping their bark (Lithuanian fauna 1988, Outwater1996, FACE 2014–2015). The force of beaver is several tons per square

Figure 2.1. The respective authors of scientific names of the Eurasian and North American beavers.
a. Carl Linnaeus is the well-known Swedish creator of the binomial nomenclature and authored a huge number of plants and animals. He named the beaver *Castor fiber* in 1758 in the 10th edition of Systema Naturae. Both *castor* and *fiber* are Latin for beaver, the former deriving from Greek. Linneaus was born 1707 and lived until old age in 1778.
b. Heinrich Kuhl is less famous, but made a rapid career when he was very young, as both botanist and zoologist in Germany, and he came into contact with important scientists of the time. Kuhl's family were Calvinist refugees from the Netherlands. He named the North American beaver *C. canadensis* in 1820, obviously relating to its origin. Unfortunately, he fell ill the following year on a collection journey to Java and died only 23 years old. Images copyright Wikimedia.

Figure 2.2. The fur of beavers consists of two layers: the dense undercoat and the longer guard hairs. Photo: Göran Sjöberg

Figure 2.3. The scaly tail of the beaver is an important instrument for steering and signalling. Photo: Göran Sjöberg

Figure 2.4. The front teeth of beavers are well adapted to cutting trees and branches. Preparation of trophy and photo: Vygandas Vasiliauskas

centimetre, making it possible for it to cut hardwood species such as beech and hornbeam. The beavers' teeth grow throughout its life and therefore require constant abrasion (Czech 2010).

Beavers have two fur layers. The first is a soft dense undercoat that is dark greyish in colour. The second, outer, layer is longer stiff reddish brown hairs called guard hairs (Fig 2.2). The fur is very dense – from 12 to 23 thousand hairs grow on one square centimetre of the skin (Czech 2010). Beavers spend a lot of time grooming their fur when out of the water, maintaining its protective ability. Beavers have two castor sacs located next to the cloacal opening. These sacs produce a pungent, sweet smelling urine-based brown musky oil containing phenolic, neutral, basic, and acidic compounds called castoreum. The composition of the castoreum depends on the diet and is subject to seasonal variation in odour. Beavers use castoreum to mark territories. Anal glands or oil glands produce anal gland secretions consisting of waxy esters and fatty acids. These glands secretions are unique chemical identifiers of individual beavers (Sun and Müller-Schwarze 1998).

The colour of pelts differs from greyish brownish to dark brown and blackish. In northern regions, pelts are darker. In Lithuania, the most frequent is dark brown colour, and only ca. 4 % are grayish brownish ones (Lithuanian Fauna 1988). The sexual dimorphism is not externally visible. Beavers have no external sexual organs. Due to the lack of sexual dimorphism, it is very difficult to identify beaver sex by external characteristics. Currently, the most reliable field method to identify genus in beaver is thought to be a combination of palpation of the penis bone and examination of anal gland secretions (Rosell and Sun 1999).

The front feet have 5 fingers, and are gripping. Beavers are very skilled at manipulating objects. They can take a twig no bigger than a pencil and twirl it around as they nibble off the bark. Their hind feet are large and have webbed toes for swimming (Czech 2010, Kowalski et al. 1991). On the second toe of each hind foot, beavers have a special "comb claw" that is used as a curry comb during grooming. The wide, flat, and leathery tail, covered with horny scales, is one of the beavers' most characteristic features (Fig. 2.3). The tail serves as a fat storage depot and helps regulating body temperature. It acts as a rudder and helps the hind feet push the beaver forward when swimming. The tail also serves as a chair. Beavers will either lean back against it when standing on their back legs or they will fold it around beneath them when sitting and grooming themselves. Beavers use their tail not only as a rudder for swimming and navigating while carrying large logs, but also for warning other beavers about danger by slapping their tail against the water with a loud smack and splash (Wilsson 1971, Bau 2001, Belova 2001, Thomsen et al. 2007).

Figure 2.5 Aspen is one of the most preferred food species (Russia). Photo: Alexander Porokhov

Habitat

The beavers are semiaquatic animals, which means they are adapted to life both in water and on land. The beaver habitat can be all water bodies from small streams to large lakes, and even sea shores (Rosell and Pedersen 1999, Pollock et al. 2003). Where drainage ditches are found, they are intensively used (Belova 2006, 2013, Zavyalov 2011a, b).

Beavers select sections of streams with a water depth of over 40 cm. This may at least in part be seen as a protection against predation (Baskin 2011). It has been shown that beavers prefer meandering streams. In streams with high spring floods, mortality may increase and these are not favoured (Gorshkov 2011). In one study, beavers preferred deep, slow-moving medium-sized rivers with broad-leaved tree cover and rich flora (Hartman 1996). Beavers prefer forest sites with a canopy closure of 0.4–0.6, diameter of stems 2.1–24 cm and a shrub layer with an average of 1.5 m height and a cover of 40–60 % (Belova 2006). These parameters are the basis for a Beaver Habitat Suitability Model and could be useful for beaver habitat assessment. It may, however, be difficult to make a habitat suitability index that is highly predictive over the beavers' whole range of habitats or population densities (Hartman 1996).

Habitat features, especially shoreline configuration, strongly affect home range shape and size. Small ponds may contain only a single family but in lakes, streams, and rivers, the home ranges of beaver are larger and more linear (Novak 1987, Wheatley 1997). In small rivers, beavers occupy on average 0.2 ha, and in ditches 0.1 ha. Territories of the newly established beaver sites are twice as large as usual family territories. In unsuitable habitats, and if the number of beavers decreases due to e.g. human disturbance, animals spread over 100–800 m from the beaver site in comparison to beavers who occupy suitable habitats (20–50 m). Different families select non-connected ditches (Belova 2006).

Lodges, burrows and dams

Beavers build a lodge with sticks of 40–60 cm in length and water vegetation piled high enough to enable them to cut a nest chamber above the water surface. The beavers cut down trees for the dam and lodge and drag or carry the logs to the edge of the water body. Sometimes, they build channels to float the logs to the pond. They add mud to the surface of the lodge to provide a weather seal, but a part of the top remains unsealed to allow air exchange. The diameter of the lodge ground is 3–5 m and up to 10 m, and its height is 1.5–2 m and up to 2.5 m. The walls of the conical lodge are very strong due to layers of mud and sticks, and are extremely insulated. One or more underwater openings lead to tunnels that meet at the centre of the mound, where a single chamber is created. This nest chamber is located in the upside of the construction. Beavers regularly change the nest's beddings of grasses, reeds and wood chips. There may be one, two, or more, main underwater entrances. One entrance is narrower and steep and used as the main entrance to the lodge. The next entrance, being wider and less steep, is used to transport food into the lodge from the store. All tunnels and chambers are cut after the main construction is built. If entrances are not submerged, the beavers first construct a dam to raise the water level in the pond where their home is to be built. A minimum water level of 0.6 to 0.9 metres is required to keep the entrance to beaver lodges underwater. One family can have several lodges or bank dens, but may during the winter use only one of them.

If the bank material is suitable enough, the soil is easy to excavate, and sharper banks are present, beavers dig burrows. Burrows, like lodges, contain an entrance tunnel starting underwater, a feeding chamber at water level and one or several sleeping chambers above water level. Burrows are typically under or near the roots of trees and shrubs as the roots can prevent the roof from collapsing. The diameter of the underwater entrance is 0.75–1.5 m under the water level. The diameter of the burrow is 30–35 cm, and the chamber diameter is up to 1 metre. Beavers may not have many entrances to the burrows so to reduce energy expenditures and possible erosion of banks due to multiple digging.

Beavers build dams on small and medium-sized, low lying streams with shallow, moving water. They prefer the lowest gradient with a slope of 1–2 % (Pollock et al. 2003, 2015). Beavers may sometimes not build dams, but instead live in bank burrows and lodges when lakes, rivers and large streams have sufficient water depth to provide access to food, ensure family safety and a place to rest, stay warm, give birth, and raise young. The dam is built high enough to hold back water at a depth of 2–3 m, so that the beavers can swim freely under the winter ice. Usually the height of dams is 50–100 cm but it can reach 2.5–3 m and a bottom width of 3 m or more. When constructing the dam, beavers use the front paws to pack mud into the cracks to ensure that the dam becomes watertight. Beavers construct dams to ensure that it never freezes at the depth of the entrances to the lodge when the water might freeze on the top of the pond. Therefore, beavers can survive a severe winter in the lodge, when the land and water surfaces are covered with ice and snow.

Food

Beavers are strict herbivores (selectors), who select food depending on the season, tree/shrub species, stem diameter and the distance from the edge of the water. The mixed diet needs to allow decontamination of secondary metabolites, avoid their quantity in the diet, and obtain additional nutrients. Secondary compounds (monoterpenes, triterpenes, phenols etc.) are most numerous in the preferable trees/shrubs during the juvenile stages of growth. These substances impede digestion, tie up proteins and arouse a negative nitric balance (Belova 2006). Beavers are perfectly adapted to consume woody vegetation. In late spring and summer beavers mainly consume aquatic plants, grasses, ferns and shrubs.Preferred species reported by Danilov et al (2011b) are yellow pond-lily, water lily, cat-tails and bulrush. The beavers' intestine is rather large, and they have a characteristic feature, caecotrophy, i.e. the animals consume the initial faecal substances, caecotrophs, from their digestive system (Müller-Schwarze and Sun 2003). Beavers eat these substances diurnally. This feature allows them to obtain a maximum of nutrients from their vegetative diet.

Beavers can fell a 5 cm tree in just a few minutes. The most preferred species are aspen and willows (Danilov et al 2011b; Fig. 2.5). Willow is often the most available and the most used woody riparian species in much of the beaver's range. Preference depends on the availability and locality of the food. Less preferred species are birch, alder, European white elm, ash, oak and lime. Conifers are rare in the diet. They prefer pines growing in the rich soils and do not like spruce (Belova 2006) while in Poland, beavers avoid pine (Borowski and Borkowski 2003). Woody vegetation comprises about 600–650 g in the daily diet. Beavers consume thinner and younger trees and shrubs in diameter of 1.5–3.5 cm and thinner. The thicker stems and branches of 4.5 cm and more are less preferred. When the thicker tree stems in diameter of 15 cm and more are cut, beavers debark stems all around. The thinner stems are gnawed partly. The remains after feeding are used for building and reconstructing dams and lodges. Beaver browsing stimulates regeneration of willows. Beaver typically cut woody vegetation from terrestrial area for food or construction material and bring it back to a central point such as a pond, a cache, a feeding station in the water, a lodge, or a burrow. Typically, beavers construct a single food cache in the autumn except where winters are mild (Novak 1987, Lithuanian Fauna 1988). The start of the cache arrangement is correlated with the first heavy frosts (Novak 1987). Beavers store preferred food under a specific raft, usually constructed from branches of less

preferred and disliked food species. This raft forces the branches beneath it to sink and, subsequently, remain below any ice and available for winterfeeding (Slough 1978).

Beavers communicate by means of scent, tail-slapping, vocalizations, and body movements. When the beaver is working outside the lodge, it has to be very careful to avoid enemies. Its distinctive smell, from the pouch at its tail, which contains the musky smelling castoreum substance, leaves scent marks as it works. Beaver kits do not have the distinctive castoreum for enemies to smell. The teeth of the beaver also provide formidable weapons if necessary. When a beaver senses danger, it slaps its tail on the water to signal to an intruder and possibly warn the others to return to the safety of their lodge. As beavers are nocturnal, their best-developed senses are smell, hearing, and touch. Beaver smell allows communication between family members. The sense of touch determines the direction and strength of the water current, so that they can stop the flow of water from a damaged dam. Beavers usually feed within 20 meters from the shore of the watercourse. Overnight they can travel 20 kilometres.

Social life and behaviour

The beavers are highly social animals living in long-lasting permanent monogamic pairs. At about 2 years of age, beavers may begin to reproduce. Beavers mate during the winter, from late January to March. Young beavers do not breed even if they are able to. Only the dominant pair (parents) mates, and produces one litter per year. Gestation lasts about 108 days. In the Baltic region, a female beaver gives birth in May–June. The single annual litter is 1–4 young. The main social group is the family or family group (parents, yearlings and second-year young). Beaver families occupy a territory from 100 to 500 m and more along banks of e.g. ditches,and large families and colonies (several families) inhabit 0.8–1.5 km belts depending on the type of water body (Lithuanian fauna 1988, Valachovič 2000, Aulak 2007–2008).

Most copulations occur at night. If a mature female is not impregnated, the first time she will come into oestrus 2 to 4 times repeatedly in the season. After mating, the pair spends as much time maintaining their relationship as they do their dams and lodges. Males and females co-parent their young and stay together. Although beavers occasionally may philander, it is not a reason to break up the family. Genetic studies (Syrůčková et al. 2015, Crawford et al. 2008) show that the Eurasian beaver is truly monogamous and all offspring have the same parents while offspring of the North American beaver may have different parents. Beaver extended-family units are called colonies which describes a spatially associated combination of individual families. A beaver colony typically contains the adult parents, the young of the current year, or kits (< 1-year-old) and young of the previous year, or yearlings (1–2-year-old). As a rule, the young are vulnerable and may benefit from protection by both parents. Both parents invest in their offspring. The main bonds in the family group are parenthood, social and personal affection, personal recognition of family members, and feeding. The young are usually weaned when 2 months old. After that, sub-adults help feed them by bringing small twigs and soft bark to them until they are about 3 months old (Belova 2001). The spring is an important period in family life as in the late spring, two-year-old sub-adults leave the family (such dispersal allows the family to avoid increased food and inbreeding preassure) and start breeding during the next year; this comprises the 3-year rotation cycle. Young beavers imitate activities of adults (learning) but their efforts are not effective yet (Müller-Schwarze and Sun 2003, Nolet 1995, Belova 2001). Young animals are the most vulnerable during their search for a suitable territory. Retreated young beavers can come back to parental territory but do not stay longer avoiding family sallies. This event is an important factor for population distribution. If there is a lack of suitable habitats while beavers are very abundant, the juvenile mortality increases, family composition changes and escalation of interrelations occurs. Beaver reproduction depends on weather changes and the number of breeding females ranges from 50 to 86 %. All family members mark territory and take care of yearlings by the age of two months (it is named “alloparental behaviour” i.e. parental behaviour exhibited by an individual towards young to which it is not parentally related). Until juveniles are 2 months of age, beavers feed close to their lodges or burrows and do not allow juveniles to get away from the home (adults grip their necks, underlay the front legs under the belly of the young and bring them back home).

Beavers are mostly crepuscular and nocturnal animals, but their activity changes seasonally with culmination in the autumn during preparation for wintering, and in spring during reconstructive activity after the wintering, when they also may be active in daytime.

They are less active above the ice in temperatures below –10 °C (Novak 1987), but do not hibernate, and stay active under the ice (Banfield 1981). Recently during the mild winters and under changeable weather conditions, the thermal factor and soil freeze depth become less significant (e.g. r=-0.12) for beaver (Belova 2006). In spring, beavers can build dams across larger rivers if spring flow is low. Seasonally, they construct dams in wetlands, estuaries and lakes and other water bodies if the water level is reduced.

Eurasian beavers are very territorial and strongly defend and mark their territory with castoreum, a form of olfactory communication. The odour is very strong and warns anybody that the territory is already occupied. The defence of the territory is more important than feeding. Beavers defend their homes using display fighting (staying on the hind legs, snapping the intruder’s fur and directly pushing them away from the territory) (Belova 2001). Beavers hold mud and vegetation tight to their chest with the forelegs and push themselves up the bank with their hind legs until they have a mound. Then animals apply castoreum to the mud pile creating a scent mound. The most intensive marking occurs in the rearing period and at the end of summer during the retreat of second-year beavers from families.

Beavers may live for 30 years, but the period of intensive breeding is between 5 and 10 years old (Czech 2010, Campbell–Palmer and Rosell 2015).

Like all species, beavers are exposed to a number of parasites and diseases. Common and obligate parasites on the Eurasian beaver in Europe are the beaver fluke *Stichorchis subtriquetrus*, and the nematode *Travassosius rufus*. Other helminth species are also occasionally found (Romashov 1969). The beaver is also a host for a large number of fur mites (see e.g. Bochkov et al 2012). A small beetle, the “beaver louse”, is also living in the fur of both beaver species but does not appear to be an actual parasite (Peck 2006). When introducing beavers, screening and possible treatment for bacterial or viral infections should be done e.g. for *Yersinia* spp, *Salmonella* spp, *Leptospira* spp and *Giardia* spp (Rosell et al. 2001, Goodman et al 2012). Tularaemia in beaver sometimes can be traced to infections in terrestrial rodents that deposit urine or faeces in water, or die in water, which then harbours *Francisella tularensis* bacteria. Tularaemia infections in beaver are typically subclinical without noticeable effects on the individual or the population, but they can be fatal to beaver and cause mass mortality from local or regional epizootics (Lithuanian fauna 1988, Field Manual of Wildlife Diseases 1999, Hollander et al. 2017).

Death

Common predators of beavers are wolves, dogs, and possibly foxes (Baskin 2011) and in the northern parts of the Baltic Sea Region countries, also bears and wolverines. Humans are obviously also an enemy of beavers, having both indirect effect on beavers, transforming their habitats, but also directly, via hunting and trapping.

Species difference

To distinguish between the two beaver species, anatomical (Danilov et al 2011a, Parker et al. 2012) or genetic (McEwing et al 2014) studies may be used as well as analysis of anal gland secretion (Rosell and Sun 1999).

North American beaver is widespread in eastern and central Finland as well as in the Russian Republic of Karelia. The number of *C. canadensis* in Finland is around 10 000 (Nummi 2005) and in Russia it was at least 3 600 (Danilov 1995), but in 2002 there was about 2 000 individuals (Danilov 2005). It has not been found in Estonia, Latvia, Lithuania, Poland or Sweden (Nummi 2010). They were also introduced to Poland (1930s), where the animal farm of Popielno is a known source of supply for game reserves and zoos in Germany, France (1975) and Austria (1976–1990). However, the status of these populations is unknown (Nolet and Rosell 1998).

Table 2.1. Features of Eurasian and North American beaver (Czech 2010).

Eurasian beaver *(Castor fiber)*	**North American beaver (*Castor canadensis*)**
Nasal bones with rather parallell edges, reaching back far beyond the back end of the jaw bone. Width between eye sockets more than 25 mm.	Nasal bones with arched edges end behind the posterior margin of the jaw. Width between eye sockets below 25 mm.
The edges of the tail roughly parallell, its end rounded.	The tail seen from above is oval in shape, its end sharpened.
Number of chromosomes: 2n = 48	Number of chromosomes: 2n = 40
Tail is narrower	Tail is broader
Scull volume is smaller	Scull volume is larger
Anal gland secretion is darker in females	Anal gland secretion is darker in males
Lodges are mostly banked	Lodges are mostly freestanding
Scent mounds are smaller	Scent mounds are larger
Average litter size is 2–3 kits	Average litter size is 3–5 kits

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Chapter 3: Distribution in Europe and country-specific population status

Olgirda Belova

Wild animals need spatially and temporally varying habitats that contain sufficient and available food supply and shelter. The Eurasian beaver, once widely distributed across the Baltic Sea Region has been affected by human activities throughout the centuries. Humans have transformed the landscape for their own needs from prehistoric times. Beaver populations are affected directly by hunting/trapping, and also indirectly through forestry activities. Forest logging changes drainage patterns and reduces the carrying capacity of once stable stream systems – the basic habitats of beaver. Silvicultural practices eliminate or shorten the deciduous shrub and tree stage in the forest regeneration cycle and, therefore, negatively impact beaver populations. Continuing human-induced landscape conversion results in habitat loss, increased isolation between landscape fragments and new disturbance types that challenge beaver populations. By the beginning of the 20th century, the global population of the Eurasian beaver was reduced to eight populations, totalling approximately 1 200 individuals (Halley et al. 2012). However, due to legal protection and targeted conservation measures including hunting restrictions, reintroductions and translocations, natural recolonization, land/water protection and habitat restoration, the beaver has made a remarkable recovery in the region.

Table 3.1. Beaver (*Castor fiber* L.) abundance in the countries in Baltic Sea Region

Country	Beaver number, n	Notes
Sweden	130 000	
Finland	3 300-4 500	plus > 10 000 *Castor canadensis*
Estonia	16 300–17 500	
Latvia	100 000–150 000	71 400 by official statistics
Lithuania	85 879–121 025*	
Poland	100 000	Statistical yearbook of the Republic of Poland, 2014
NW Russia	120 500	plus 15 000 *C. canadensis* **

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

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 countries of Baltic Sea Region. In Europe, the Eurasian beaver is most abundant. Conservation measures are ongoing to prevent the population from declining again, and the species is now in the category of Least Concern (IUCN 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 and 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 3.1). The main exceptions to date are Portugal, Italy, and the south Balkans where beavers still have not returned (Halley and Rosell 2002) (Figure 5.1).

The partial protection of the 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).

Decline of the beaver

The majority of species inhabiting the earth today have existed for more than a million years (May et al. 1995, Soulé and Terborgh 1999). Both the Eurasian and North American beavers declined significantly simultaneously with an increase in human population. However, the now sympatric species Eurasian (European) beaver (*Castor fiber* L.) and North American beaver (*Castor canadensis* Kuhl.) have a different history and further development in the Baltic Sea Region. If the Eurasian beaver was known since pre-historical time and was exterminated in vast areas of this region in the 19th century, North American beaver was introduced in the same habitats, in Finland since 1937, and spread via the Republic of Karelia and Leningrad Region (northwest Russia) where their population is still stable. Crossing is impossible due to the different number of chromosomes. More data on the differences between the species are available in the Chapter 2.

Certain landowners and forest managers consider beavers to be problematic species since they cause damage to forests and adjacent agricultural lands. The beavers' building activity significantly alters the characteristics and appearance of water bodies and modifies species composition. It also 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. 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, Pollock et al. 2012, 2015, Lunkas 2013, Lönnqvist 2014, Samas and Ulevičius 2015, Glabischnig 2015, Virbickas et al. 2015, Vehkaoja 2014, 2016a, b, Bouwes et al. 2016, BACE 2016, Malison et al. 2016, others; see Chapters 4 and 10). The impact of beavers needs, however, to be assessed in a catchment and landscape context. The beaver impact to the forest is rather ambiguous. While the effect of beavers on biodiversity is most likely beneficial in catchments poor in lake-like (lentic or standing water) systems, damming of stream-like (lotic or running water) sections by beavers might have a negative impact in catchments that are already rich in lentic systems. Only one beaver family on average damages 0.84–0.14 ha of forest (Ruseckas 2011). Flooding of 163 ha of forest causes losses in wood productivity up to 264 m^3 due to beaver building and foraging activity. Unfortu-

Figure 3.1. a. Norway spruce drying along beaver ditch. b. Effect of beaver flooding on threes. c. Norway spruce intolerance to flooding. (Lithuania) Photo: Olgirda Belova.

nately, the most sensitive species to flooding is Norway spruce that is one of the economically most important species in northern and central Europe (Figure 3.1 a–c). The spruce elimination starts with 20–60 % of dried trees at the level of groundwater 10 –15 cm (Ruseckas 2011).

Coppicing bank side vegetation by beavers could be considered as cost-effective and sustainable (BACE 2016). In excessively dried marshes, beaver activity induced regeneration of black alder (Ruseckas and Grigaliūnas 2008). 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 are used for assessing environmental status and biogeographic changes in the environment, and ponds could act as water cleaning factory (Beaver Ponds Fact Sheet 2015) (see Chapter 4). 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, damage occurs locally and on small areas, e.g. 2.2 ha (Härkönen 1999). It is a 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 damage caused by beavers 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 consider these parameters in evaluations of how beavers affect the environment.

Management of beavers

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 the species' social structure as monogamic family and corresponding social and other behaviour)
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 problems 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 to help protect forest and watersheds (see the Lithuanian case, Figure 3.10).

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.

If we will look at the legal ground of the proper management of beaver populations, we see that the countries of the Baltic Sea Region, 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), and the EC Habitat Directive (Council Directive 92/43/EEC) into their national legislation. These countries have also adopted the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats).

Countries of the Baltic Sea Region have different goals when it comes to game management. Special guidelines for beaver management and monitoring have been adopted in some WAMBAF countries: Lithuania (2003), and Poland (2004). Annual monitoring of beaver ponds is performed in Latvia from 2001 (LVM, Latvia's State Forests) and in Estonia.

SWEDEN

Göran Sjöberg

The Eurasian beaver is today reported as resident in all of Sweden except the six southernmost counties, including the large Baltic Sea islands Gotland and Öland. In one of these counties, Halland on the western coast, the information is considered uncertain (Artdatabanken 2019a; Fig 3.2). The maps for Life Watch databases show data on reports of beaver more in detail, with many observations in Central Sweden and along the coast of the Gulf of Bothnia (Artdatabanken 2019a; Fig 3.3). The frequency of observations coincides, however, with human population density so the beaver is probably more evenly distributed in north and central parts of the country. Beavers are observed far north, even in the mountain areas and far above the Arctic Circle (Figure 3.4).

In the densely inhabited south, the situation is likely correctly showing near total absence of beaver occupancy. This situation may change in the near future. In the decade from 2005 and onwards, beavers have spread for example in the counties of Uppsala and Östergötland. The North American beaver has not yet been reported observed in Sweden (Artdatabanken 2019b), although it is known from the Finnish side of the border river Torne (see Finland section). On the other hand, it is not possible to see any species differences in the field so observations of North American beavers could have been misidentified.

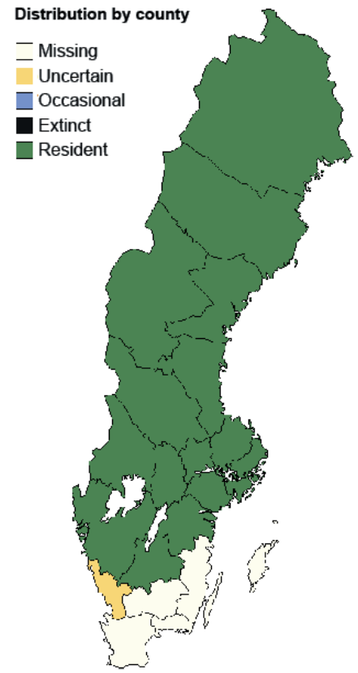

Figure 3.2. Occurence and status for Eurasian beaver in Sweden by county, based on compilation and judgement of observations. Published by Artdatabanken, SLU. (January 2019)

The spread of Eurasian beaver in Sweden was studied by Hartman (2003). He found that in one Swedish province, beaver population density increased from 0.10 to 0.21 colonies per km^2 over a 23 year period, and then levelled off. The development of beaver populations in Sweden followed models of irruptive mammal populations with densities peaking before decline. This means the densest populations will occur between the core area and the front of the range (Hartman 2003, 2011). Near the front, densities will be low partly because dispersing beavers will move long distances (Hartman 2011). Expansion speed in one studied province was up to 19.7 km/year along drainage areas but only 3 km/year across divides (Hartman 1995).

The abundance of beavers

The latest attempt to estimate the size of Swedish population was in 1992, and it was concluded that the figure was likely to have surpassed 100 000 individuals. Based on patterns of regional development, it is probable that the increase has continued since then, but at a slower rate than before (Hartman 2011). Based on regional population increase rate, a potential of 30 % increase per 12 year is possible. There is, however, considerable local variation in population growth. The Eurasian beaver is in any case considered to be above the population size for red-listing in Sweden and placed in the category of Least Concern (Artdatabanken 2019a). In Appendix 1 of the Swedish Species

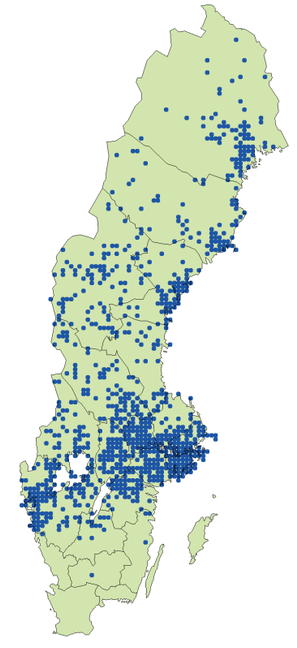

Figure 3.3. Blue dots show observations of Eurasian beaver in Sweden registered in LifeWatch databases. May contain unvalidated observations. Published by Artdatabanken, SLU. (January 2019)

protection regulation (Artskyddsförordningen 2007), it is referred to the beaver being listed in the EU Habitat directive's (1992) Appendix 5, as a species of community interest whose taking in the wild and exploitation may be subject to management measures.

However, due to the high population numbers of beavers, and the population status mentioned, it is not considered any problem to maintain a favourable conservation status of the species population of Eurasian beaver. In consequence, a legal season for the hunt is stated in Appendix 1 of the Swedish Game Regulation. There are also other parts of the Regulation that concern the beaver, for example about removing dams and lodges (Jaktförordningen 1987; see Chapters 6 and 9). These two regulations are the only laws or regulations that explicitly regulate the management of beaver in Sweden. In addition, there are more detailed instructions for shooting and trapping of beaver issued by the Swedish Environmental Protection Board (Naturvårdsverket 2018). The Board has also published handbooks and guidelines, concerning interpretation of the legislation, e.g. protective hunt, trapping, and water activities, where beaver is mentioned.

Legislation that could be said to indirectly concern beaver includes the Environmental Code (Miljöbalken 1998), e.g. concerning water operations, the Game Act (Jaktlagen 1987) which states the general framework for hunting in Sweden, the Forestry Act (Skogsvårdslagen 1979) and the Forestry Regulation (Skogsvårdsförordningen 1993). The two latter documents regulate forestry activities, including conservation measures. There is also information published by regional authorities, about prevention of damage from beaver, and the rules for this (see Chapter 9). Hunting issues in the regions are generally handled by the County Administrative Boards.

Two systems for forest certification are used in Sweden, FSC – mainly large business – and PEFC – mainly family forestry enterprise (FSC 2018, PEFC 2018). They cover about 12 Mha each of productive forest land. Both include regulations for forest conservation including prevention of damage to forest water, and aquatic biodiversity. None of these explicitly mention beavers.

Land owners, forestry companies, or hunting organisations have no particular rules or guidelines for beaver management. Beavers are not perceived as a general economic problem, and when risks for damage appear, these are handled on a case-by-case basis (see Chapter 9). The attitude to beaver in Swedish society is generally positive and there has not been any motivation for increased management other than in certain city environments. Nevertheless, media often report when the beaver activities create problems for landowners (Figure 3.5).

Figure 3.4. Beaver in the mountain areas, close to Nikkaluokta, northern Lapland.
Photo: Thomas Leinfors.

Figure 3.5. Even though beaver is generally well accepted in Sweden, newspapers frequently write about controversies concerning damming and tree-felling. Photo: Göran Sjöberg.

FINLAND

Kaarina Kauhala

At present, the Eurasian beaver occurs in the provinces Satakunta, Etelä-Pohjanmaa, Pohjanmaa, Pirkanmaa, and western parts of Lapland where beavers probably have wandered from Sweden (Fig. 3.6). Some observations come from Kanta-Häme, and the first verified observation from Varsinais-Suomi is from 2016. The population size, based on monitoring counts in the autumn of 2017, is estimated to 3 300–4 500 individuals (Natural Resources Institute Finland, Luke 2018). The main distribution area is in Satakunta but the Eurasian beaver is also abundant in southern parts of Etelä-Pohjanmaa (especially Kauhajoki).

The main distribution area of the North American beaver is in the lake district of eastern and central Finland, where the species is abundant, but it also occurs in the provinces of Pirkanmaa, Etelä- and Pohjois-Pohjanmaa, Kanta-Häme and sporadically in Lapland (Fig. 3.6). A couple of observations have recently been done also in Uusimaa, near Helsinki. The present size of the NA beaver population is estimated to 10 300–19 100 individuals (Luke 2018).

The North American beaver is probably spreading westwards and approaching the distribution area of the Eurasian beaver, which has aroused concern over the future of the native species in Finland. Because habitat use and diet of the two beaver species are fairly similar (Danilov et al. 2011, Kauhala and Turkia 2013, Kauhala and Karvinen 2018), it is likely that there is inter-specific competition for the best habitats between them, and in the worst case, the invasive species might replace the native one. At present, the two species are partly sympatric in Pirkanmaa and close to each other in Etelä-Pohjanmaa. Both species occur also in Lapland. NA beavers should be controlled at least in Pirkanmaa, Etelä-Pohjanmaa and Lapland to prevent it from spreading to the distribution area of the native beaver in Finland and to prevent its spread to Sweden from Lapland.

The Eurasian beaver is considered as 'near threatened' in the Finnish Red Book from 2015 (Liukko et al. 2016). It is not included in the class 'least concern' because its distribution area is still fairly small compared to its original distribution during the past centuries.

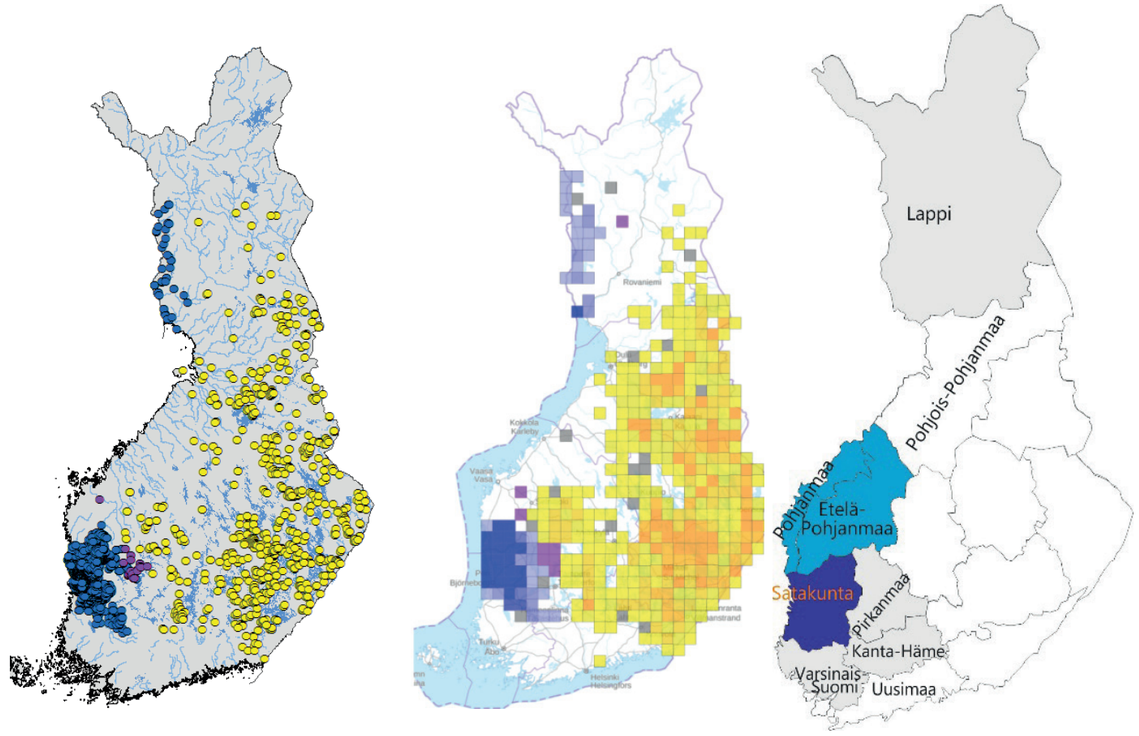

Figure 3.6. Present distribution of beavers in Finland. Left: Observations and signs of beavers in Finland mainly sent by hunters in 2015–2017 (original data: Suomen riistakeskus). Middle: Beaver lodge density in Finland, based on monitoring counts of winter lodges in the autumn of 2017 (original map: http://riistahavainnot.fi/). Blue: Eurasian beaver, yellow: North American beaver, violet: both species/species uncertain. The grey squares indicate areas where monitoring was carried out but no signs of beavers were found. Right: Occurrence of the Eurasian beaver in different game management districts in Finland. Dark blue: abundant, light blue: abundant but only in southern parts of the area, grey: sparse and sporadic. Also other provinces mentioned in the text are shown.

ESTONIA

Nikolai Laanetu and Elve Lode

Nowadays, the beaver is distributed throughout the mainland of Estonia and also on the islands including Hiiumaa and Saaremaa (Figure 3.7).

The maximum number of the beaver population in Estonia was registered in 2005–2010, when 4 500–5 000 beaver family groups were counted with a population of 18 000–20 000 individuals. In 2015, the number of beaver families had declined to 3 500–3 600 with a population of 12 000–13 000 individuals. Presently, due to intensive hunting, it has been further reduced to 10 000–12 000 individuals.

Problems

The high population density and distribution of the species in the forest-drainage systems have led to considerable economic loss in large areas, due to the destruction of the forest stands. An assessment of 58 % of Estonian water bodies during 2004–2011 shows that these were settled with 3 189 beaver families. One fifth, i.e. 19 % or 609 beaver families, had no impoundment or damming activity. The average number of beaver dams was thus 2.65 per family group, including non–damming family groups.

Based on research data, it can be concluded that as a result of the beaver activities, there were 10 000–12 000 impounded sections of water bodies formed in Estonia, with a total open water area of about 2 500 ha of micro-water bodies formed and more than 7 500 ha of waterlogged soils (without open water area) of riparian habitats. Totally, over 10 000 ha of riparian habitats of surface water bodies were created due to the beaver-induced micro-water bodies or waterlogged soils. Beaver dams also affect the hydrological conditions of fluvial water bodies and drainage ditches, to an extent of about 5 700 km.

However, 72 % of all beaver dams occurred on drainage systems of ameliorated land, and only 28 % in natural watercourses. More than 40 % of the damage occurred on forest land (Laanetu 2000, 2001). Solving the issues associated with the beaver activity requires the existence of an appropriate management plan for the species and the implementation of its requirements.

The beaver population has been included into the Estonian Habitats Directive, Annex V. According to this document, the beaver population should be managed according to the requirements of the management plan. In order to maintain a sustainable beaver population in Estonia, the Action Plan (2000–2005) for Protection and Use of Beaver (*Castor fiber* L.) requires to keep the beaver abundance within permitted limits, which implies a quality assessment of the beaver habitats and planning of the beaver occurrence in accordance with the needs of species protection and the impact of beaver activity on environment and economy.

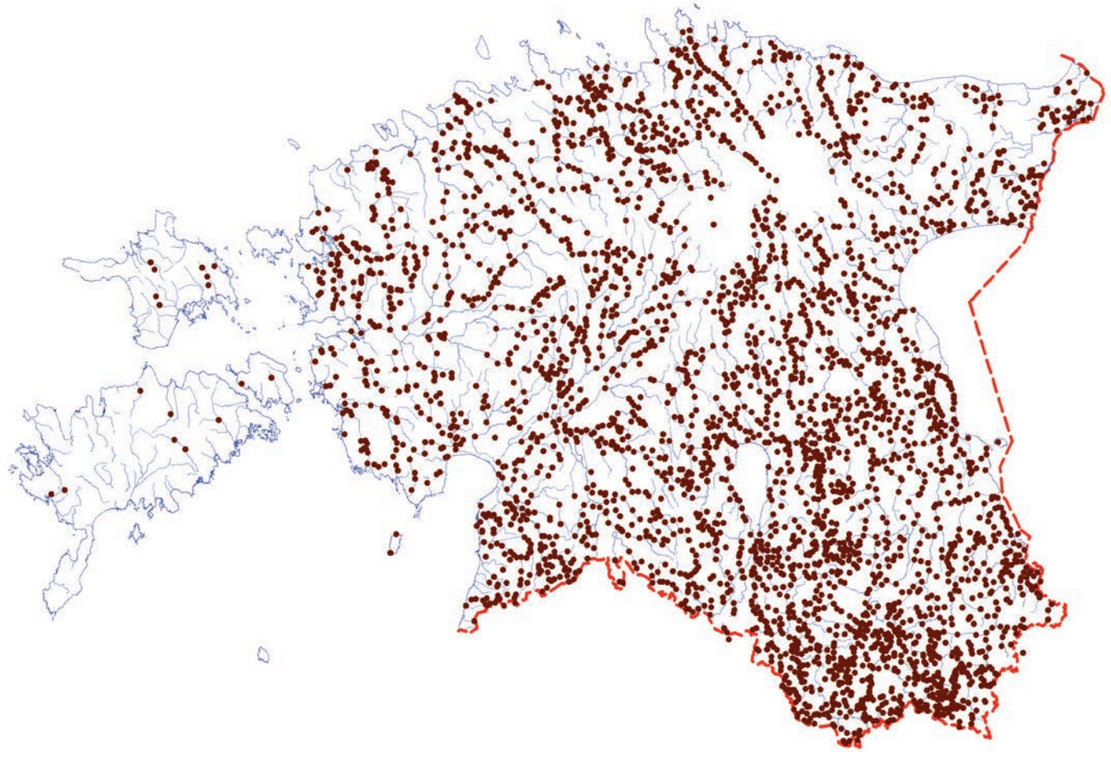

Figure 3.7. Distribution of beaver family groups in Estonia by elaborated count in 2015–2016.

According to the Estonian Hunting Act, the beaver is included in the list of small game animals and its hunting season is indicated in the hunting calendar, from the 1st of August to the 15th of April, while the hunting bag size is not limited. Under the current law, a hunter–landowner, as well as hunting area user, i.e. licensed hunter of the Hunting District area, can hunt beavers and restrict their activities without taking into account species conservation needs and hunting management principles. The family counts are carried out in order to evaluate the beaver abundance according to the Estonian Hunting Districts division.

Strategy of beaver population protection and use in Estonia

According to the beaver management plan, including environmental and economic considerations, beaver habitat is suitable habitat on such parts of the water bodies, where the activity of the beavers is resulting in little economic damage and having significant increase on environmental protection and recovery effects. As a result of these principles, the beaver habitats could be defined in three categories of protection and use:

I –Water bodies, where the beavers are allowed

In these water bodies, the environmental impact of beaver activity is positive and the harmful effects on society and on other environmental values are small or absent. There is no restriction on the occurrence of beavers in these areas, and no intentional hunting is planned. However, those areas are defined on the base of the number of beaver individuals during the Planning and Assessment procedure in the way that the beaver population increment does not exceed the local carrying capacity due to the beaver population growth and corresponding negative consequences. In Estonia, such habitats are located on larger rivers and lakes, and also in economically low-productive floodplain forest between the moraine landscapes. Beaver families living in these areas ensure the survival of beaver as a species also during critical periods of population decline. These beaver habitat sites are also a permanent habitat for many rare species, and in addition to nature conservation areas, the beaver population level in these areas is preserved, which will ensure the population's recovery ability in general.

II –Water bodies, where the beaver activity is kept under control

Such water bodies are mostly recipients of land reclamation waters, medium-sized Estonian rivers and lakes, and the shores of water bodies of which there are species-rich communities and high-value tree stands, or high recreational values. In the cases when the beaver damage exceeds the local carrying capacity of beaver damage, the owner or user of the Hunting District is obliged to catch or hunt beavers, or use mitigating measures to limit the damage. This type of beaver-colonised water bodies are also the beaver habitats, where the main portion of the economically exploitable part of the hunting is planned.

III –Water bodies, where the occurrence of beavers is not allowed

These are water bodies or sections of the water bodies, where the beaver activity causes great economic loss or undesirable effects on environment and key habitats. Such water bodies are predominantly forest drainage ditches and low-sloped watercourses, with valuable and high productivity tree stands, often protected meadows with well-developed and species-rich permanent (climax) communities, or arable land in the riparian areas. It also includes spawning streams for migratory fishes including several salmonids, and water bodies with protected and threatened habitat species (e.g. freshwater pearl mussel *Margaritifera margaritifera*). In these areas, beavers should be caught or hunted, and restriction of beaver activity could take place even outside of the officially determined hunting periods by permission from the Environmental Board. Based on these three principles, 58 % of Estonian surface water bodies have been evaluated for the quality of beaver habitats and the level of permissible abundance. Thus, the maximum allowable beaver abundance in Estonia can range from 20 000 to 21 000 individuals, an optimal abundance from 10 000 to 11 000, and a permitted minimum abundance from 3 000 to 3 500. When abundance decreases below the permitted minimum, hunting must be stopped and it is necessary to ensure that the species is recovered or restored. Principles of the beaver conservation and population utilization designed in this way ensures positive status of the beaver population together with positive effects of the beaver's activity on the environment and keep the negative effects within permissible limits. With the help of the beavers, it is possible to create preconditions for biodiversity increment, survival of a number of rare species, and local recovery or improvement of the quality of surface and groundwater resources.

LATVIA

Jānis Ozoliņš

In Latvia, recently the Eurasian beaver (*Castor fiber*) occurs all over the country. This is achieved by a strict protection after reintroduction in 1927 till 1981 when the first permits for beaver harvest were issued. In-between, several population supplementation and translocation actions were performed promoting dispersal (Balodis 1990).

After regaining political independence in 1991, Latvia has signed the Convention on the Conservation of European Wildlife and Natural Habitats (Bern 1979). The Eurasian beaver is listed under Annex III Protected fauna species.

This means that governments that have signed this convention should organize management of the species with certain limitations (closed season, types of hunting) as well as regulating the trade of animals and their body parts. Its enforcement in Latvia is implemented by the Law On the Convention on the Conservation of European Wildlife and Natural Habitats (Bern 1979) (adopted on the 17th of December 1996, enforced since the 3rd of January 1997).

After joining the European Union on the 1st of May 2004, Latvia became a so-called geographical exemption for the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, transposing the species from Annexes II and IV to Annex V, which means that hunting for beavers may be conducted by means not prohibited by the Directive, on the condition that population monitoring and a favourable conservation regime is ensured.

Hunting regulations

Recently, the beaver is a game species without restrictions in cull numbers, but there is still a closed season from 16th April till 14th July. Generally, the hunting rights in Latvia belong to the landowners. If a landowner has no right to practise hunting, he or she can agree with the hunters to use the game resource, beavers in this case, in his/her territory. Wildlife is nobody's property unless a wild animal is legally killed by somebody who has the right to hunt, and the government is not responsible for the damage done by the beavers because the landowners have sufficiently wide options to control their numbers. In order to preserve widely ranging animals from being exploited by countless landowners (elk, red deer, roe deer, and wild boar), legislators have appointed a minimum size of hunting grounds. This restriction does not concern beavers and they can be hunted regardless of estate size. Since the average size of private forest in Latvia is only 9 ha, this might be a risk if the beaver population would decrease to a low density and too many forest owners would be capable of eliminating beavers. The largest forest manager – the stock holding company "Latvia's State Forests" – has elaborated a special agreement system with the hunter clubs. Managing the state forests in over a century, the company maintains and renovates historical forest drainage systems as well as provides recreation and hunting services. Major part of the woodlands is leased for hunting to the local hunter clubs. If a renovated drainage system is present in a hunting ground, the hunters have to sign a written agreement about beaver management to prevent ditches from damming. The agreement includes a framework for actions and a timetable, which are mandatory for the users of hunting rights. If required management actions are not performed, the authority can break the lease contract and hunters may lose the rights to hunt in the state forest also for other game species. However, usually disagreements are negotiated and beaver damage to forest infrastructure eliminated as prescribed by the contract (Fig.3.8).

Conservation issues

Another challenge to beaver management in Latvia is related to beaver impact on nature conservation, especially the conservation of natural habitats being in a tight mutual connection with beaver activities (Kawata and Ozoliņš 2014). A striking example is from Lubana Wetland Complex. This protected area preserves (NATURA 2000 site) about 480 km^2 of wetland area, important for rare bird, mammal and plant species as well as being famous for its untouched raised bog ecosystems. However, Teiči bog (150 km^2) still suffers from land reclamation by the drainage of surrounding forests and wet meadows. As a result the forest is slowly overgrowing the open bog area designated for conservation. An EU-funded project (LIFE03 NAT/LV/000083) was initiated in 2002 to prevent bog drainage by artificial damming of reclamation ditches; 67 artificial dams were built while beavers were efficient assistants in maintaining the artificially made dams.

Figure 3.8. Beaver damage to a local public road (top) and the same place after road repair two weeks later.

In contrast to the above described example, beaver activities appear obstructive for habitat conservation of the freshwater pearl mussel (*Margaritifera margaritifera*). This mollusc inhabits a few small and medium-sized natural, rapidly flowing rivers in vicinity of Smiltene town where Latvia's Fund for Nature funded a project for its habitat management. Reproduction of the mussel depends on an abundance of brown trout (*Salmo trutta fario*) which also prefers rapids. Beavers turn the rapids into chains of ponds and slowly flowing stretches. Destroying the beaver dams and eliminating the beaver families is the only solution to save this mollusc from complete extinction in residual waterways. The project involved local hunters with whom the project manager signed agreements on beaver catching and cleaning the riverbeds. The work was supervised, expenses reimbursed and the pearl mussel population monitored before and after control of beaver activities.

Another, however, insufficiently understood, aspect of beaver presence is their contribution to habitat improvement for other wildlife. For instance, it is noticed that beaver sites are frequently visited by the carnivores belonging to the species of importance in the European Community and either requiring full protection or being subject to conditions of restricted exploitation. These are otters, wolves, lynx and brown bears. In theory, beavers make the habitats that attract the carnivores searching for their prey and shelter. However, just the inaccessibility to humans of many beaver sites should be considered in particular when assessing interactions between beaver and the distribution of large predators. Supposedly, a high abundance of beavers in Latvia probably has promoted favourable status of the carnivores. Beavers also provide a prey for carnivores by themselves, and their remains are found when studying both wolf and lynx diet from stomach contents (Žunna et al. 2009, 2011).

Beavers in Latvia are also well known for their ability to live close to the people, including highly modified waterbodies and urban environments. Regular signs of beaver presence in the very centre of Riga city became evident in the mid-1990s. Recently, beavers have been using the 3 km long Riga canal surrounding the old town and running through the central park. They can be seen at dusk and leave their tooth marks on the majority of tree stems along the canal. Formerly, park managers requested permission to abolish the settled animals by all means. Actually, the capturing or killing of beavers would be useless and never ending because the beaver population density is very high in lower reaches of the Daugava River passing the city and being the main stream side by side with the canal. In 2010, the City Council announced a competition for the best proposal on how to solve the beaver problem in Riga's centre. The judging committee of the competition met an unexpected responsiveness, and 70 proposals from the city inhabitants, people all around Latvia and even foreign countries were submitted. Proposals were evaluated in two rounds and the three best were finally selected. They all accepted coexistence with the beavers in the city and made use of mitigation strategies. Management actions include preventive protection of the trees and shrubs by decorative metal grids, supplementary feeding of beavers by tree branches brought from the forest and improving public awareness of the city inhabitants and visitors. Since 2011, the management strategy is successfully implemented.

The estimated population size in 2016/2017 was 58 000 animals (State Forest Service, 2018) but, according to the

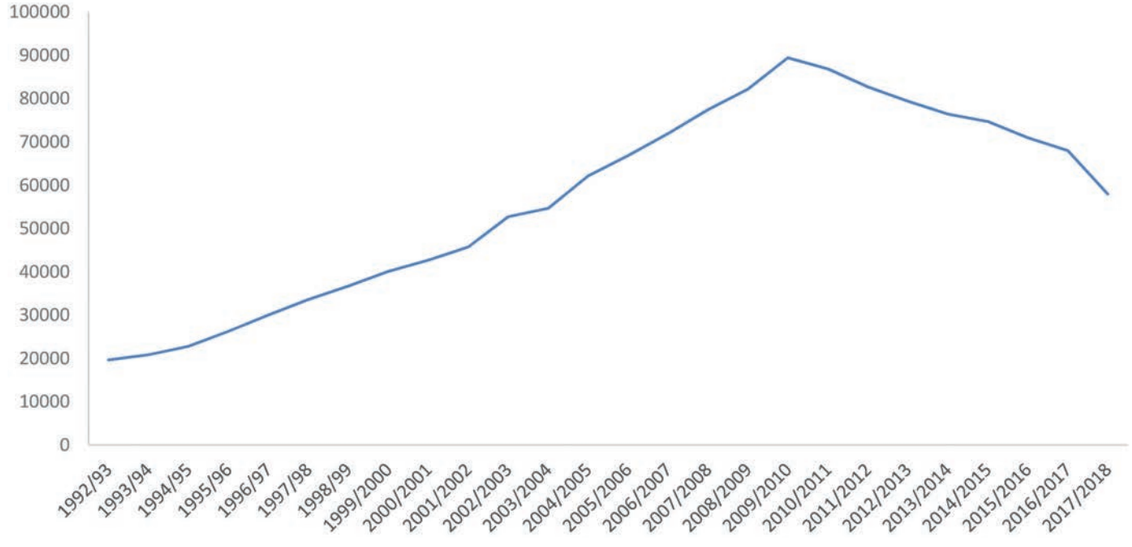

Figure 3.9. The estimated population of Eurasian beavers in Latvia from 1992 to 2018.

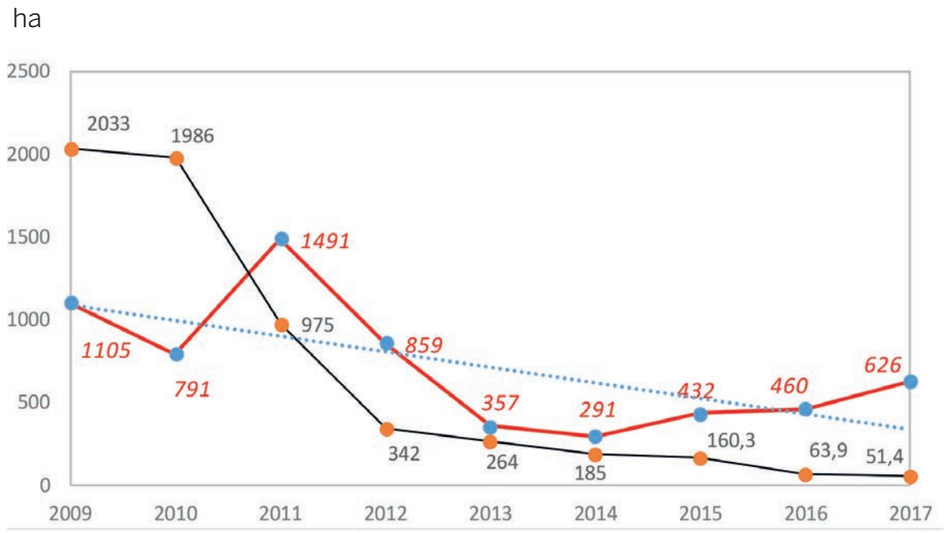

Figure 3.10. Example of the management of beaver dams: forest area (ha) of the removed unallowable beaver dams (red line; damage to forest) and remained allowable (black line; no damage/damage negligible) dams in Lithuania, (blue dotted line is the trend of the damaged area) (Source: The figure is based on data obtained from the Department of Forest Sanitary Protection of the State Forest Service, Lithuania)

expert opinion, the actual population size could be as high as 150 000 animals (Jānis Ozoliņš, pers. comm.). The population increased steadily during the first decade of 21st century, peaked in 2009/2010 when the formally estimated number of beavers reached almost 90 000 animals and is now gradually decreasing (Fig. 3.9).

LITHUANIA

Olgirda Belova

The quantitative management (the assessment of number) of beaver populations in Lithuania is based on the specific national regulations (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 "allowable" beaver sites, where damage is negligible or in the absence of damage and habitat conditions meet species-specific requirements); and unallowable 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 (Fig. 3.10). The list of such watersheds is governmentally approved (Žin. 2004, Nr. 137-4995).

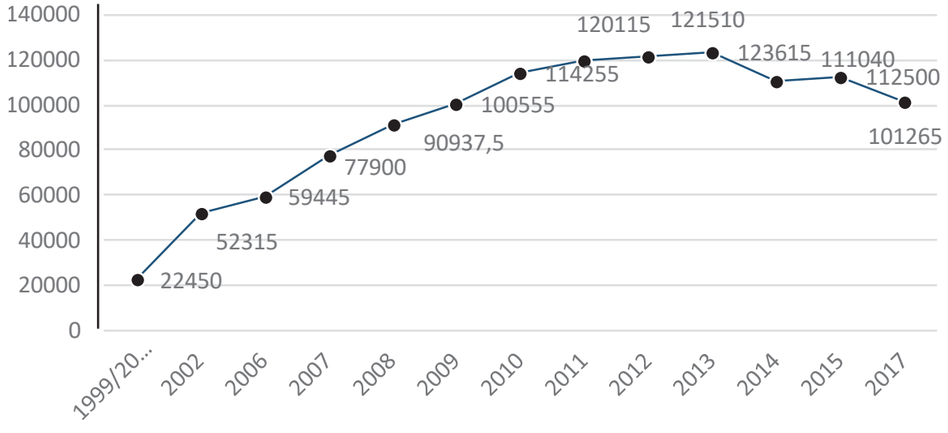

Figure 3.11. Long-term changes in the number of beavers in Lithuania.

Landowners, forest owners, forest holders and users of a hunting ground unit have the right to remove beaver dams in the "unallowable" beaver sites using manual and mechanic means (Conibear traps, dogs, dam removal) during the entire year. The role of city beavers is not so markedly expressed as most citizens accept their existence positively, moreover, such beaver sites are under attention of the Environment Protection Department and hunters who help to manage beaver dams practically.

Such practice requires 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.

The Eurasian beaver, once widely distributed in Lithuania, was affected by human activities for centuries. However, the beaver has recently made a remarkable recovery due to legal protection and targeted conservation measures, which have included hunting restrictions, reintroductions and translocations, natural recolonization, land/water protection and habitat restoration (Fig. 3.11). Many reasons, both human and natural ones, caused significant increase in beaver number.

The most abundant local populations have formed in North Western Lithuania including Žemaitija highland, while beaver number decreases towards South Eastern Lithuania, and from Central Lithuania beaver number increases again. Beavers select habitats with rich food supply and suitable habitats. In Lithuania, beaver is most distributed in the drying ditches (near 36–40 %), in streams and rivers (near 18–20 %), lakes (16–17 %) and different swamps and other wetlands (15 %).

POLAND

Michał Wróbel

In Poland, the Eurasian beaver is under partial protection according to the Regulation of the Minister of the Environment of 6 October 2014 "On the protection of species of animals" (Journal of Laws No. 1348). The beaver in Poland is also under protection by European legislation as the Berne Convention and Council Directive 92/43 / EEC. Berne Convention – Convention for the Conservation of Species of Wild Fauna and Flora and Their Habitat, done in Bern on 19 September 1979. The objective is to protect wildlife species and their natural habitats, especially those species and habitats whose conservation requires the cooperation of several countries, promoting cooperation in this area. The Eurasian beaver is listed in the Annex III, Council Directive 92/43 / EEC of 21 May 1992 "On the conservation of natural habitats and of wild fauna and flora" (the so-called Habitats Directive) Annex II and V.

The Polish legislation related to the beaver has set up prohibitions referred to in Article 52 sec. 1 of the Act of 16 April 2004 on Nature Protection (Journal of Laws of 2009, No. 151, item 1220) as follows:

- deliberate killing, mutilation and capture;
- transportation, acquisition, detention, possession and breeding of live animals;
- collection, retention and possession of specimens of species;
- deliberate destruction of young animals;
- destruction of their habitats and refuges;
- destruction of their lodges, burrows, dams, and other shelters;
- preparation of specimens of the species;
- selling, acquiring, offering for sale, exchanging and donating specimens of the species;

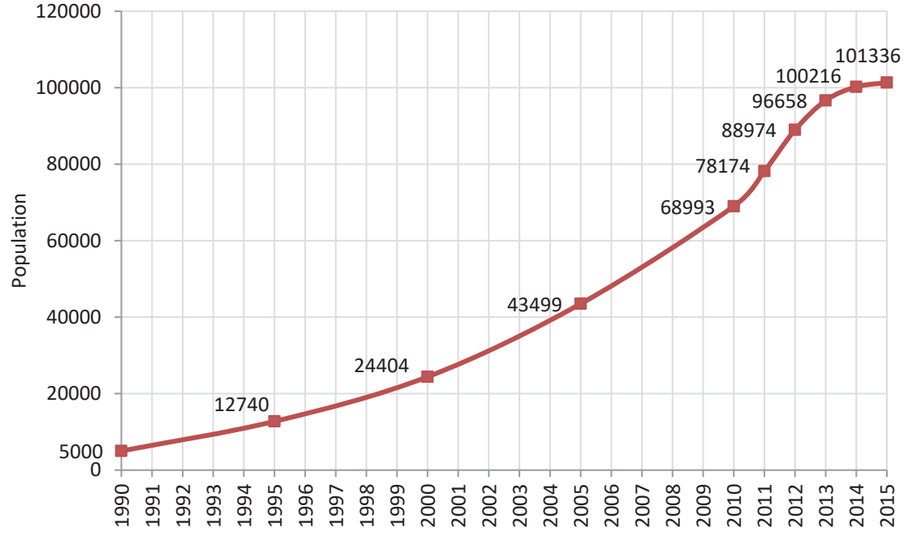

Figure 3.12. The Eurasian beaver population in Poland [*Central Statistical Office*].

- import from abroad and export of specimens of the species;
- intentional disturbance;
- photographing, filming and observation, which may cause scare or disturb them;
- moving from their habitat to other places;
- relocation of born and reared captives to natural sites.

In Poland, the beaver is not listed as a game species in The Regulation of The Minister of Environment of 10 April 2001 "Defining the list of game species and determine hunting seasons for these animals" (Journal of Laws No. 43, item. 488).

However, removal of beaver dams is possible on the basis of appropriate assumptions and requirements, and obtaining a permit from the Regional Director for Environmental Protection or the General Director for Environmental Protection. Also, in the forest certification documents there are regulations protecting the beaver as a species:

FSC (Forest Stewardship Council) – 20.01.2014: Forest managers are aware of the obligation to protect the species on the official list of protected actually occurring in the forest. Beavers are protected but are not explicitly mentioned in the document.

PEFC (Programme for the Endorsement of Forest Certification) – 18.02.2005: General statement. Forest management seeks to preserve, protect and enhance forest biodiversity at the genetic, species, and ecosystem levels. Beavers are not explicitly mentioned in the document.

In Poland, the beaver population has increased significantly in recent years. The number of individuals was in 2015 estimated at over 100 000, which means it has doubled since 2005. The dynamic population growth observed in recent years is however in the last years replaced by stabilization (Fig. 3.12).

The inventory carried out under the Natura 2000 programme and in the Forest Districts showed that the beavers are present practically throughout Poland. The exception is the northern areas and the southern part. The greatest numbers of beavers were found in the north-eastern and western areas (Fig. 3.13).

The most common conflict situations are related to the negative impact of beavers on the agricultural economy. The most common is the flooding of land as a result of construction, and blocking culverts and destroying causeways. In forest areas, damming is most often encountered, blocking culverts, destroying dykes, and digging canals. As a consequence, the trees are weakened or killed. In the vicinity of waterfalls, there is a danger due to trees being cut by beavers. Forest damage caused by beavers is very rarely reported. Methods to solve problems that are caused by beavers are presented below.

Compensation

The most common solution used by nature conservation services is to pay compensation for losses caused by beavers. This method is rarely used in other countries, and represents a serious burden on the budget of the voivodships (provinces). It limits the availability of funds needed to carry out other security work. It does not solve the conflict, and only to some extent compensates for damage.

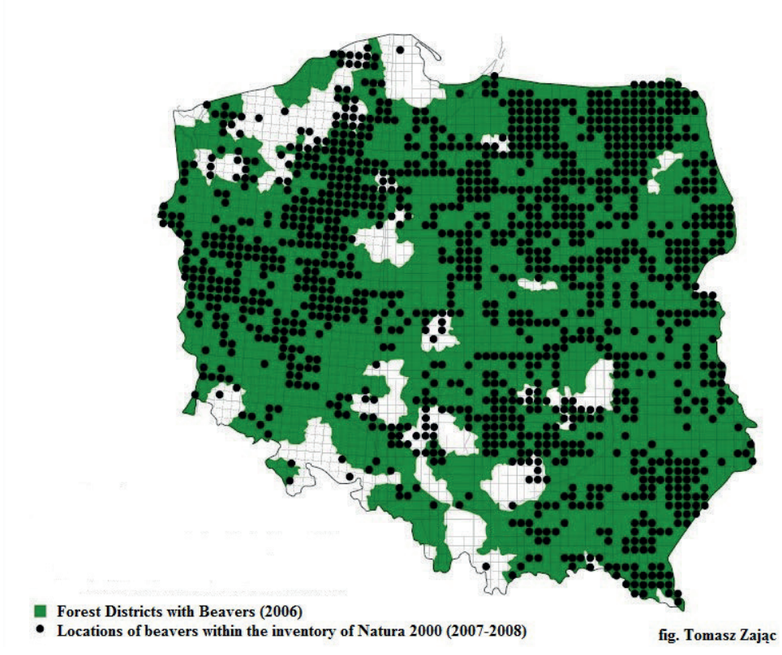

Figure 3.13. Locations of beavers in Forest Districts in Poland (2006) (Czech 2010).

Resettlement

In the event of a conflict, all the beavers at a given location are caught. However, when the beaver density in a certain area is large, the vacated habitat is rapidly colonized by other beavers and the conflict reappears, at the latest, within a few consecutive years.

Removal of dams

Dismantling of the dam is possible, but requires permission from the relevant services. The effectiveness of this method is not high, because the beavers quickly rebuild the dam, and most often in the same place. Also, removal is expensive, especially when heavy equipment is used.

Securing land and upgrading of dams

Conflicts also appear in the area of protection of culverts, fencing or modernization of dams. Methods to minimize or mitigate conflicts are based on the application of appropriate technical means such as protection and expansion of the shoreline of watercourses and reservoirs, the protection of valuable trees by wire mesh wrapping, and the protection of potentially endangered culverts through the use of pipes and nets.

RUSSIA

Alexander Porokhov

At the beginning of the 20th century, within the borders of the modern CIS (the Commonwealth of Independent States) and BSR countries, beavers were preserved in some parts of the Neman, Dnieper, Don, Ob and Yenisey river basins, such as the following:

- Belarus (Neman, Berezina, Sozh and Pripyat basins)
- Ukraine (Pripyat, Teteriv and Ubort basins)
- Russia: Smolensk and Bryansk regions (Sozh basin)
- Russia: Voronezh and Lipetsk regions (Voronezh and Don basins)
- Russia: Urals, Tyumen region (Konda and Sos'va basins)
- Russia: Republic of Tuva (Yenisey upper reaches and Azas river).

By 1934, the total number of beavers within former USSR borders did not surpass 1 500–2 000 animals (Dyakov 1975). At the beginning of the reconstruction of the Eurasian beaver's natural habitat the main population was concentrated in the European part of former USSR, mainly in Voronezhsky State Nature and Berezinsky Biosphere reserves and territories near the same rivers, including the Sozh river basin. These populations became the principal source of breeding material for introduction in another regions (Dyozhkin and Zharkov 1960, Dyakov 1975).
As for the North American beaver, it did not occur in the wild in the Russian Federation until the middle of the 20th century. If we consult M. Y. Mavrin (1951) data on Karelo-Finnish SSR fauna, we find that beavers did not reside there at all. Later the same author (Mavrin 1959) stated that beavers had appeared in the territory of the Republic of Karelia, defining them as the Eurasian species. This hypothesis was refuted by L.S. Lavrov (1965, 1981), who together with G.A. Troitskiy and P.I. Danilov concluded, after their field studies late summer 1964, that the beavers residing in Karelia at that time could be classified as North American beavers. It is noteworthy that North American beavers came into the Russian Federation after their 7 ancestors first were released in Finnish water bodies in 1937. Two of them had been released in the border district Sääminki, and five animals in South Central Finland (Linnamies 1956). According to data provided by S.Lahti and M. Helminen (1976), the beavers in question originated from the Northern part of the state of New York (USA) and became the origin for a large beaver settlement near Sääminki. During 15 years (1940–1954) several groups of animals settled in other places, including six North American beavers in the Koitajoki river basin. In this way, the second group of North American beavers near the Russian border appeared. Several groups of animals spread to today's Republic of Karelia from there on their own (1952), and in the late 1950s to the beginning of the 1960s, they were observed on the Karelian Isthmus in the Leningrad region (Provorov 1963, Lavrov 1981).

In the late 60's they had already settled in ponds of the Kalevalsky, Kondopozhsky and Pryazhinsky Districts of Karelia (Danilov 1975). In a few years, North American beavers reached the Belomorsky District, and the total number of animals in the republic was about 1 100–1 200. By 1985, about 1 500 animals resided there (Kanshiev and Nikanorov 1988). In the mid-1990s, the North American beaver colonies were noted near the rivers Olonga, Pistaeki, Volada, and Rolonga in the Lopukhsky district and at the rivers Vomzha, Vyg, and Nyukhcha and its tributaries in the Belomorsky, Segezhsky and Medvezhyegorsky Districts. In 2000, the beaver population in Karelia comprised 800 animals. North American beavers reached the Arkhangelsk region from Karelia and tried to settle in the habitat of Eurasian beavers (Danilov 2005, Danilov et al. 2007, Kanshiev et al. 2007). It may be noted, that the first beaver colonies had been registered in the Murmansk region near the rivers Tennieyoki, Tuliche, and Yavre in 2006 (Kanshiev et al. 2007). In the Karelian Isthmus in the Leningrad region, in addition to the Vyborg district, water ponds in the Priozersky District had been occupied by North American beavers by 1967. By the mid-1970s they had been observed throughout the major part of the

Karelian Isthmus. By 2006, the number of animals was about 1 000 (Danilov et al. 2006). In the territory of the Leningrad region there were 2 276 North American beavers in 2014, and later somewhat fewer – 2 158 animals (State…, 2015). Since the 1970s, North American beavers were established in the Russian Far East. For example, 45 animals were released in the Khabarovsky Krai in 1975, and the same number in the Amur region in 1976. 50 animals appeared on Kamchatka in 1979. In total, 800 North American beavers were released in Russian Federation. According to data provided by V.G. Safonov and A.P. Saveljev (2001), there were about 200 beavers in 1995 in Kamchatka only. Hunting was banned there, as well as in the Primorsky Krai. In the Khabarovsky Krai, two beaver species together numbered 400 animals in 1995.

Success of the beaver

We can now say with certainty that during the past 80 years, beavers in Russia almost completely reconstructed their previous habitat, and their number approaches 650 000 animals (Survey…,2016). In the North-Western federal district only, comprising the Republic of Karelia, the Republic of Komi, Archangelsk region, Vologda region, Kaliningrad region, Leningrad region, Novgorod region and Pskov region, the beaver population was 155.7 thousand animals in 2015. Details of the regional distribution of the beaver population are presented in Table 5.2.

In the North-Western federal district of the Russian Federation, the number of beavers increased from 2005 to 2015 by 45 % (from 107 300 animals to 155 700 (Table 5.2). The minimum number during the period was registered in 2005, and the maximum was registered in 2013 in most parts of this federal district. In 2014, the number of animals was still high, and in 2015 it reached 155 700 animals, which means 21 % less than the number in 2014 (189 3000). Beaver population figures decreased in 2015 as a consequence of natural changes in the population, possible errors during the field census studies, and loosening of control on the behalf from executive authorities of subjects of the Russian Federation (State…, 2014). Furthermore, fur trade products are not demanded on the market, and as a result, the demand on the hunting bag for the two beaver species (*C. fiber, C. canadensis*) decreased. This may also have brought down the officials' interest in the registration of this hunting resource, as it said in the report in question.

Table 3.2. Beaver population estimates (*C. fiber* and *C. canadensis* combined) in the Russian Federation.

Federal districts, subjects of Russia	Beaver population estimate, N thousands of animals										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Russian Federation, total number	385.50	438.57	465.10	550.75	614.98	633.81	620.56	662.63	669.12	645.35	621.14
Northwestern Russia	107.30	115.02	117.50	153.40	158.80	160.50	158.05	180.06	191.96	189.30	155.70
Karelia Republic	9.00	10.00	10.00	14.00	14.00	14.00	1.39	6.67	14.60	15.00	16.00
Komi Republic	8.80	9.00	9.50	10.60	12.00	14.50	14.10	15.90	16.00	13.40	13.00
Archangelsk Region	20.50	21.00	21.00	22.00	22.00	21.00	21.00	30.30	30.30	30.30	19.50
Vologda Region	15.00	16.00	17.00	32.40	32.40	32.60	38.99	38.90	38.99	38.99	29.78
Kaliningrad Region	3.00	5.02	5.50	5.00	5.00	5.20	5.20	7.08	7.62	6.74	6.47
Leningrad Region	23.00	24.00	24.50	24.50	25.00	23.00	24.35	25.13	26.59	26.65	25.60
Novgorod Region	16.00	18.00	17.00	32.40	32.40	32.60	38.99	38.90	38.99	38.99	29.78
Pskov Region	12.00	12.00	13.00	12.50	16.00	17.60	14.03	17.18	18.87	19.23	15.57

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Beaver pond near Surahammar, Västmanland, Sweden. Photo: Frauke Ecke

Chapter 4: Beavers as ecosystem engineers

Frauke Ecke

There are many examples of ecosystem engineers with beavers however being one of the most prominent representatives (Jones et al. 1994). Lake- or stream-living beavers that don't build dams can have a major impact on for example local tree species composition and plant succession or also sediment dynamics. The engineering function of beavers is mainly associated with their dam building that has cascading effects on biogeochemistry, hydrology, ecosystem structure as well as biodiversity (Naiman et al. 1988). It's also the effects of dam building that distinguishes beavers from most other ecosystem engineers since the damming not only alters the environment locally (the scale of engineering activity), but potentially at the scale of entire catchments or even landscapes (Figure 4.1). Beavers modulate their abiotic and biotic environment in such a way that they not only are engineers, but also keystone species. As such they play a central role in community structure and their removal results in comprehensive alterations of ecosystem processes and functioning (Jones et al. 1994).

Beavers became almost continent-wide extirpated in most European countries for more than 100 years and lack of ecological impact for probably almost 200 years. Today, beaver systems with cascades of dams are often still regarded as peculiarities, while they in fact have been common or even dominated stream systems in many European countries for thousands of years, shaping today's riverine landscapes.

There have been numerous reviews that have addressed the engineering potential of beavers especially at the scale of individuals ponds and beaver systems (e.g. Collen 1997, Gurnell 1998, Janiszewski et al. 2014, Naiman et al. 1988, Parker et al. 2012, Rosell et al. 2005, Stoffyn-Egli and Willison 2011, Stringer amd Gaywood 2016), while the attempt to quantify the environmental impact of beavers is still rather limited (but see Ecke et al. 2017, Kemp et al. 2010). The focus of the here presented overview is on the environmental and ecological impact of beavers at the catchment and landscape scale.

Despite being different species, the engineering activities of the North American (*C. canadensis*) and Eurasian beaver (*C. fiber*) do not differ (Danilov and Fyodorov 2015, Parker et al. 2012). Hence, in this chapter, the engineering role of beavers is illustrated by examples from both species.

Hydrological effects

Dam construction converts stream sections into ponds upstream of the dam, increasing both the upstream water volume and area and decreasing velocity (reviewed by Ecke et al. 2017). This conversion significantly reduces the length ratio between stream like (*lotic*) and lake like (*lentic*) stream sections (Andersen and Shafroth 2010). The extent of the hydrological effect largely depends on the geomorphology of the dammed area (Johnston and Naiman 1987). In flat areas, the increase in water volume increases both flood risk and the water table in productive forests or agricultural areas with subsequent significant economic loss (Bhat et al. 1993, Sund 2009; see also section on coarse woody debris). Hydrological effects are however not restricted to upstream areas (Figure 4.1). A significant amount of water bypasses beaver dams, increasing surface runoff and groundwater seepage (Westbrook et al. 2006). By increasing water retention in low order streams, beavers provide the so far largely underestimated ecosystem service of flood control downstream in the catchment (Puttock et al. 2017). In analogy, the collapse of a beaver dam increases flooding risk downstream (Andersen and Shafroth 2010), an effect that might be mitigated by the presence of cascades of beaver dams.

Considering these significant effects of beavers on the hydrological regime at the catchment level, their regulating role might even become more pronounced considering climate change scenarios. In northern latitudes, frequency and extent of extreme weather events are predicted to increase (IPCC 2014, Pecl et al. 2017). In summer, this will result in longer periods of high temperatures in combination with low precipitation (Francis and Skific 2015), posing an increased risk for droughts. In winter, we expect higher incidence of rain (Post et al. 2009), which increases flood risk. Hence, under scenarios of drier summer climate, beavers might contribute to maintain groundwater levels or at least to mitigate its decrease (see also Hood and Bayley 2008). In regions with expected increased precipitation, the role of beavers as flood controllers deserves more attention.

Beaver-mediated sedimentation

Siltation of streams affects water biogeochemistry (Pinay et al. 2000) and is a major threat to freshwater biodiversity (Dudgeon et al. 2005). Despite sedimentation of abiotic and biotic material in freshwater being a natural process, it is augmented by especially land use change that induces soil erosion (Dudgeon et al. 2005).

Due to reduced water velocity, fluvially transported mineral and organic material sediment in beaver ponds make them effective sediment traps as long as beaver dams are maintained. The amount of trapped material varies as it depends on the geomorphology of the river bed and valley, but sedimentation rates can be significant. In a 3rd order stream in Germany, the annual sedimentation in four cascading beaver ponds was 0.2 m^3 m^{-2} $year^{-1}$ adding to a total of 1890 m^3 sediment (John and Klein 2003). Similar amounts have been reported from North America (reviewed in Gurnell 1998). Even though beaver ponds act as sedimentation traps (see also Puttock et al. 2017), collapse of dams results in the release of large amounts of previously trapped material (Kroes and Bason 2015). Naiman et al. (1994) highlight the role of sediment accumulation in beaver systems to build a standing stock of nutrients that become available to plant growth upon dam failure.

Along with other large freshwater molluscs, the freshwater pearl mussel (*Margaritifera margaritifera*) is endangered worldwide (Mollusc Specialist Group 1996) and a species of community interest according to the EU Habitats Directive (European Union 1992). Beaver dams induce sedimentation in beaver ponds and result in low particle concentrations downstream beaver ponds (Ecke et al. 2017). As sedimentation is one of the major threats to the freshwater pearl mussel (Grundelius et al. 1991), beaver dams might, therefore, help to recover populations of this species at the catchment scale. However, this beneficial effect of beavers is likely only evident in streams where the population of the mussel is distributed over large areas. Local and small populations of the mussel might be buried in sediment in case beavers build a dam immediately downstream of such a population; while such a population might benefit from a beaver dam if it is built upstream of the population. Hence, the sedimentation-induced effect of beavers on freshwater mussels and other freshwater species is scale-dependent (Figure 4.1).

Generation of coarse woody debris

Trees, especially coniferous ones, flooded by beaver dams usually die within a couple of months due to oxygen deficiency in the root system. Apart from the flooded areas as such, the amount of dead wood produced by this flooding is one of the most pronounced and striking signs and results of dam construction by beavers. It is, therefore, surprising that only few studies have focused on the amount of produced dead wood (Ecke et al. 2017), especially considering the crucial role of dead wood for biodiversity (see next section). The amount and quality (e.g. tree species, stem diameter) of dead wood in beaver systems is intrinsically defined by the flooded forest. Dead wood starts usually –

The amount of dead wood in running water has a positive impact on aquatic biodiversity. The great crested newt (*Triturus cristatus*) is one species that occurs in beaver systems. Photo: Joel Segersten

if not actively felled by beavers – as snags, viz. standing dead trees. The costs of such flooding vary considerably among forests and forest types, and have in Sweden been estimated to be up to approximately € 20,000 per ha in reforestations (Sund 2009). Eventually, the snags will fall over and form logs that either emerge from the pond water surface or will be flooded. Initially emerged logs might also be flooded if the water surface rises with increasing pond age as beavers increase the height of the dam.

Large areas of the European forested landscape are characterized by an unnatural deficiency in coarse wood debris (either standing or lying) (Stokland et al. 2012). This is in particular true for riparian and in-stream areas (Degerman et al. 2005). In southern Finland, beavers created on average 31 m^3 dead wood per ha, an amount that was significantly higher compared to non-beaver sites (Thompson et al. 2016). By taking aerial photographs with a drone in a beaver system in south-central Sweden, Ecke and Levanoni (2016) identified 217 snags per ha and 800 m of logs per ha. Despite the important role of dead wood for enhancing biodiversity, studies on the amount and quality of especially coarse dead wood at the pond, stream and catchment scale (Figure 4.1) are surprisingly scarce (see also Wohl 2015).

The impact of beavers on local (e.g. pond or stream section) biodiversity have frequently been quantified (see e.g. some of the reviews mentioned in the beginning of this chapter). The response of organisms to environmental impacts is scale dependent (Wiens 1989). It is therefore important to evaluate the effect of beavers on biodiversity at scales ranging from local to catchment and to view these effects within a landscape context, i.e. the scale that is beyond the direct impact of beavers (Figure 4.1). For example, the effect of beavers on the amount of dead wood is more significant in landscapes with deficiency in coarse woody debris compared to landscapes rich in dead wood. Likewise, the effect of beaver dams on macroinvertebrates that prefer coarse sediments such as gravel will likely be more pronounced in streams poor in coarse sediments. If beavers build their dams upstream of such streams, the effect on macroinvertebrates being dependent on coarse sediments will be positive, while the response will be negative if a dam is built downstream of such sections. Wright et al. (2002) identified the role of beavers for plant species richness at the landscape scale. Plant beta diversity is higher in beaver systems compared to other wetlands, largely attributed to increased habitat heterogeneity in beaver systems (Willby et al. 2018). Networks of beaver dams can play an important role for bird conservation at the regional scale (Chandler et al. 2009). Indeed, especially from a management perspective, the engineering effect of beavers needs be assessed at the catchment and landscape scale (Törnblom et al. 2011).

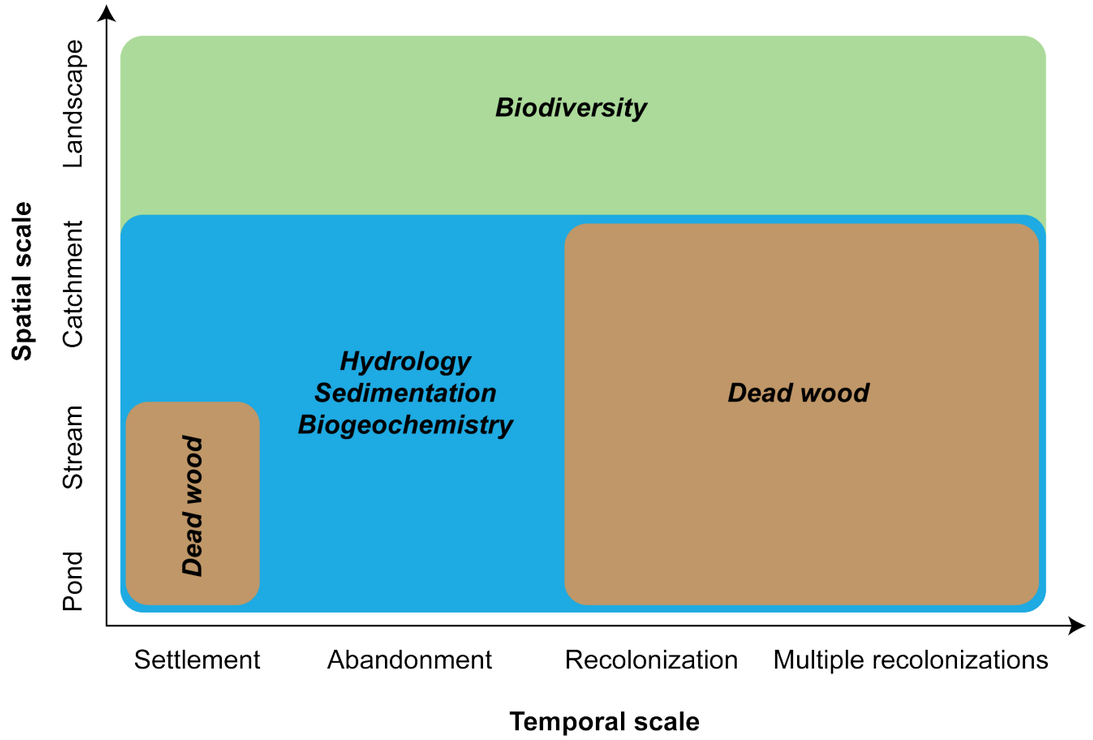

Figure 4.1. Conceptual illustration of the environmental and ecological impact of beavers at different spatial and temporal scales. Pond formation by dam building affects hydrology, biogeochemistry (see Chapter 10) and sediment far beyond the pond scale, where the actual damming takes place, and beyond the time scale of the actual pond formation. When colonizing a new system, beavers increase the amount of dead wood by building dams (resulting in flooding of forest and subsequent death of trees) and tree-felling. Initially, this impact is most pronounced at the pond and stream scale and when a beaver system is abandoned, forest recovers. When recolonizing former beaver systems, and especially after multiple beaver cycles (colonization, abandonment, recolonization and abandonment), beavers increase the amount of dead wood also at the catchment scale. Beavers increase habitat heterogeneity that in combination with the high availability of dead wood increases biodiversity at multiple temporal and spatial scales; including effects at the landscape scale.

Provision of functioning green infrastructure is a prerequisite for maintenance and restoration of viable populations of various species in terrestrial systems (Snäll et al. 2015). In recent years, the link between green and blue infrastructure for ecosystem functioning has been highlighted (Barbosa et al. 2019). This linkage is also of high relevance to fulfil the requirements of several EU directives including the Water Framework Directive (European Union 2000), and the Habitats and Birds Directive (European Union 1992, 2007). By digging channels, beavers increase the spatial contact between aquatic and terrestrial systems (Hood and Larson 2015). As reviewed above, beaver-induced flooding has cascading biogeochemical, hydrological and ecological effects that likely increase the green-blue linkage. Especially the creation of dead wood (Thompson et al. 2016) that is beneficial for many species, both terrestrial and aquatic, contributes most likely to the linkage. At present, there is however no study that systematically has investigated the beaver-induced role in green–blue linkages.

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Transport of beavers for the first reintroduction to Sweden. Photo: Nils Thomasson - copyright Jamtli museum.

Chapter 5: Short history of Eurasian and North American beaver populations around the Baltic Sea

Göran Sjöberg

Eurasian beaver

The Eurasian beaver *Castor fiber* was historically distributed over most of continental Europe and Great Britain, parts of the Middle East and northern Asia (Nolet and Rosell 1998). Remnants of beaver constructions and foraging can be traced thousands of years back (Coles 2006). Beaver teeth remain even from tertiary times (Fries 1960). Beavers were rapid to recolonize Northern Europe after the retreat of the glacial shield up through 4 500 years BP (Rosell and Parker 2011).

The beaver has been an important game species during human history, which is shown both by numerous fossil findings of beaver bones from human settlements dating back to the Stone Age, and images picturing beavers in rock carvings and paintings (Lepiksaar 1975, Forstén and Lahti 1976, Danilov et al. 2011 a, Rosell and Parker 2011). There were a multitude of methods for capturing and killing beavers. Beavers were also treasured as a game by native Sámi hunters – the meat was considered as "clean" (Högström 1980). Beavers were pictured on about ten of the remaining noaidi (Sámi shaman) drums from Sweden and Finland (Kjellström 2003). Also burial place findings at Lake Onega indicate that beaver may have had a religious significance (Gurina 1956 in Danilov et al. 2011 a). Meat as well as fur and castoreum were important products from beaver used by humans (Fries 1960). The importance of beaver is also shown by the large number of place names containing beaver in e.g. Karelia (Danilov et al. 2011 a), Great Britain (Coles 2006), Norway (Rosell and Parker 2011) and Sweden (Curry-Lindahl 1967). In many places, taxes were delivered in the form of beaver pelts (Fries 1960, Danilov et al. 2011 a). Beaver was everywhere in Europe exposed to intensive trapping and shooting as both beaver pelts and castoreum were in high demand. The use of the beavers' wool hairs for hat-making only intensified this (Fries 1960).

However, the intensive hunting also finally lead to the near extinction of the species (Halley et al. 2012). Beavers were quite early hunted to extinction in more populated and exploited areas such as the Mediterranean, and later Great Britain, when the species was still abundant in the Nordic countries and Russia (Halley et al. 2012). In late 19th century beaver was extinct in most Northern areas, e.g. all of the Baltic Sea Region. However, for various reasons, beavers remained in a few areas in Norway, France, Germany, Ukraine, Belarus, Russia, China, and Mongolia (Halley et al. 2012).

In the late 19th and early 20th century there was a spread of conservation ideals in general, and a realization about the need for measures for preserving and re-establishing the beaver (Festin 1922 a). Beavers from the remaining population pockets were used for re-introduction in the Baltic Sea region, in other parts of Russia, and later on in most European continental countries (Halley et al. 2012; Figure 5.1). The species' number globally is now estimated at over 1 million individuals. Recently, introductions have been made also in Great Britain (Campbell-Palmer et al. 2016).

North American beaver

The North American beaver (*Castor canadensis*) has its origin in what is today Canada, USA and Northern Mexico. The species differ in the number of chromosomes which prevents cross-breeding between the species (Lavrov and Orlov 1973, in Lahti and Helminen 1974). There are also some somatic differences, e.g. in the internal anatomy and the reproductive physiology (Danilov et al. 2011 b,c; see Chapter 2). The North American species is however both externally and ecologically very similar to the European beaver (Danilov et al. 2011 b,c). North American beavers have been introduced to various places, with varying success and resulting in substantial populations in e.g. Chile and Finland (Skewes et al. 2005, Parker et al. 2012).

When beavers were reintroduced into Finland, a number of the individuals belonged to the North American species (Lahti and Helminen 1974). This resulted in the main part of the present beaver population in Finland being of non-native origin (see below). The North American beavers also spread over the border to the Western parts of the Russian Republic of Karelia, while Eurasian beavers at the same time spread into the Republic from the East. This process has resulted in the unique situation that large populations of the two species today have met and occur in adjacent territory (Danilov et al. 2011 a). It is still not possible to determine generally which species will prevail since trends are inconsistent in different areas of North-Western Russia (Danilov and Fyodorov 2015). There is also a risk for spread of North American beaver from Finland into Northern Norway and Sweden (Parker et al. 2012). Also in Western Europe, North American beavers are established, and efforts have been made for their eradication (Dewas et al. 2012). Arguments for eradication are based mainly on environmental ethics and legal considerations (Parker et al. 2012).

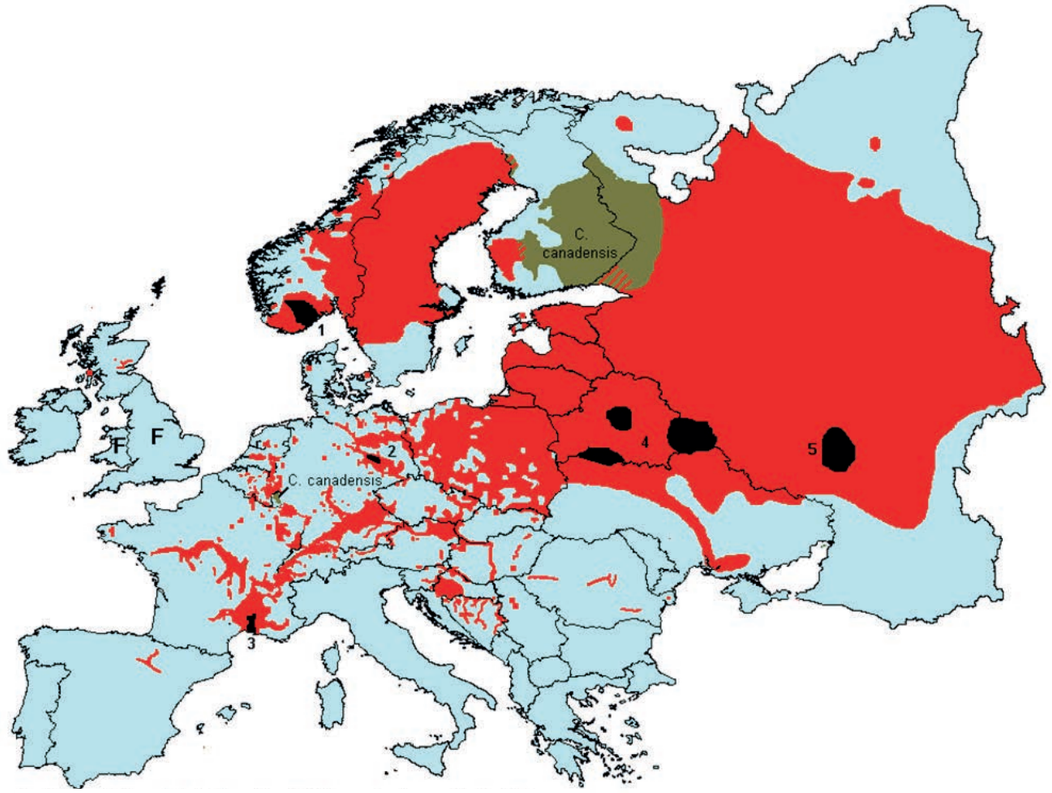

Figure 5.1. Remaining Eurasian beaver populations in early 20th century (black), and 21st century distribution of Eurasian (red) and North American (brown) beaver. From Halley et al. (2012).

SWEDEN

Göran Sjöberg

Beaver is believed to have occupied what is present-day Swedish territory during a warm period after deglaciation about 6 000 BC coming from the South, and later during cooler and wetter time spread up to the tree line (Curry-Lindahl 1967). Beaver was always hunted and trapped. In the 16th century, historian Olaus Magnus, however, wrote about the beaver that "in the Nordic countries he still builds with wonderful art, only taught by nature, his nests at innumerable rivers". Still, only from Stockholm, over 3 000 beaver pelts were exported in one year and a few decades later, they began to decrease in supply and increase in price. Only two centuries later, there were complaints that the relentless hunt forced the beaver to recede to distant and uninhabited areas. With increased hunting efficiency and more commercial pressure it began to become regionally extinct (Fries 1960).

A traditional form of beaver hunting in Sweden was stalking. Dogs were used for beaver hunting by travelling hunters, mainly when the beavers were far enough from water. The dogs would bark when finding the prey so it could easily be shot. Sometimes, however, it would have to be dug out or captured with a net (Danell et al. 2016). In northern Lapland the priest L.L. Laestadius reports that Sami hunters covered the entrances to the lodge and pursued the beavers on land by skiing, killing them with the ski sticks. Along the Lule River, Sámi hunters hunted with dogs only (Ekman 1983). According to a thesis on beavers, by Nils Gisler in 1756, hunters in Central Sweden crawled into the entrance of the lodge with a torch and a spear to kill the beavers (Ekman 1983).

One traditional method for beaver capture was by net. These were made from hemp or linen, one meter deep, and with large meshes. If the beavers did not drown, they were beaten or speared to death, see above. This is described in another thesis on beavers, by Aeschill Nordholm in 1749. A printed picture of such capture is found in the book "History of the Nordic peoples" by Olaus Magnus from 1555. Net capture is reported to have been widespread in Northern Sweden, and several beavers could be captured in a day or a night, even as late as the 18th century. Other forms of capture, described by Nordholm, were underwater leghold traps, log traps and cage traps. The cage traps were constructed so that the beaver fell down into them. Leghold traps and cage traps were baited with twigs of aspen or willow, cabbage, or root of bogbean (*Menyanthes*). This method appears to have been used in late winter when the beavers were running short of stored food. Log traps were placed on land and the beaver was killed by the weight of falling logs and rocks, according to Gisler's thesis (Ekman 1983, Fries 1960).

Figure 5.2. Lake Leipikvattnet – first reintroduction site in Sweden. Photo: Göran Sjöberg

It was most likely the efficient combination of hunting and trapping with nets, specially trained Norwegian elkhound dogs, and spears, that was responsible for the eradication of beaver in Sweden (Ekman 1983).

At the mid-19th century, beavers remained in only two of the Northern provinces. The last known beaver to be killed in Sweden before the extinction, was shot by the huntsman Abraham Abrahamsson in the province of Jämtland in 1871. His motif for this was based on a superstitious belief about the beaver's front teeth. Two years later, the beaver was legally protected (Festin 1922 a, Fries 1960).

After the failed conservation efforts to protect the last beavers in time, plans were made, and money raised, for the reintroduction of the species. After various candidate areas were dismissed, the Bjurälven ("Beaver river") valley at lake Leipikvattnet in Jämtland, close to the Norwegian border, was decided as most fit (Fig. 5.2). Visits were made to Norway to secure animals for release, and in July 1922 the box with the first beaver pair was transported by train, boat, horse carriage, and human carriers to the site under the leadership of the county antiquarian Eric Festin (1922 a, b; see chapter vignette photo). Up through 1939, about 80 beavers from Norway had been released at 19 sites over a wide geographical range in Sweden and reproduction was successful at 11 of these (Fries 1960, Hartman 2011). The reintroduction was followed by a large number of translocated beavers and spontaneous spread, and by 1995 the total number was estimated at over 100 000 (Hartman 1995). The range has later increased, but density has at the same time decreased in areas, colonized earlier (Hartman 2011).

In 1974, a hunting license system was introduced in the areas with dense populations but seasons and rules differed widely between localities (Hartman 2011, Swedish Hunters' Association 2018). At least from 1979 beavers were abundant enough to have hunting seasons covering six municipal districts from October – May while being protected in the rest of Sweden. Similar hunting seasons where adapted in successively more areas until they covered the whole country from 2001 (Swedish Hunters' Association 2018).

FINLAND

Kaarina Kauhala

The Eurasian beaver has inhabited Finland at least 7 000 years. It increased in numbers during the warm Atlantic period (8 000–5 000 BP). Beavers were still abundant all over the country in the 1500s. In the 1700s they were common only in Lapland but scarce in other areas due to intensive hunting for the valuable fur. The original beaver was hunted to extinction from Finland in the late 1800s. The last beaver was shot in 1868 in E Lapland. The species was protected the same year (Lahti 1972).

After being hunted to extinction in 1868, the Eurasian beaver was re-introduced to Finland in the 1930s when 19 beavers were brought from Norway to several places. Also seven North American beavers were introduced, some of them to same places as Eurasian beavers (Fig. 5.3, Lahti and Helminen 1969, Lahti 1972). Furthermore, since 1945 some North American beavers were relocated from the Lake Saimaa district, where the population grew fastest, to some other areas. Eurasian beavers survived only in Noormarkku, the province of Satakunta, where no North American beavers were released, and the population started to grow slowly.

In 1955 there were only twenty Eurasian beavers in Satakunta around Noormarkku but 450 North American beavers, the population of which increased much faster than the Eurasian beaver population (Lahti 1972). In 1975 there were more than 2 000 North American beavers but only 150–200 Eurasian beavers in Finland (Lahti and Helminen 1980). Thereafter both populations continued to increase and in 1998 there were 1 400–1 900 Eurasian beavers and 10 000–19 000 North American beavers. The figures were obtained by multiplying the number of lodges (Fig. 5.4) with the size of the family groups (2.8–3.8 for the Eurasian beaver and 2.8–5.2 for the North American beaver; Parker et al. 2012). The differences in the population growth rates may be partly due to important dispersal routes (water courses), partly to the larger litter size of the North American beaver (Ermala 1996, Brommer et al. 2017).

The Eurasian beaver population has increased slowly but steadily until today whereas the North American beaver population seemed to decrease after 2001 (Fig. 5.4, Brommer et al. 2017). The monitoring count in 2017 indicated, however, that the population was about the same size as in 2001. The seemingly decreasing trend in the number of North American beaver lodges from 2001 to 2013 may be due to changes in motivation to report (hunting license for the North American beaver was not demanded after 2001 and therefore hunters reported less lodges than before 2001 when they had to apply for licenses). In 2017, a new Internet application was available for reporting beaver lodges, which probably resulted in more lodges reported than earlier. A hunting license is still demanded for the Eurasian beaver (below). Abundance index (number of reported

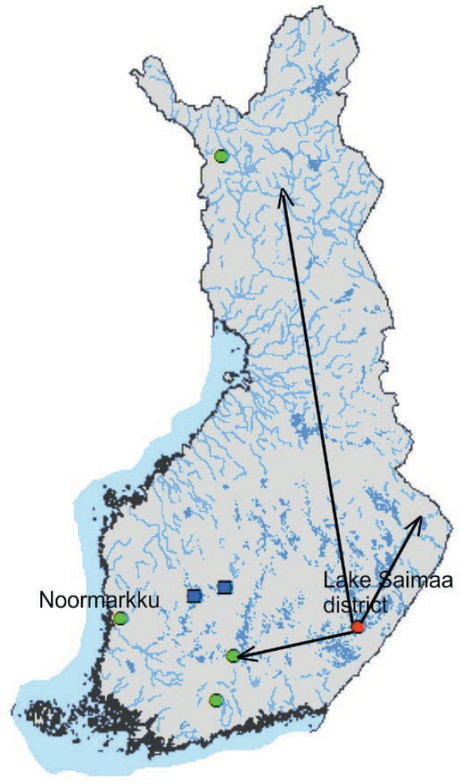

Figure 5.3. Introduction sites of beavers in Finland.
Green bullets: European beaver. Red bullet: North American beaver. Blue Square: both species.
Arrows show relocations of North American beaver (Lahti 1972).

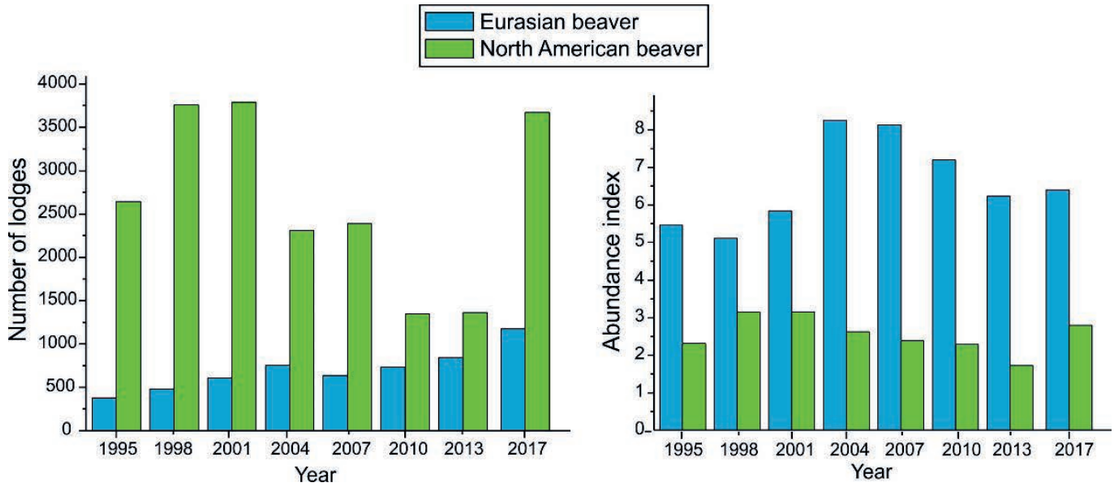

Figure 5.4. Numbers of reported lodges of Eurasian and North American beavers from 1995 to 2017, obtained from monitoring counts of inhabited winter lodges about every third year (left), and abundance indices (number of reported lodges/hunters' association, right).

lodges/hunters' association) shows that the average density of the Eurasian beaver population in areas occupied by beavers is greater than that of the North American beaver population (Fig. 5.4).

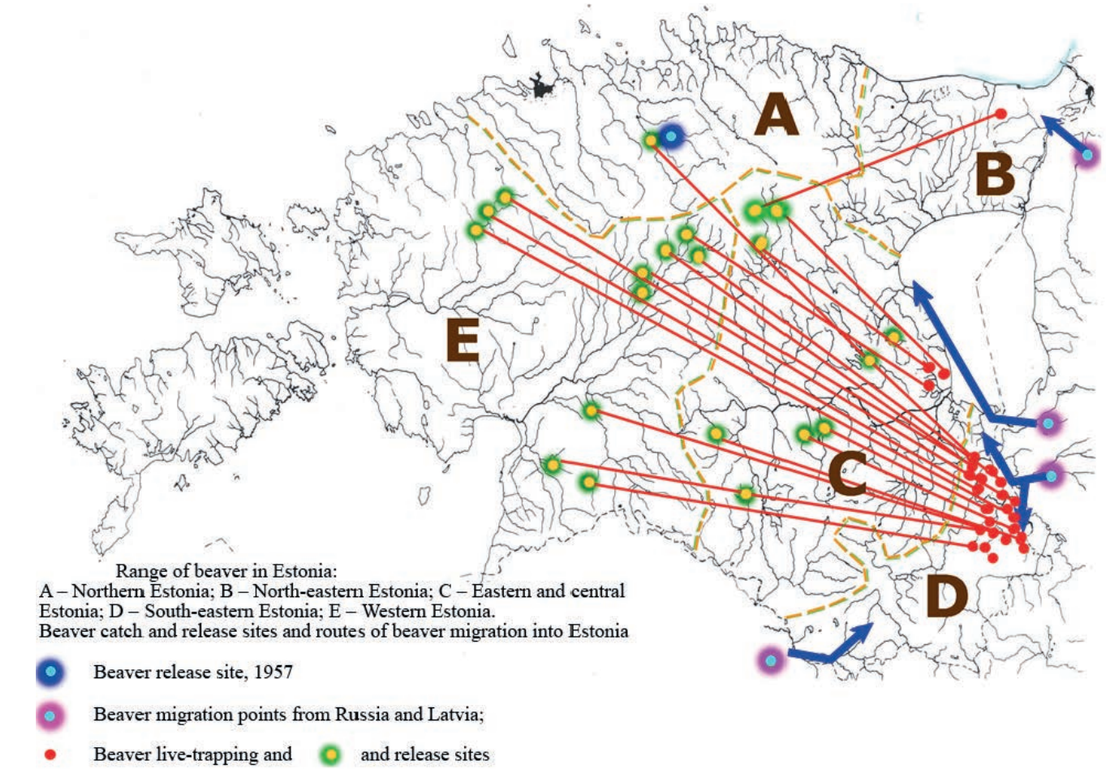

Figure 5.5. Beaver distribution districts and points of re-distribution in Estonia.

ESTONIA

Nikolai Laanetu and Elve Lode

The beaver is a native animal in Estonia. The oldest fossil remains of beavers are known from the early Holocene. Beaver bones are recorded in all bone discoveries of Middle and Late Holocene ancient settlements in the mainland of Estonia (Paaver 1965).

According to Greve (1909), the beaver was rare in Northern Estonia at the beginning of the 19th century.The last notes of beaver appearances in Estonia fall into the middle of the 19th century. According to Löwis (1885), the last beaver was killed in the upper course of the Koiva River in former Livonia in 1841.

In 1957, ten Belarussian beavers (Ling 1958, 1961, 1963) were released in the Jägala River Basin in northern Estonia, but this group of animals disappeared almost completely (Laanetu 1983). Simultaneously, beavers appeared at several water bodies in the East and South-East of Estonia (Laanetu 1966, 1969, 1983, 1995, 2000). These beavers originated from the eastern coast of the Lake Peipsi, introduced here in 1951–52 (Djoshkin and Žarkov 1960, Žarkov 1961, 1966, 1969, Provorov 1963, 1969).

Between 1952 and 1964, beavers also settled in the Leningrad Province, at the Dolgaya River, a tributary of the Luga River of Slantsevsky District, and later also at the River Plyussa, a tributary of the Narva River in Russia (Provorov 1963, 1969, Novikov et al.1970). From there, beavers spread to the North-East Estonian rivers, entering into the Narva Reservoir.

A third beaver population formed in the 1970s on the Mustjõgi River in the border area of Valga and Võru Districts. Beavers came there from the Latvian Koiva River basin (Fig. 5.5). The population of Eastern and Southern Estonian beavers mostly originated from the Voronezh area, in Southern Russia (Žarkov 1961, Balodis 1990). In 1976, live capturing and resettlement of beavers started in Estonia on purpose to expand their distribution area. Over the next ten years, 115 beavers were resettled with human help in different regions of the Republic. (Fig. 5.5).

The increase of beaver population during 30 years (1957–1987) after the restoration period was relatively slow (5–15 %). Later, however, the abundance began to grow steadily and peaked in 2005–2010. The number was then estimated to be between 18 000 and 20 000 individuals (Fig. 5.5).The intensive hunting of beavers, man-caused destruction of beaver habitats (dams, lodges and burrows), opened coastal zones of water bodies (i.e. bushes and trees are removed) together with reclamation of beaver-damaged drainage systems and increased activity of predators all caused an increase in beaver mortality. As a result, the beaver population has decreased to 12 000–13 000 individuals in 2015–2016 (Fig. 5.6).

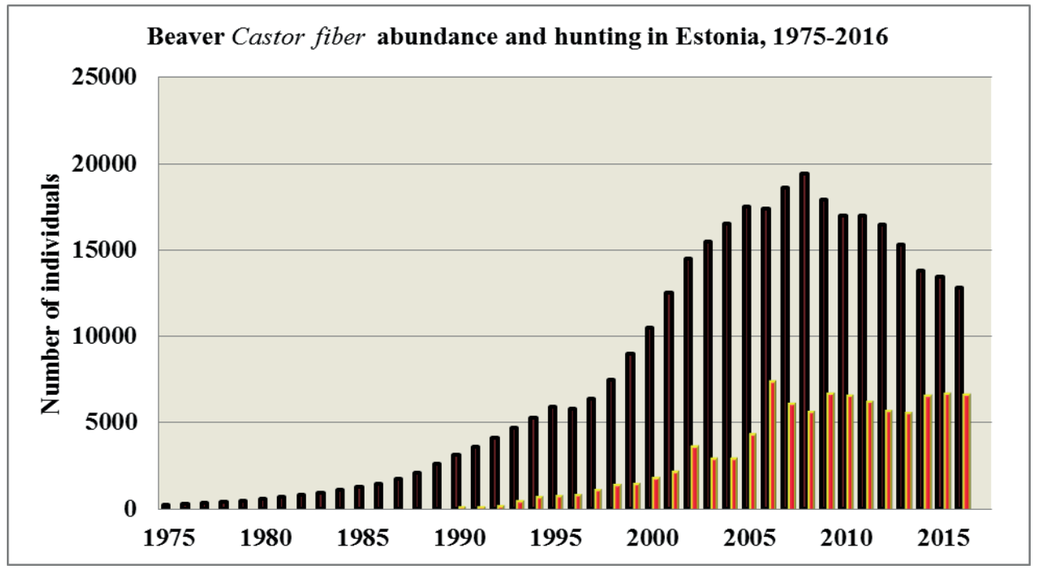

Figure 5.6. Changes in beaver abundance and hunting (the lower bars in the figure) in Estonia 1975–2016.

LATVIA

Jānis Ozoliņš

Historically, beavers were distributed in the whole territory of Latvia. Historic human use included hunting for fur, scent sacs (castoreum) and meat. Beaver went extinct in Latvia in the 1870s.

The first reintroduction took place in 1927 from Norway and the last one in 1952 from Russia. Afterwards, several local translocations and releases within Latvia were made during 1970s and early 1980s. Since 1927, the beaver was protected over the residual period of Latvia's first independence, annexation to the Soviet Union, the Second World War and the post-war period until 1981. Restricted use of the species was started in 1981 when formally estimated population size reached 4 000 individuals. At that time, only trapping with the leg-hold traps installed under water for prompt drowning of a captured animal was allowed. Trapping was performed by the specially trained and reliable persons in particularly designated hunting grounds. All fur had to be sold to the governmental purchase stations and the price per pelt was comparatively high. Beaver damage was not much considered because fur industry was an important branch of economy.

Since the 1990s, beaver has spread again to the whole country, and at higher population densities than ever before. After regaining political independence in 1991, market for pelts across former socialist countries collapsed and beaver lost its economic value. International obligations concerning wildlife conservation became relevant in the new political situation.

LITHUANIA

Olgirda Belova

The Eurasian beaver, *Castor fiber* (L.), is listed among the animal species of EU community interest (Annex II, Council Directive 92/43/EEC). However, the species falls under exemption from the Annexes of the Habitat Directive in Lithuania. The Eurasian beaver is presently not a main and preferable game species. In ancient Lithuania, beaver was a common game species mentioned in legal acts of those times. Its protection was approved by the Statutes of the Grand Duchy of Lithuania (1529, 1566 and 1588) (Gudavičius 2002). The Second Statute (1566) prohibited landowners, who had beaver sites on their lands, from cutting trees and shrubs and from ploughing land close to beaver sites. There were fines on illegal killing of beavers. The fine was increased twice in the 3rd Statute. The landowners' ownership of the beaver was unchanged even if it had moved to a neighbouring territory. Although landowners protected beavers, they trapped beavers themselves, as furs and castoreum were a good source of revenue.

However, the beaver population was reduced markedly and at the beginning of the previous century, it was almost exterminated, even if single individuals occurred up to 1938. Beavers were re-acclimatized from the Voronezh reserve, Russia, in 1947 and from the Gomel region, Belarus, in 1948 and 1959. There were also re-locations among the different territories of Lithuania as well as preventive measures. The number of the population increased from 70 animals in 1950 to 700 animals in 1959 when the census of the beaver population had been started. In 1965, beavers inhabited 65 rivers and 19 lakes (Palionienė 1970). According to the official statistics, the population number increased up to 13.5–14.7 thousands in 1986–1987 and up to 35.9 thousands in 2000 with some decrease in 1988–1995 (14.1–18.4 thousand). Recently, its number reached 85 879–121 025 (see Chapter 3). The beaver population reached its ecological carrying capacity as far back as about 1990–1995. Beavers drew foresters' and landowners' attention due to the damage caused to forests, lands and the hydrotechnical system. No North American beavers have been observed yet.

POLAND

Michal Wróbel

In the Medieval Period, beavers were widespread throughout Poland (Sawicki 1989). Nobles and kings cared for beavers. In the 11th century King Boleslaw the Brave has forbidden beaver hunting on his areas. He has created a beaver protection office, which took care for the beaver (Wdowińska and Wdowiński 1975). The number of beaver began rapid population decline in the 13th century. The Lithuanian Statute in force since the middle of the 16th century, contained provisions concerning the protection of beavers in Polish lands. After 1805, beavers were only present in Neman, Pisa and Pasłęka regions (Linstow 1908).

In the interwar period, beavers were found in the Neman and Pripyat basins. After the Second World War, it was assumed that Eurasian beavers were no longer present in Poland. Naturalists from the USSR were then asked to deliver a number of beavers in order to multiply them in Poland. In 1948, the first beavers from Voronezh, Russia, were brought in.

The numerical growth of the beaver population was unsatisfactory until 1970, due to incomplete protection of the species. Therefore, in 1974, the programme "Active protection of European beaver in Poland" was launched (Kasperczyk 1990, Żurowski 1984). The programme was implemented in cooperation with scientists from the Polish Academy of Sciences and hunters from the Polish Hunting Association. The reintroduction action was a very important element of the active protection of beavers. According to the inventory carried out in 1977, the number of individuals in Poland was estimated at over 1 000 individuals (Żurowski 1979), and in 1987 the number of Eurasian beavers in Poland was estimated at about 3 000.

At the end of the 1990s and after 2000, the beaver population in Poland was so large and widespread across the country that the species was no longer threatened by extinction. According to various data, its size ranged from 15 000 to 20 000 individuals (Czech 2000). Long-term efforts of hunters and scientists in reintroduction action have resulted in presence of the beaver throughout Poland.

RUSSIA

Alexander Porokhov

Archaeological and paleontological materials, as well as historical sources give evidence of beaver being widespread in Russia in the past. That is why humans made extensive use of beaver products from the earliest times. According to V.I. Tsalkin's works based on a large historical data (1970), the amount of beaver bones in various accounts dated 1st century BCE came to a considerable proportion in comparison with the bony remains in any other places.

These data give us evidence that beavers were harvested mostly by tribes which lived in Middle and Upper Volga basin, upper reaches of Dnieper, as well as the upper and middle parts of the Don basin, but less within Middle Dnieper, in Belarus. The least number of animals was stated in Trans-Ural areas. N.G. Timchenko (1972) notes beaver as widespread in the Middle Dnieper region in the past and beaver value for harvesting. In the 14th–17th centuries beaver hunting areas were often included in the selling, investiture or exchange of manors. Beaver remains were found only at three medieval sites of the Middle Dnieper region, such as Kiev, Vyshgorod and Voin. No integral crania were found, which helps to make a conclusion that beavers were not used as food there.

In the Baltic region, the number of beaver bones was also high enough. For example, in the modern territory of Latvia, it ran to 25.8 % of the total number of fur animals' bones in Latgale hillforts, and 40.5 % and 50 % in Curonian spit. Beaver bones were also found in some archaeological sites in Estonia (Tsalkin 1956).

During the excavations at Ryurikovo and Georgievo Gorodishches dated to the 1st millennium CE (Great Novgorod), beaver bones were found together with those of domestic animals, and of other wild animals, like deer, bear, squirrel and others (Nosov and Goryunova 1994). It shows that ancient Novgorodians did not forget about hunting, which provided people with food and fur before animal breeding.

Later data on beavers were achieved by excavations at the Nefedyevo burial ground (11th– 12th centuries) in the East of Belozerye, between Sheksna river and the lake Kubenskoye (modern Vologda region). Arrow-heads used during harvesting of fur animals, mostly beavers, were found there (Gaidukov and Makarov 1993).

Birch mark manuscripts

Famous birch bark manuscripts present us with some interesting facts about beaver processing (Yanin and Zaliznyak 1986). For example, manuscript No. 7 "Letter on Koroman", dated to the 11th century, mentioned six beavers. Otherwise, in the manuscript No. 600 is indicated "hatyniane", that is Hatynya village residents nearby Hotynka

river, Mshaga river, a left-side tributary joining Shelon' river. The Hatyniane promised someone payment in beaver furs. Their legal case on a river was connected to beaver hunting areas and the right to use the beavers of the river. It is supposed that all rivers and lakes populated with beavers had already been divided between hunters, who struggled for manor right of use too. It is noteworthy that medieval princes and feudal lords had also tried to establish their property right on beaveries in the 9th century, which was stated in the first Russian legal Code "Russkaya Pravda" (Skalon 1951).

Birch bark manuscript No. 420 provides some information on the price of beaver fur. In the years 1110–1160, forty beaver furs cost about 10 grivnas, which was equal to 2 kg of silver (Porokhov 2005). In 1483 a beaver cost 16 half-copecks in Western Rus. In Vladimir in 1556, one adult brown beaver and two dark-brown yearlings of beavers cost one rouble (Artsikhovskiy and Yanin 1978). In that period the number of animals had been reduced overall. It is known that 16 sable furs and 110 squirrel furs for every beaver fur from under-yearling, yearling or an adult animal passed through northern Ustyug customs at the average in 10 years.

According to Kilburger, beavers were in 1674 regarded as a kind of goods "which Russia itself had not got enough of, so it imported them from Holland and Hamburg ". That leads us to make a conclusion that at the beginning of the 17th century, beaver trapping was strictly banned in order to reduce exploitation of beaver. Thus, it is fair to say that trapping was banned, but these measures were inadequate (Grakov and Saphonov 1997, p.93).

By the end of 18th and beginning of the 19th century, the beaver population in North-Western Russia was completely exterminated. Animals were eliminated violently not only because of their fur, but also because of their meat. This was Russian hunters' and numerous monks' favourite food, considered as fish and consumed during long-time fasts, such as Lent. Castoreum was also highly valued as a sort of panacea of all illnesses (Bogoyavlenskiy 1966, Smolovik 1984).

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Photo: Kenneth Johansson

Chapter 6: General aspects of beaver hunting and trapping

Olgirda Belova

The Eurasian beaver *Castor fiber* L. is still under special protection across Europe by a number of international legal acts as EC Habitat Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora) and Annexes II and IVa as species of "Community interest", and the Bern Convention (Appendix III). Harvesting of beaver is strictly controlled and, in general, is limited in most countries of the BSR. Some countries have derogations for beaver management from strict protection set out in the EC Habitat Directive (see below).

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, agriculture and infrastructure;
- to manage water quality in terms of nutrients and hazardous substances.

The last aim was most revealed in recent years, simultaneously with the start of Interreg Baltic Sea Region project Water Management in Baltic forests, WAMBAF, that seeks 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.

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 improves human health and safety.

Beaver hunting and/or trapping is currently permitted throughout much of Eurasia including EU member states Sweden, Finland, Latvia, Lithuania and Estonia, which are listed in Annex V of the Habitat Directive (Table 6.1).

Beaver trapping

Trapping is a legitimate and indispensable activity for regulating beaver populations. Trapping is diverse activity and each country and region has different methods that are allowed and used to trap. Because of that it is necessary to understand and follow the national legislation or regulations pertaining to that species or methods used. Trappers must be aware of days of trapping season, and special requirements.

Since 1987, the International Organisation for Standardization ISO through its Technical Committee TC 191, where FACE (i.e. the European Federation of Associations for Hunting and Conservation. Established in 1977 that represents the interests of 7 million hunters in Europe as an international non-profit-making non-governmental organisation) has an observer status, started working to agree acceptable trapping standards from a point of view of animal welfare. Although good progress was made, the process did not manage to establish the welfare thresholds for which it strived.

In 1991 the Council of the European Union adopted the "Leghold Trap" Regulation 3254/91 prohibiting the use of leghold traps in the Community and the introduction into the Community of pelts and manufactured goods of certain wild animal species originating in countries which catch them by means of leghold traps or trapping methods which do not meet international humane trapping standards.

In 1995 negotiations began on the Agreement on International Humane Trapping Standards (AIHTS) between the EU, Canada, Russia and the US and concluded in 1998. It came into force much later, in July 2008 after the ratification by the Russian Federation.

The EU and its Member States have, therefore, an international obligation to comply with the standards set by AIHTS (Agreement on International Humane Trapping Standards). According to the standards, Parties to the Agreement will have until 2013 (5 years after entry into for-

Table 6.1. Beaver harvesting (N of harvested beavers, animals) in the Baltic Sea Region 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)	
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	01/08 – 15/04***	
Latvia	24 248	31 376	24 711	15/07 – 15/04	
Lithuania	19 544	21 749	11 778	01/08 – 15/04	
Poland*	133 /22 %	93 /24 %	38 /15 %	01/10 – 15/03	
Republic of Karelia (Northwestern Russia)	238	165	150	01/10 – 28-29/02	

* ***Note***: Partially 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; Swedish data: www.viltdata.se; 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.

*** See Estonia section for exceptions.

ce) to test and certify trapping methods, and until 2016 to implement the use of certified traps (FACE 2014–2015).

Traps are used to minimise environmental damage or to assist conservation by helping to control over-abundant. To avoid the capture of non-target animals, carefully planning and setting the trap are needed. The most important factor in selective trapping is location. In EU member countries, beavers caught squarely on the neck are killed quickly with no unnecessary suffering or a chance to escape. As a rule, traps of the Conibear model #330 (250 x 250 mm) are used.

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 (Loven 1985, 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 (see Chapter 3). Despite these activities, dam removal is widely used helping to protect forest and watersheds.

SWEDEN

Göran Sjöberg

Hunting

Beavers were hunted since early times (see Chapter 5). After the eradication and reintroduction of beavers in Sweden, it took several decades before the population was considered large enough in some districts for hunting in 1977 (Hartman and Georén 1993). The regular hunting period for beaver, as stated by the Swedish Game Regulation, is from October 1 to May 10 or 15 (depending on county). In the autumn, however, the beaver hunt is negligible. During the winter, beavers are seen more rarely, so the most intense hunting period is in springtime. In large parts of Sweden this still means there is a snow and ice cover, and the hunter can benefit from the ice limiting the area where the beavers can move (Hartman and Georén 1993).

For beaver hunting, only bullet rifles of certain calibres are nowadays permitted and a sight will likely be needed. Shotguns are nowadays not allowed for beaver hunt in Sweden. A lightweight high-speed bullet is recommended, with a shot in the neck or shoulder (Hartman and Georén 1993). A moose rifle may serve well, at least for older beavers (Rosell and Pedersen 1999). The hunter should also sit fairly high and use binoculars (Hartman and Georén 1993). The beaver should ideally be shot when it is on land as far as possible from the water's edge (Rosell and Pedersen 1999). Equipment for salvaging and carrying the beaver will usually be needed. Using a canoe for the hunting, it may be possible to come closer to the prey (Hartman and Georén 1993). Stalking is difficult and is not used much nowadays (Rosell and Pedersen 1999).

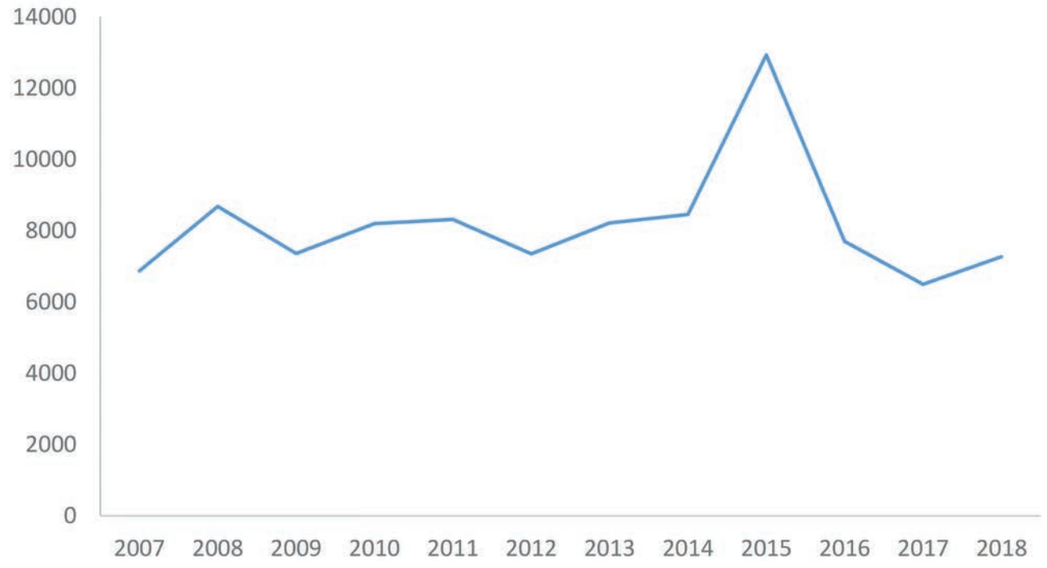

Figure 6.1. The number of beavers reported shot in Sweden from the hunting season 2007/2008 to 2018/2019.

The easy part about beaver hunting is that it is quite evident where beavers are active, and their range of movements is fairly small. On the other hand, the beaver has a very good sense of smell and can be very wary if disturbed (Rosell and Pedersen 1999).

Harvested beavers, and other game species, are reported voluntarily by hunters to the Swedish Association for Hunting and Wildlife Management who display the statistics on the website www.viltdata.se. This means it is a minimum number. The numbers are fairly stable, although with some annual variation (Fig 6.1). The county with on average largest number of beavers shot is Jämtland, with an annual average of ca 1 300 of the national 8 400 individuals. The county of Jämtland also happens to be where the first beavers were released for the reintroduction.

Trapping

Historically, several types of traps were used in Sweden (see Chapter 5). Today, it may under some conditions (see Chapter 9) be permitted to trap beavers using certain trap types. Only two brands of traps are presently permitted in Sweden for beaver capture, both of them killing (Swedish Environmental Protection Agency 2017). For the trap to be effective it is important to place it in a correct way (Hartman and Georén 1993). It is recommended to place it at the entrances/exits to the lodge, at passages over the dams, or at channels etc. Either castoreum or anal secrete from beavers may be used as bait (Rosell and Pedersen 1999).

FINLAND

Kaarina Kauhala

Beavers were still abundant and wide-spread in Finland in the 1500s but thereafter increased hunting caused a decline of the beaver population. Also the distribution area decreased (Lahti 1972).

Beavers were hunted mainly in spring, all possible methods were legal and no licenses were demanded (Järvinen 1950). One method was used in late winter when there was still ice cover in lakes and rivers. Hunters made the dam higher so that the water level rises in the lodge and beavers were forced to come out through holes made in the ice by hunters. Beavers were then hit to death. Another method was a trap put inside or near the lodge. Beavers were also shot in the evening after the sunset. Then the hunter waited until all beavers from the lodge were outside. It was important not to shoot the first one, the scout, which came out because then other beavers would stay in the lodge.

In the late 17th century restrictions were placed on beaver hunting because beaver numbers were declining (Järvinen 1950). The hunter had to swear an oath that he would hunt only the number of beavers agreed and give the catch to the benefit of the whole village. Furthermore, he had to pay tax of each hunted beaver to the king and also to the priest. The hunting areas were also divided between local hunters but nevertheless, quarrels between hunters were common and many hunters were even killed when they were fighting for valuable beavers (Järvinen 1950).

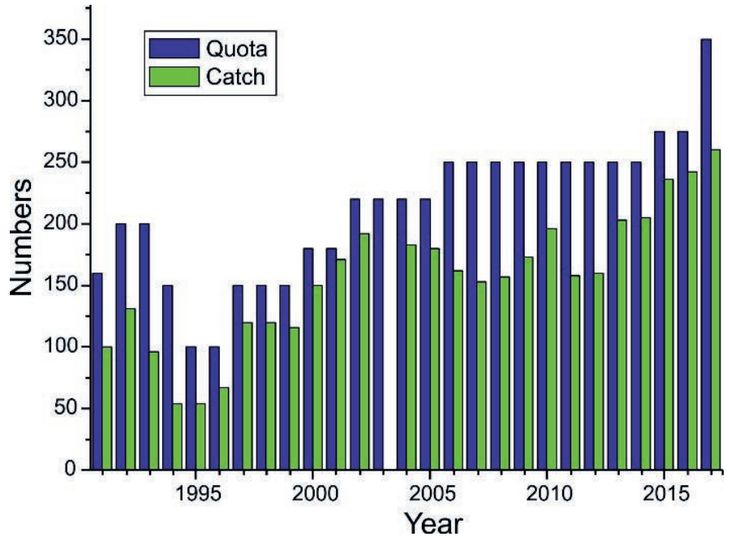

Figure 6.2. Annual quota and catch (hunting bag) for the Eurasian beaver in Finalnd since 1991.

After introductions, hunting of beavers has been allowed since the early 1960s, mainly because of the damage to industrial forests caused by beavers (Ermala 1996). The hunting season for beavers is from 20th August to 30th April (Suomen riistakeskus: https://riista.fi/metsastys/metsasty-sajat/). A hunting license for Eurasian beaver is demanded, and, for the hunting season 2017/2018, the quota is 350 (Ministry of Agriculture and Forestry 2017, Fig. 6.2). Hunting bag was 242 in the hunting season 2016/2017. Hunting is allowed in all municipalities of the province of Satakunta, and in some municipalities in the provinces of Etelä-Pohjanmaa, Pohjanmaa and Pirkanmaa. In other areas, hunting of some individuals which cause a lot of damage may be licensed. A license to hunt North American beavers is not required but the hunting season is the same as for Eurasian beavers.

ESTONIA

Nikolai Laanetu and Elve Lode

Until 1980, the beaver was under strict protection in Estonia and had a low abundance. Then beaver was excluded from the list of protected species, but hunting for fur was granted since 1983.

The most common form of beaver hunting in Estonia is the capture with traps (Conibear type). Hunting with firearms, live capture with dogs and hunting with bow are methods preferred by those hunters who highly appreciate the culinary qualities of beaver meat.

Therefore, most animals are hunted with traps, but it is also common to catch beavers with dogs or with the so-called live capture method. After the animal is captured by the scoop-net, the animal is killed. When firing a bow, the arrow must be fastened to the bow by a string. This is a new way of beaver hunting in Estonia since 2017.

Current beaver hunting regulations are settled in Estonian Hunting Rules (JahiEK 2013) and Hunting Act (JahiS 2013). According to JahiEK (2013) beavers may be hunted:1) from 1 August to 15 March, with hunting trap, scoop-net, or hunting dogs belonging to the FCI (Fédération Cynologique Internationale) group 3 and 4 ;2) from 1 October to the end of the beaver hunting period (i.e. 15. April) with all type of hunting dogs; 3) ambush and stalking hunt with the dogs of FCI group 3 and 4 from 1 August to 15 April; and 4) in the cases of beaver-damaged sites, the year around as ambush and stalking hunt with the dogs of the FCI 3rd and 4th groups, with the permission of the Environmental Board.

LATVIA

Jānis Ozoliņš

In Latvia, beaver hunt is practiced using mainly three methods: shooting from a high seat located next to a beaver dam; trapping by 'Conibear' traps and chasing by hunting dogs in a burrow system after draining a beaver pond. These methods are frequently combined in order to completely eliminate a beaver family from a site where they cause damage to forestry, agriculture or road embankments. Elimination of a whole beaver family is rarely successful within one day. Usually the hunters have to repeat attempts in a few weeks, when escaped individuals restart their activity. It is very important to improve and disseminate hunters' skills for trapping. If the beaver traps are set improperly and kept for several nights at the same location without success, there is a heightened risk for a bycatch of non-targeted animals, e.g. otters. By the end of each season, the hunters have to report the numbers of hunted beavers to the local authority of the State Forest Service. The annual hunting bags fluctuate between 20 000 and 30 000 beavers from 2010 to 2017 (Figure 6.3).

LITHUANIA

Olgirda Belova

In Lithuania, the beaver hunting is not limited. The hunting is limited only by the hunting season. As an example of beaver quantitative management, Figure 6.4 is presented below.

The beaver 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 beaver hunting is conducted strictly by the Law of Hunting, The Regulation of Hunting in the Republic of Lithuania and other related legal acts. Sit-and-wait hunting, hunting with dogs, and beaver trapping are the basic hunting methods as legitimate and indispensable activities for regulating beaver populations. Only hunters have the right to regulate beaver number. Hunters–trappers must be aware of days of trapping/hunting season from 1st August to 15th April only, and special requirements.

As other member countries, Lithuania has an international obligation to comply with the standards set by AIHTS (Agreement on International Humane Trapping Standards). According to the standards, only certified Conibear model #330 (250 x 250 mm) traps are used for beaver trapping.

The sit-and-wait hunting is the most preferred hunting method in Lithuania. Hunters wait for beavers at their foraging points, near the dams, lodges or along the beaver ditches and elsewhere in beaver habitats (Ribikauskas 2014). The use of artificial light during hunting is forbidden.

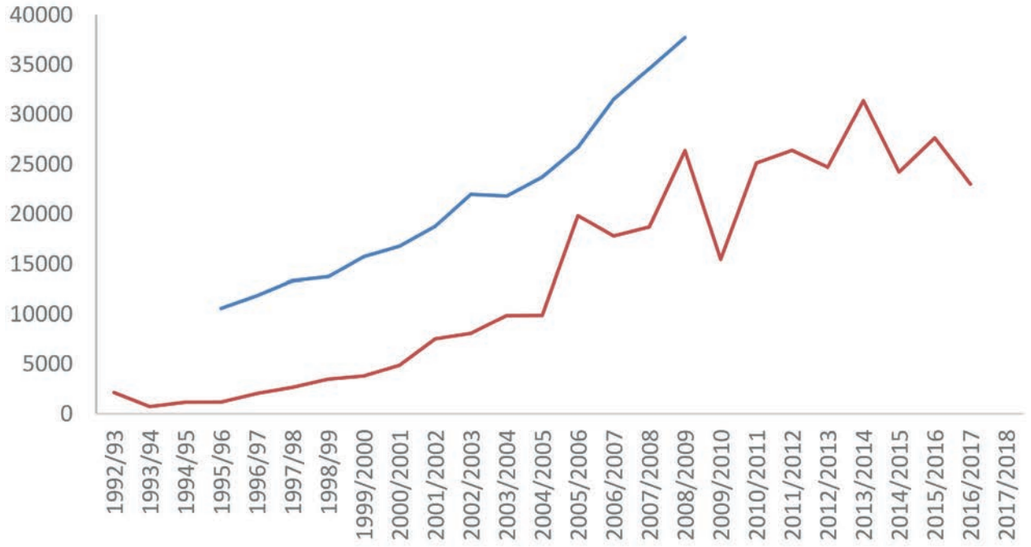

Figure 6.3. Harvest quota (blue; 1995–2009) and reported harvest (red; 1992–2017) of beavers in Latvia.

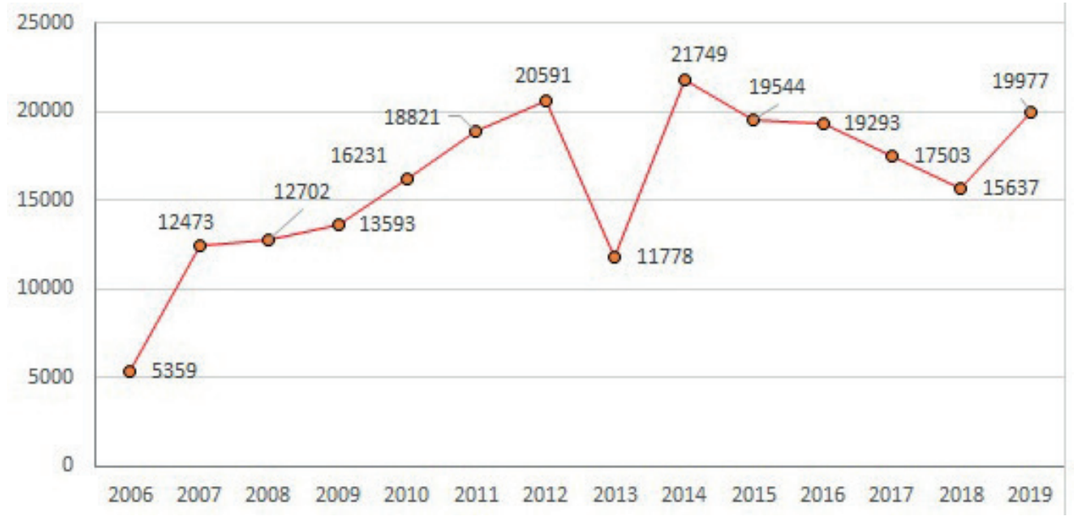

Figure 6.4. Changes in the beaver (*Castor fiber* L.) hunting bag in Lithuania.

POLAND

Michal Wróbel

In Poland, the beaver is considered a partly protected species, and hunting is allowed depending on the damage caused to landowners and forest owners/holders (see Chapter 9).

The procedure for obtaining a hunting permission includes an application filed by the owner of the land to the Regional Directorate for Environmental Protection. The Regional Director for Environmental Protection may authorize hunting of individual animals, transfer to another site, and destruction of dams and burrows, unless alternative solutions are available and if this is not detrimental to the conservation of the wild populations of protected animal species. The application should describe the damage and hazards that may arise as a result of the damage. It is also necessary to describe the place of occurrence of damage and describe alternative activities that were carried out before applying for permission to reduce the population of beavers.

Regional Directors of Environmental Protection issue regulations on the basis of the Act on Nature Protection concerning the reduction of the beaver population (Figure 6.5). Hunters – members of the Polish Hunters' Association have hunting permit to hunt beavers.

Obtaining a permit does not necessarily mean that the indicated number of animals will be hunted (see Box 6.1). Hunting is often ineffective because we observe a reluctance of hunters to hunt down beavers. The reason for this is the lack of traditions of hunting beavers, the difficulty in shooting a beaver, or the trouble of taking care of the dead animal because of a difficult terrain.

In addition, based on the experience of countries where hunting is allowed, it can be concluded that reducing damage this way is not very effective. Beavers live in specific family units, unique in the world of mammals, consisting of a pair of reproductive parents and a varying number of young. Therefore, hunting several individuals usually does not result in the family leaving the territory, and the problem with the beavers will remain. Hunting all individuals in the family is extremely difficult technically, and also not very effective, because in an area abundant with beavers, the vacant space is immediately occupied by young, wandering individuals, and the problem will remain.

Box 6.1 Share of permits resulting in actual hunting or trapping of beavers

Podlaskie province:
Hunting permits 2008 – 2015 (per individuals):
2354 permits – 640 made; 27.2 % hunted

Trapping permits 2008 – 2015 (per individuals):
209 permits – 72 made; 34.4 % hunted

Warmian-Masurian province:
Hunting permits 2008 – 2015 (per individuals) :
916 permits – 135 made; 14.7 % hunted

Pomeranian province
Hunting permits 2011 – 2014 (per individuals):
321 permits – 43 made; 13.4 % hunted

Trapping in Poland

For culling or breeding purposes, including exports, and scientific purposes, live-trapping of animals is allowed using nets or non-hurting live traps. The leaseholder or the manager of a hunting circuit may trap predators according to the regulations of the Minister of the Environment regarding the use of live traps. The lessee or the manager of the hunting circuit kills the live-caught predators using hunting weapons or methods used to slaughter livestock.

According to the regulations, the following predatory species can be caught in live traps:
1) fox (*Vulpes vulpes*);
2) raccoon dog (*Nyctereutes procyonoides*);
3) American mink (*Mustela vison*);
4) raccoon (*Procyon lotor*).

For other species, such as beavers, the regulations do not allow for use killing traps.

Live-trapping

Polish law attaches great importance to the protection of wildlife against poaching, thus securing protected species. This does not mean a total ban on live traps. Individuals who have problems with foxes, beavers or hawks may use live traps, after obtaining the consent of the regional director of environmental protection. The captured animals, e.g. beavers, should be displaced from the areas where they cause damage, to locations with their natural environment far away from the place of human residence.

Permission to use live traps can be issued when all other possibilities have been exhausted.

Current types of traps are found on the website: https://rmax.istore.pl/pl/pulapki-zywolowne
Branches of the regional directorate for environmental protection keep such statistics. several are available online.

Data should be collected by regional directorates of environmental protection. There is access to several. The rest of the applications and requires the consent of the Director.

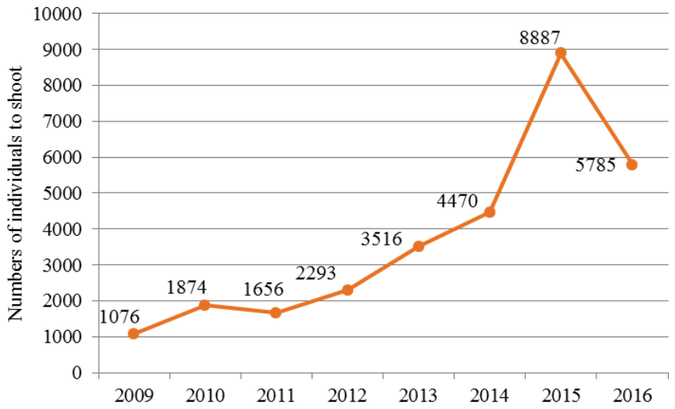

Figure 6.5. Number of beaver individuals to be shot in Poland according to permits issued by the General Director for Environmental Protection and the Regional Directors for Environmental Protection.

RUSSIA

Alexander Porokhov

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).

As we have essential information on beaver hunting bags in Russian hunting game preserves it is interesting to know how many animals are hunted or trapped here. Let us consult Table 6.2.

On the basis of data presented in Table 6.2 and in Chapter 3, we can conclude that in the hunting season 2012–13 only 16 968 of 662 630 of animals were harvested, or 2.56 %. It is not enough. This tendency continued in the season of 2013–14, when 14 429 animals, or 2.16 %, were harvested. For Northwestern Russia, there is a standard of required beaver harvesting of 15–30 (or 20) % of the population. To reach a harvest rate of 20–30 %, it is needed to reach no less than 55–65 % of the beaver colonies (Tschennikov 1990). Note that this figure was never registered in the Novgorod region for 49 years of beaver hunting since 1968 (Porokhov 2005), throughout all Northwestern Russia.

Now, beavers are excluded from the list of animals with limited harvest in Russia, because of their large abundance and the damage caused to the country's forestry and agriculture.

Table 6.2. Beaver harvesting in the Russian Federation

Kind of hunting resources	Beaver hunting bag, N of animals		Hunting bag in 2014 compared to 2013, %
	2012–13	2013–14	
Beavers (Eurasian, North American)	16 968	14 429	- 15

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Photo: Gintautas Urbaitis

Chapter 7: The processing, marketing and use of beaver products

Olgirda Belova

The main products from beaver are its high-quality fur, castoreum and meat. Furs of beavers have been the most valued. The density of beaver pelage on the back is 12 000 hairs per cm^2, on the belly 23 000/cm^2 in the growing period and 27 000/cm^2 in winter (Belova 2006). Prized for their warmth, luxurious texture, and the longevity of fur as a material, furs have played a large role in clothing people since the beginning of human history. Furs have been used for the production of outdoor wear as coats and capes, garments and shoe lining, a variety of head coverings, and ornamental trim and trappings. Depending on the supply of animals, Russia, Northern Scandinavia, and Central Asia were the major suppliers of this trade through the 15th century (Wolf 1982). There were substantial populations of the Eurasian beaver throughout northern Europe and Siberia, until they were severely depleted in the 17th century due to over-hunting. The depletion of Eurasian beaver populations coincided with the establishment of European colonies in North America by the early-to-mid 17th century (See Chapter 5).

Today the importance of the fur trade has diminished. It is based on pelts produced at fur farms and regulated fur-bearer trapping, but has become controversial. Animal rights organizations oppose the fur trade, citing that animals are brutally killed.

Castoreum

Since medieval times, the tail of the beaver covers an even more singular feature, the castor sacs. The beaver's sexual organs are modestly tucked up inside its body, while a pair of sacs in the anal area of both sexes secrete castoreum, the musky oil the beaver uses to grease its coat and mark scent mounds to delineate its territory. Castoreum was a popular medicine in the medieval period against ailments ranging from headaches to impotence. It is high in salicylic acid (that is the basic ingredient of aspirin), which the beaver ingests by dining on willow bark. Long used as a base for perfume, its scent is described as a pungent, waxy, burnt-orange odour, with smoky notes of Irish peat fires and good pipe tobacco and undertones of cardamom and tea (Svendsen 1978, Outwater 1996).

Meat

The archaeological excavations and geomorphological investigations have revealed the presence of beaver bones from 5.50 % to 66 % of all animals found in different settlements of the Baltic region during the Late Neolithic (Balodis et al. 1999). The recent limited consumption of beaver meat may be partly due to the lack of public knowledge of its nutritional quality. A beaver carcass on average constitutes 48.6 % of beaver body mass and contains 62.8 % of meat, 14.5 % of fat and 22.4 % of bones (Jankowska et al. 2005, Razmaitė et al. 2011, Strazdina et al. 2015, Żochowska-Kujawska et al. 2016). Beaver meat is a high-quality protein and lysine source due to its well-balanced essential amino acid composition. With predominant polyunsaturated fatty acids and the n-6/n-3 PUFA value of 2.1, it could be n-3 PUFA-rich food in the diets (Razmaitė et al. 2011, Strazdina et al. 2013). Smaller muscle fibres, thicker perimysium, and lower amount of IMF material in comparison with pig muscles characterize beaver meat. It is a good substitute for pork in sausage production (Żochowska-Kujawska et al. 2016).

An increase in consumption and sustainable hunting as a management tool for beaver population is highly demanded. It should be considered that the most common diseases found in *Castor fiber* are different types of infections in the intestinal tract. Most dangerous is Trichinellosis which is a parasitic disease of public health importance caused by the nematode *Trichinella spiralis*. Human infections occur by consumption of insufficiently cooked infected meat. In Baltic Sea Region EU member countries, fresh meat must fulfil the animal health requirements laid down in the EU legislation applicable to each classification of game animal.

Every game production should be under hygiene and veterinary inspection. In EU member countries including Baltic Sea Region countries, the principles of risk management of food safety have to be incorporated wherever appropriate in the design and implementation of meat hygiene programmes. Legislation includes provisions for hunters, gamekeepers and managers to note any unusual conditions observed during hunting and, where appropriate, during evisceration of each game specimen, and to report any anomalies to the veterinary inspectors. Legislation also contains guidelines and rules for hygiene standards and design of larders and processing premise for game. These actions can ensure that game meat is safe from the point of origin to that of consumption (EEC 1992, FACE 1995, Lecocq 1997, Anon 2002, LR ZUM 2007, EU EC 2009, EU EC 2011).

Box 7.1. EU regulations concerning animal products.

- The data on by-products hunting (the same due beaver) are available including required legislation. E.g. European Union Legislation.
- Regulation (EC) No 178/2002 which sets general food law requirements, including establishing traceability of food, feed and food producing animals.
- Regulation (EC) No 852/2004 which sets general hygiene rules applying to all food businesses.
- Regulation (EC) No 853/2004 which sets additional hygiene rules applying to businesses producing food of animal origin. Section IV of Annex III of this regulation covers wild game supplied to and processed in approved game handling establishments.
- Regulation (EC) No 854/2004 which lays down the official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare and more fresh legal acts too (e.g. ELI: http://data.europa.eu/eli/reg/2011/142/oj

SWEDEN

Göran Sjöberg

Many parts of the beaver have historically been used as a resource in Sweden − meat, castoreum, teeth, fur and tail (Danell et al 2016).

For the quality of the meat and other products from the beaver, it is important to remove the entrails and skin it immediately and in a proper way – the beaver fur will otherwise keep the carcass warm. It is also important to be careful and avoid damaging the castoreum and anal glands. The beaver is not easily skinned and very sharp knives are needed (Hartman and Georén 1993, Rosell and Pedersen 1999; Fig. 7.1). For the tail, a scalpel may be needed (Westman 2010). The best quality of the skin is found in the wintertime (Rosell and Pedersen 1999). Detailed instructions for the skinning are provided by Hartman and Georén (1993) and Rosell and Pedersen (1999). Beaver skin is very fatty so it is important that it is properly scraped before further preparation (Rahme 2003).

Figure 7.1. The beaver meat needs careful preparation at all stages. Photo: Lars Strand.

For preservation until use or sale of the skin, it may be dried, frozen or salted. Salted skins should not be frozen afterwards (Hartman and Georén 1993, Rosell and Pedersen 1999). The preserved skin may then be sent to a tanning factory. The price for tanning of a fully prepared beaver fur is 800 – 2 000 SEK (75 – 190 €) depending on size and company, but if preparation is needed the price may be up to about 3 000 SEK (285 €). Mounting of a large beaver may cost up to about 11 000 SEK (1 000 €). There are also services for various other kinds of trophies such as skulls, penis bones or teeth of beavers.

In tanning industry, however, toxic substances such as chromium compounds are often used. It may be a good idea to learn more environmentally friendly handcraft tanning using agents such as bark or grease from brain or other sources (Pettersson 2010). For beaver and some other skins, rawhide softening is also an option – a process where the grease in the skin is used so no additions are needed (Kleppe-Turunen 2010). Human urine may be used to prepare the hide before grease tanning (Rahme 2003). Further advice on traditional tanning may be found in Tunón (2010) and Rahme (2003).

There is today no market in Sweden for the sale of beaver furs, neither raw nor tanned, but a well-tanned beaver fur, or beaver tail, is useful for preparing many useful products. At least earlier, the guard hairs of the fur were removed, leaving only the wool pelage (Rahme 2003). The fur may for example be turned into a hats, jackets or gloves.

Castoreum

Castoreum was used as a medicine in Sweden and elsewhere. Mixed in alcohol, it was assumed to cure eye diseases and hernia, far into the 20th century. It was also exported, and used as an additive in snuff tobacco (Danell et al 2016). The castoreum is a soft, yellowish substance with a strong smell and taste, containing salicylic acid. Traditionally the castoreum pouches were cut into strips and dried before marketing (see Chapter 5). Castoreum was listed in the *Pharmacopoea svecica* as late as 1847 and was sold in drug stores still in 1939. The Eurasian castoreum was more valued than the North American, as long as it was available (Fries 1960). A recipe for a castoreum extract for flavouring of aquavit is given by Rosell and Pedersen (1999).

Figure 7.2. A beaver wool kaplin, a raw material for hat-making. Photo: Catharina Carlsson.

Meat

Beaver meat was eaten everywhere in northern Sweden, and was said to be similar to pork but with a hint of fish. In the province of Jämtland, it was at times included in the church tax (Ekman 1983). It was also reported by the zoologist Sven Nilsson in his Scandinavian Fauna in 1847 that beaver was eaten and said to be delicious (Danell et al 2016). As a semi-aquatic animal, beaver was declared as "fish" by the church, and could thus be eaten during lent during the catholic period (Fries 1960).

Wool

The soft underfell of the beaver, or beaver wool, was valuable for making fashionable hats, and the trade with this contributed both to the exploration of North America and to the near extinction of beaver in both continents (see Chapter 5). The beaver wool is still used today although on a smaller scale. For hat making, the wool is processed and formed into a rough hat-shape, so-called kaplin (Figure 7.2).

Figure 7.3. Tanned beaver tail. Photo: Göran Sjöberg.

Beaver casserole with apple and lingonberries

This recipe comes from the Swedish book Bra Kött, with recipes by game chefs Gert Klötzke and Niclas Wahlström.

Beaver meat is both juicy and tasty, and is well suited for casseroles and slow cooking.

4 servings

Ingredients
2 deboned beaver briskets
1 tbsp. butter
½ garlic clove
1 carrot, sliced
1 onion, coarsely sliced
1 cinnamon stick
2 star anise
3 slices of fresh ginger
½ tsp of orange peel
1 tsp coriander seed
½ tsp chili flakes
5 dl game or veal stock
Garnish
2 apples
1 tbsp. butter
2 tbsps. sugar
2 tbsps. lingonberries, fresh or frozen
Serving
Potato purée
Pickled root vegetables

Method
Cut the briskets in small cubes. Add salt and pepper and brown the meat in butter in an oven safe casserole dish or stew pot.
Add the vegetables and spices to the casserole disk or stew pot, and pour in the stock. Boil up the casserole and let simmer for approx. 1½ hours. Reduce the stock to intensify the flavor. Season with salt and pepper.

Garnish
Peel and cut the apples in cubes and fry them in butter and sugar. When the apples are soft, add the lingonberries and dilute with water if the sauce is too thick.
Serve the casserole with the fried apples, potato purée and pickled root vegetables.

Photo: Lena Runer

Beaver in wine (“Coq au vin” with beaver)

Recipe by Niclas Wahlström.

Beaver is particularly suitable for slow-cookers or for cooking for a longer time on the stove or in the over because it contains much connective tissue which takes time to break down. Classical casserole dishes such as Boeuf Bourguignon or Coq au vin are recommended. Marinating the meat in wine overnight adds a nice flavor, but this step can be skipped if you want to prepare it directly.

4 servings

Ingredients
800 g beaver meat in cubes, from leg, brisket or rump
1 bottle red wine
2 bay leaves
3 garlic cloves, pealed
5 sprigs of thyme
8 black peppercorns

Stew
Butter
2 carrots
1 celeriac (also known as celery root)
2–4 dl stock
2 tbsps. butter
2 tbsps. flour
1 pinch of sugar
15–20 champignon mushrooms
15–20 small boiled onions
125 g smoked pork belly, shredded
Parsley, chopped

For serving:
Purée of celeriac or potatoes

Method:
Cut the beaver meet in cubes. Place the pieces in double plastic bags and add 3 dl red wine and bay leaves, garlic, thyme and peppercorns. Seal the bag well and place in the refrigerator overnight.
Take the meat from the refrigerator and drain off all liquid. Heat a casserole and brown the meat on all sides in 2 tbsps. butter. Add peeled and sliced carrot and celery, add the remaining wine, and cover with stock.

Boil up and skim the surface. Add the herbs from the marinade and let simmer for approx. 2 hours until really tender. When the meat is ready, remove it and place in an oven safe dish or casserole. Strain the sauce and boil it up. Make a roux of butter mixed with flour, and season with sugar, salt, and pepper. Add the meat. Fry the shredded pork. Fry the champignon mushrooms and onion in butter. Place it all over the meat and heat for a few minutes in the oven. Garnish with fresh chopped parsley. Serve the casserole with a purée made from celeriac or potatoes.

Photo: Lena Runer

Barbecued beaver leg with beer basting sauce

Recipe by Niclas Wahlström.

Beaver meat has a somewhat higher fat content than many other game meats, and unlike many game species, in beaver the fat is seen as marbling rather than as a layer on the outside of the meat. Therefore, beaver meat is particularly well suited for the barbecue as a replacement for the ordinary pork shoulder.

4 servings

Ingredients
Deboned beaver thigh

Beer basting sauce
33 cl beer, preferably ale
1 dl apple cider vinegar
1 dl water
1 dl rapeseed oil
1 garlic clove, crushed
1 tbsp. Worcestershire sauce
1 tsp black pepper
1 tsp salt
½ tsp cayenne pepper

Method
Mix all the ingredients for the beer basting sauce. Place the leg on the barbecue or in an oven safe baking dish in the oven. Grill at low heat, about 120 °C. Brush with the basting sauce cover every 20 minutes to prevent the surface from drying out, and to add flavor. After 2–3 hours, remove the meat from the barbecue or oven and let it rest for at least 30 minutes. Serve the beaver in thin slices, and serve in a pita bread with vegetables and a yoghourt sauce.

FINLAND

Kaarina Kauhala

Beaver fur was formerly used as money to pay taxes. The secretion of the castor sacs (castoreum) was used as medicine, and the meat was eaten. At present, some people still eat beaver meat and use the fur.

ESTONIA

Nikolai Laanetu and Elve Lode

The skin and meat of the hunted beavers is used by hunters for their own use. Skins are used for the production of fur products: hats, waistcoats, collars, etc.

The objections of animal right supporters and environmentalists to the use of fur have caused a decline of the beaver fur consumption and low prices for hides. Therefore, many hunted animals, and the valuable raw materials obtained from them, remain unused and the carcasses are left as food for natural predators and scavengers.

Meat

Historically, the beaver meat has been valued, primarily due to its very good culinary qualities, in Estonia. Smoked spicy products, smoked sausages, steaks and stews are preferred. In the catering establishments, the use of beaver meat, as any other game meat, is regulated by the food safety standards, as an integration with EU corresponding regulation (EU No 178/2002) into the state regulations (HRsGC2006). National regulations are given by the Estonian Veterinary and Food Board (VFB2000).

Because of disproportionately high hygiene requirements of the game meat handling, storage and treatment, only bigger food establishments are surviving. The result is that there are many private/home consumptions, where only the preconceptions and the specific taste of the meat can be decisive.

The beaver meat has the best quality when it is hunted with a firearm or by live-catching.The meat of animals captured with the Conibear type of traps contains a lot of blood, and also, meat from drowned or suffocated animalsis not usable for cooking. A necessary procedure of draining the blood of the hunted animal together with cleaning the carcass is settled also in the HRsGC(2006) state regulation.

Therefore, partly because of the traditions and also because of state regulations, hunters use the meat of trapped animals to feed the dogs. But in practice, for the manufacture of smoked meat and sausages there is no significant difference in the way how the animal is hunted. Only the time limit is important, so that meat should be used within one day of capture.

Castoreum

The beaver's castoreum is increasingly used in folk medicine, although there are no known, scientifically proven, positive results for its efficiency. The steeping of castoreum bags in strong vodka or spirit is the most traditional use, whereby the castoreum bags could be either in raw or dried conditions. In addition to alcohol-based extracts, the castoreum in combination with the beavers' fat is usable for making ointments. In that case, the dried and milled castoreum is mixed with different oils and those medical mixtures are used against joint pains.

The positive influence on potency enhancement has been described positively by many producers of alcohol-based extracts, but nevertheless, population growth in Estonia has not increased. Such interest is spread among gentlemen of respectable age or people whose potential is rather poor due to a careless way of life. The use of castoreum mixture for the purpose of raising potency is not rumoured to have given revolutionary results.

However, this does not mean, that the castoreum does not have healing and stimulating effects – since it was historically very widely used in Estonia because of its antiseptic properties.

LATVIA

Jānis Ozoliņš

Beaver composes a significant part of the hunting bags in Latvia.

In an inquiry performed among 75 hunter clubs in the season 2016/2017, the numbers of hunted animals were reported as follows: 375 elks, 1 749 red deer, 1 971 roe deer, 5 040 wild boar individuals and 2 507 beavers, thus on average 33 beavers per club. In total, beaver was the second most hunted species in this season in the country, after wild boar but before the roe deer – 34 084, 23 089 and 17 319 individuals accordingly.

In total, 17 000 pelts are obtained from the hunted fur bearing animals in the season 2016/2017 (see Table 7.1) contributing to the hunters' budget nearly 163 th €. Beaver pelts prevail considerably over other game species.

Beaver meat is used for personal consumption as well as to feed the dogs. Castoreum has a varying demand on the market; sometimes limited amounts have been exported to China.

Table 7.1. Total amount of pelts from the game animals hunted in Latvia in the season 2016/2017.

Species of fur-bearing animals	Number of pelts	Average price (€/pelt)	Total value (€)
Beavers	11 555	8	92 440
Red foxes	2 270	5	11 350
Raccoon dogs	1 766	15	26 490
Pine and stone martens	1 410	23	32 430
Total:	17 001		162 710

Fantastic snack – a smoked beaver's tail

The experience I have had with beaver's tails has not always been enjoyable. When prepared as a meat jelly, the beaver's tail wasn't to my taste at all. I could try it, but that was about it. I had tried the smoked ones as well, and while other people were overjoyed, I didn't really understand what to do with the bite – either to swallow it or spit it out. The biggest problem with the beaver's tail is the specific taste and also the texture. If the right connection between taste and feelings is missing, then I am sorry to say but this part of the beaver cannot be enjoyed.

Blanch the tails – just like tomatoes, pour them over with boiling water, keep for a few minutes, then scratch off the scales. They say that you don't necessarily have to remove the scales as it would be delicious anyway, but I haven't tried it. The scales come off quite easily, even with your fingers. Then put the whole tails in a bowl and properly cover them with salt. For both tails, you will need about 400 grams of salt. Then add a handful, if not more, of ground black pepper, slightly burnt bay leaves, juniper berries. Mix everything and leave for two hours. After two hours, pour it all over with warm water of 41 degrees. Stir this terrible salt and pepper water, and leave it for another two hours. Then you can smoke the tails straight away, or wrap them in foil or put them in a plastic bag and in the fridge. I would suggest not to pour the marinade in the sink, but rather in the toilet bowl or flower bed as the mixture is kind of horrible.

You may also cook the tails in the oven, and the result will be good as well. Professionals suggest to put a burnt wood billet in the oven to have a better aroma, and to cook the tail for 40 minutes at 100 degrees.

Tails were prepared at Abas.lv portable smokehouse. The tails were smoked for about 30 – 40 minutes. An important reminder – before you put the beaver's tails or any other meat in the smokehouse, the meat should be dried in the sun until it's dry. If there is no sun, then at least wait until the tails are completely dry, otherwise instead of smoking, the meat will be stewing.

The tails turned out to be unexpectedly good, honestly speaking – they were great. They were hot-roasted rather than smoked, but it was not that important, because both the taste and texture were enjoyable. I would even say – fantastic. The meat didn't even have the typical and specific taste of beaver. It tasted a bit like an eel, but without any bones. Men can have it as a snack with beer, but ladies will enjoy it with salad.

Author: Linda Dombrovska, magazine Medības, Latvia

LITHUANIA

Olgirda Belova

Preparing beaver for meat and food

In Lithuania, beaver meat is considered a product having health benefits when compared to meat from domesticated animals or those raised in captivity. The meat of the females is more valuable. The losses of female meat during cooking are smaller, 1.34 % less than males. The indices of female meat are greater than the ones of males. Female meat has also a higher range of colours (brightness – 37.58, pinkness – 21.72, yellowness – 7.85). The textural properties of beaver meat as softness/hardness (softness displays a slight resistance to deformation, while hardness shows substantial resistance to deformation) of the beaver meat is largest – 1.55 kg/cm^2, and the mildest meat is 1.23 kg/cm^2 in comparison with other game. The average rate of beaver meat softness is 1.37 kg/cm^2. Furthermore, the average water holding capacity index was identified to be 63.77 %. The female meat is leaner, drier and harder than the males'. It has also a high degree of DM (dry matter) content (23.76 %), lower intramuscular fat content (1.32 %) and average ash content (1.14 %) (Kerutytė 2014). The water holding capacity of the meat depends on the gender, age, nourishment and other factors. Water holding capacity of female meat is smaller (2 %) comparing to males, and, as a result, male meat is more suitable for technological meat processing and high-quality products.

Comparing pH between beaver meat and other animals, beaver pH is lower than broiler, but greater than lamb and turkey. Beaver meat redness accounts for 17.99 %, even when compared with beef and veal, pork, lamb, turkey and broiler meat. The water holding capacity was largest in beaver meat is, but the difference between broiler meat and beaver was only 0.04 %. Beaver meat had lower hardness and lower cooking losses than beef and veal, pork, lamb, and also marked the lowest meat colour L * (lightness, a parameter for meat colour that is measured at 24 h after slaughtering) – 32.87 %. The biggest difference between the L * in beaver and broiler meat was 23.5%. (Razmaitė et al. 2011, Kerutytė 2014).

Preparation of the beaver tail

The beaver products are in great demand in society. An exclusive meal obtained from beaver hunting is its tail. Regardless of cooking method (smoking or frying etc.), the first step to any cooking is washing, cleaning and pickling. The tail is scalded with boiling water and skinned. The pickling takes nearly two days.

Smoked beaver tail

Beaver tail smoking is a complex production of very complicated compounds that occur during the thermal decomposition of wood. The smoked beaver tail has a taste which is somewhat similar to smoked eel. The main ingredients for cooking are as follow: beaver tail (with skin); salt, garlic, ground pepper, laurel leaves, and juniper berry. The beaver tail is carefully washed and cut into 4–5 pieces depending on the size. The garlic is mixed with salt, ground pepper and crumbled laurel leaves. The tail is seasoned with this mixture and stored cool during three – five days depending on the tail size. For smoking, the sawdust of grey alder (*Alnus incana)* is recommended. The tail smoking is similar to the one of fish, using the same smoking box. An amount of 0.5 litres of water is used for the smoking. The process should not be too long (15–20 minutes are enough) otherwise the fat will trickle from the tail rapidly. The average temperature is the same as for fish, 80–90 °C. The smoking should be finished as the water will vapour away within half an hour, and the sawdust burns for 10–15 minutes.

Fried beaver tail

One or two beaver tails are put into the pot and scalded with boiling water (as chicken). After 2–3 minutes, the tail is easily skinned. The skinned tail is sliced into 4–6 parts and rubbed with garlic and a special spice mixture for game meat (the simplest way instead of several separate spices that we have to measure and mix ourselves; however, if there is not any spice mixtures, the separate ingredients are used (i.e. 1.42 grams of pepper, 170 g vinegar, 85 g butter, 14.3 g salt, 56.7 g sherry or cooking wine, 28.3 g soda, 5.69 g dry mustard, 56.7g flour, 5.69 g sugar, 2.84 salt and 14.3 g Worcester sauce). Then the treated tails are foil-wrapped and fried. If frying at home and the oven is used, frying takes 30–45 min under 200°C (depending on the tail size); if frying on a fire or grill, it takes 30–50 min.

Roasted pickled beaver tail

One or two beaver tails are selected for the dish. The main ingredients for the pickle are 1 lemon, 2 larger garlic bulbs, 2 carrots, leaves of horseradish, dill, a pinch of salt, teaspoon of sugar and tomato sauce, juniper berry and special game spices. The tails are scalded with boiling water and cut into pieces. The marinade includes fresh juice of garlic and lemon, horseradish leaves and dill stems, salt, sugar, tomato sauce and game spices. Beaver tail pieces are put into the marinade, pressed and put into a refrigerator for 1–2 days. Before roasting, carrots are cut in small pieces or shredded and added to the pickled beaver tail. The meat is foil-wrapped and fried on a bed of hot coal for half an hour.

Beaver tail stewed in beer

The main ingredients for the pickle are 3 garlic cloves, a sprinkle of Worcestershire sauce, allspice and black pepper, 2 laurel leaves, dill and parsley sprinkles, sunflower oil, and salt. For stewing: 4 garlic cloves, 3 carrots, oil for roasting, 1.5 glass of beer, salt, two teaspoons of parsley and 100 ml cream. The beaver tail is carefully scalded with boiling water or kept in the hot water for half a minute. Then the tail is skinned and cut across the joints. All ingredients for the marinade are crushed down. The tail is seasoned with this mixture and stored in the refrigerator for one – two days depending on the tail size. When marinating finishes, the remains of the marinade are removed from the tail and slightly fried in the oil. The oil and bits of carrot are added into the pod for stewing and fried for several minutes. The garlic cloves are added and are also fried shortly. The fried tail pieces, beer and remains of marinade are put into the pot and are stewed for 1 hour. If a pressure-cooker is used, the stewing takes half an hour. At the end of stewing, the salt, parsley and cream are added. Champignons and stuffed potatoes could be added too.

Beaver haunch roasted in beer

The ingredients needed are the beaver haunch, 10 garlic cloves, 100 g smoked pork bacon (traditional Lithuanian cuisine), 250 g small onions, 500 ml beer, 4 sprinkles of thyme. To marinate, 3 glasses of water, 1 glass of 6 % vinegar, onion, carrots, 3 garlic cloves and a spoon of special beaver spices (available in the market) are needed. The membranes are removed from the haunch. The haunch is seasoned with pieces of smoked pork bacon and garlic cloves and steeped in a marinade. Marinating time is 1 day at least. Then the haunch is put into the baking tray adding the beer, thyme and garlic, closed with cover or foil-wrapped. Roasting continues until the meat becomes soft. Then the roasted haunch is removed from the oven and kept warm for 5–10 min. The liquid from the baking tray is poured into the pot and boiled for 5–6 min. The small onions are put into the bowl and covered with boiling water for 5 min until the peel becomes soft, then remove the water. The onions are not cut into pieces but added to the roasted haunch.

POLAND

Michal Wróbel

Looking at the management of beavers in historical times, they were used for meat, skins, other parts and also castoreum, as medicine against many diseases. In ancient Polish studies like the one by Jakub Haur in 1689, one can find descriptions that luxurious fur and hats were made of beaver skins. All kinds of hats were special because it was believed that they would improve the memory of the person who was wearing them. Patients with gout were wearing beaver fur which was thought to have a good effect. Beavers were also killed for the dried exudate of the castor sacs, the so-called castoreum, which in nature served to mark their territory.

According to contemporary medical principles, castoreum treated ear diseases, headaches, toothache or liver pain. It was used for curing of melancholy, insomnia, poor eyesight and menstrual disorders. Castoreum was also used to smooth out visible scars and against wrinkles. It was also widely believed in the miraculous properties of the beaver's fat, which healed all kinds of wounds. The beavers' teeth and tail were also valuable for hunters. With the tail a delicacy could be prepared on fast days. Currently castoreum is still used, but for completely different purposes, for example as a component of expensive perfumes.

Preparation of permits

At present, in Poland, it is necessary to have appropriate permits for the preparation, keeping and possession of beaver specimens. Permits need to be obtained by the owner of the animal. Hunted animals in a hunting ground are in accordance with the regulations in the law owned by the holder or manager of the hunting grounds. On the territories not belonging to the hunting grounds, the ownership rights belong to the State Treasury. The holder of hunting grounds can give the hunter a dead animal. Hunters can use the animal handed to them at their own discretion, excluding resale.

The permit for specimens of protected species is issued by the Regional Director of Environmental Protection. In the application it should be specified, for example, data of the institution in which the preparation will be carried out. The institution must be approved by the Veterinary Inspection.

Meat

Beaver meat is rarely used in Poland for food purposes. However, you can find recipes for beaver meat. The beavers' meat has excellent culinary properties and was once considered a delicacy, especially the hind legs, liver and tail. You can make cutlets, sausages and even skewers or soup. The meat can be subjected to a variety of thermal treatments. It tastes delicious baked or stewed, but often it is smoked. Due to the specific taste and smell, it requires proper seasoning with herbs, spices and oil. The meat has a fishy aftertaste. It is characterized by a high content of protein and minerals, especially phosphorus and iron. The muscle fat contains a large amount of unsaturated fatty acids.

Beaver tail

(a recipe from almost 200 years ago)

"Cut off the beaver's tail,. Pour boiling water frequently so that you can clean it from the scales. Sliced lard, butter, onions and cloves, a bit of dry herbs into the pan. Put the cleaned beaver tail in it, and quickly grill it to make it brown. Then pour a glass of red wine and broth and cook slowly. Remove the fat from the remaining sauce, boil it well, add capers, truffles and lemon juice. Serve the cooked beaver tail with a spiced sauce on the table. "

Beaver stew (goulash)

- 150 g of beaver meat
- 1 onion
- 15 g lard
- ground red paprika
- 250 g of mushrooms
- salt
- 1 green pepper
- 2 tomatoes
- buttermilk for marinade

Marinate the meat for 3 days in buttermilk, then wash and dry.

Get rid of the bones and cut the beaver into pieces. Chop the onion finely, and fry it in the lard. Add the meat, sprinkle with salt and paprika. Stew until tender, adding water several times. Peel the tomatoes from the skin and cut into cubes. Cut the pepper into strips, as well as the peeled mushrooms. Add everything to the meat and cook for about 15 minutes. To improve the taste of the finished stew, you can add cream with a small amount of flour.

Beaver stewed in beer

- 1 kg meat
- 1 bottle of beer
- 6 cloves of garlic
- 1 glass of chopped parsley
- 2 teaspoons of pepper
- 1 bay leaf
- 1 tablespoon of hot chili sauce
- 1 teaspoon of salt
- 1 teaspoon of black pepper,
- 1 large onion, finely chopped
- 1 tablespoon of olive oil
- 1 cup of wild rice.

Rinse, dry and divide the meat into pieces. Make a marinade with garlic, parsley, bay leaf, chili sauce, salt, pepper and beer and pour over the meat. Leave in the fridge overnight. Chop the onion and fry in a pot of olive oil. Add meat from the marinade and slightly brown, then pour the marinade and simmer for about 2 hours on low heat. Season with salt, pepper and garlic. Cook rice, preferably in 2 cups of broth. Serve on lettuce leaves with sauerkraut salad.

http://orlik86.pl/potrawy-z-bobra/

Jakub Haur: Skład abo Skarbiec Znakomitych Sekretow Oekonomiey Ziemianskiey. Kraków, 1689.

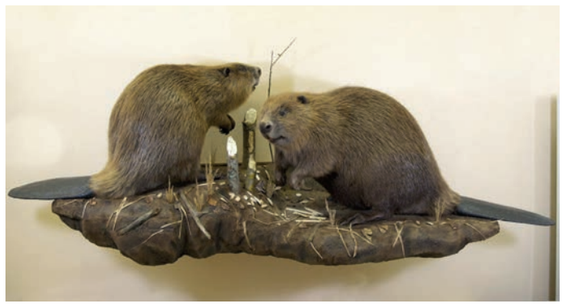

Figure 7.4. Beaver taxidermy.

RUSSIA

Alexander Porokhov

For the past 10 years (from 2005 to 2015) furs of the two beaver species were not listed for the S:t Petersburg International Fur Tender, so their turnover is unknown (Review 2016). The volume and direction of export of beaver fur and castoreum, and the use of pelt for hat manufacturing, also remains unknown nowadays.

Beaver handling and skinning for taxidermy

In the late 1980s in the Soviet Union, game hunting began to develop, and taxidermy as well. Later, after the disintegration of the Union, game hunters from Western Europe and America started to visit Russia with hunting tours. Main destinations were Kamchatka, Magadan, and Sakhalin. In the European part of the Russian Federation (Arkhangelsk, Murmansk, Leningrad, and Novgorod regions, as well as Karelia and Komi), the most desirable game species were bear and wolf, black grouse, duck and wood grouse. During autumn hunting tours, beaver becomes a game species of interest, equally with bear or deer. Below I would like to draw your attention to beaver as game.

The two beaver species (*C. fiber* and *C. canadensis*) are a challenging prey for any predator. In the water these rodents are even beyond the power of wolf and bear. Meanwhile, being careless while eating or trees gnawing, it could be attacked by wolf or lynx. In this case the beaver instantly attacks its opponent, trying to bite it to death. Knowing this, it's recommended to make beaver taxidermies dynamic to depict its wildlife habits (Fig. 7.4).

So, you shot or trapped your game and intend to make a mount. What do you need to do? First, determine its sex, which is impossible to do externally. However, an adult female who just once in a lifetime has been nursing a cub could be defined by the nipples visible between the limbs, which are invisible in males because of thick fur. The simplest method of beaver sex determination with yearlings and older is the different colour of the anal glands' secretion disposed behind the abdominal cavity. The male beavers' adipose glands' secretion is tough and looks close to mayonnaise and has a yellowish colour, while the females' has a greyish colour. To see the anal glands' secretion, you have to find large enough glands by feeling – it is soft in comparison with the castoreum. Then you press them gently and displace the secretion in the direction of the anus; it's sufficient with one gland. The gland duct goes over the anus and you should be able to observe a few secretions. If not, press again.

When the sex of the beaver is determined, you need to weigh it to know its approximate age. For example, the weight is 500–600 grams for cubs soon after birth, about 8–12 kg for yearlings, and 15 and up for 2-years' animals. A beaver can be defined as an adult if it weighs more than

15 kg. The maximal beaver weight recorded in Russia was 36 kg.

With all these procedures completed, you need to freeze the animal, or deliver it to a taxidermist within 24 hours. Otherwise you or the gamekeeper have to dissect it at the spot. Before dissection of the beaver meat, you have to measure it with measuring tape and slide calliper and write down the following parameters to get a precise mount: 1) from the tip of the nose to the eye; 2) from the tip of the nose to the occiput (back of the skull); 3) from the tip of the nose to the bare tail part (along the back); 4) the neck circumference; 5) double body-hold behind limbs.

Beaver meat quality and preparation

Beaver meat has been used as food for a long time. In the Middle Ages, it was used during long-time fasts, but this stopped with the almost complete extinction of the beaver (see Chapter 5). The main characteristics of beaver meat and fat, as presented by M.M. Iljin (1960), provides explanations for the possibilities of using beaver meat for food. Nine Eurasian beavers were studied, of which 5 were captured in their natural habitat (4 males and 1 female) and 4 were hand-reared (2 males and 2 females) in Voronezh. Three males and 1 female were exsanguinated; the rest of the animals were partially exsanguinated. The meat from all 9 beavers was used by the researches, and 1 served for degustation. Organoleptic properties were studied in all animals – there were 12 muscle tests and 2 fat tests. The meat got in 24–48 hours after harvesting. The following characteristics were studied:

1) pH of meat extract, colorimetrically;

2) moisture by drying at 105 °C until constant weight;

3) Soxhlet fat characteristics;

4) Kjeldahl albumin characteristic. External and paranephric (kidney) fat was fused at +80 °C for 1.5–2.0 hours. It was washed in cold water (7–9 °C), then small cut.

Fat test was taken by:

1) organoleptically testing of raw fat ;

2) the same for fused fat, including clearness.

The following tests were made: fusion temperature with J-capillary, acid value, iodine value by Goble, and refraction coefficient.

Partially exsanguinated meat of one beaver was tested. Five tests were taken: thoracic wall, abdomen, lumbus, limbs and tail with fat. Two methods of preparation were used as follow: boiling in a litre of water with salt for 2.5 hours, or preparation of ordinary potato soup, using the same time. Eurasian beaver meat is dark red, while the meat from non-exsanguinated animals is bluish. Beaver meat has no unpleasant odour as can be the case with other game meat.

The stringiness and grain of the meat is normal. The acidity of beaver meat (pH) in 24 hours after butchering ranges about 5.4–5.8.

External fat goes liquid at +16–18 °C, but the paranephric fat is more solid. Two layers were seen: a liquid and yellowish upper layer, and a white amorphous bottom layer. The fused fat was completely clear. The fresh fat has no specific flavour. The chemical composition (%) of the meat is presented in Table 7.2.

The albumin content in beaver meat is 18.31–23.92 %, and on average comprises 21 %. Beaver meat is mildly fat. No differences were found between limb muscles and hind limb muscles, therefore, beaver meat is close to chicken and rabbit. In ash and nitrogen content, it is similar to any other domestic animals' meat.

As seen in Table 7.3, the fat fusion temperature varies strongly, e.g. from 13.7 to 22.8 °C with subcutaneous fat and from 15.4 to 25.5 °C with paranephric fat. Paranephric beaver fat is 3 degrees hotter than external fat, which is explained by the proportion of fusible and infusible fat fractions. Beaver fat has high iodine value; thus, it is off-peak. Ethylene link shows high oxidation, and the fat easily deteriorates. Unsaturated fats are very active, that's why beaver fat is often used in folk medicine, like the dog's or badger's fat.

During beaver meat testing a rich fat concentration was discovered in the broth, and also a lot of scum (albumin). Without the scum the broth is clear, and has a pleasant odour, and a light after-taste like goose meat. The meat is easy to cut and bite, and soft, juicy, and tasty, with a medium stringiness.

The prepared potato soup with beaver meat had the same meat characteristics, but onion, bay leaf, and black pepper added odour and flavour to the enriched meat and broth, partially covering its own pleasant odour and flavour, which in that case is shown a little bit weaker.

The data presented above say that meat from healthy Eurasian beavers is esculent, as well as that from any other game (Iljin 1960).

There are some recipes for beaver meat preparation which are used in Villa Aston restaurant in Saint-Petersburg (A. Krasniy 2012a,b).

Castoreum removing and processing

The castoreum is found in a special pair of sacs in the abdomen. Other fat glands (which are not used) are also present there. The castoreum sacs are large, thick and a little bit contracted. The contents are dark coloured and differ from the light and greasy oil-bags' products. One castoreum sac is about 7–12 cm long and 4–7 cm wide.

The castoreum sac is cut off after the skinning. Be careful when you cut off the sacs, to avoid pressing the contents and spoiling with the knife. Both sacs in the pair must be connected, and the mouths untied but transported in a hard vessel in order to preserve the contents.

At the hunting base, or at home, the castoreum sacs are to be thoroughly peeled from blood and layers, and then to be hung near a window in a warm place, at a distance from the heating source. Tying of excretory ducts is optional.

In severe winter, it is recommended to put the sacs in an unheated room on a glass sheet, until transportation in a firm container, in order to avoid that the castoreum sacs' contents are pressed out.

Beaver tail baked in sour cream sauce

1) Peel a beaver tail;
2) Flavour it with salt, pepper, garlic and rosemary;
3) Put it in a casserole, add a little bit of water. Then close the casserole and stew for two hours at 180 °C;
4) Bake carrots and potatoes, cool and peel them and cut in large and long slices;
5) Slice marrows, fry vegetables in oil, and add coriander, salt and pepper;
6) Cut the prepared tail into 4–5 pieces, cover it with a thin layer of sour cream with rosemary and paprika and bake;
7) Serve the beaver tail pieces on fried vegetables. The dish can be ornamented with fresh salad and pickled mushrooms.

Beaver carpaccio

Ingredients
Trimmed beaver meat, rosemary, olive oil, rocket salad, cherry tomatoes, salt, pepper.

Preparation
1) Take the beaver meat off the bones and beat it. Add salt, pepper, rosemary and olive oil;
2) Roll in a gauze and tie around with a thread;
3) Smoke on alder chip for 7–8 hours;
4) Cool and unroll;
5) Serve with rocket salad and cherry tomatoes.

Table 7.2. Chemical composition of the Eurasian beaver meat.

Test name	Moisture	Ashes	Fat	Nitrogen	Dehydrated and fat-extracted residuum, %
Limbs muscles, range	67.4–74.5	0.93–1.25	3.74–10.84	18.42–23.92	–
– average	70.85	1.09	7.16	21.07	21.99
Hind limbs, range	68.1–73.66	0.98–1.18	3.70–11.11	18.31–23.7	–
– average	70.88	1.08	7.20	21.04	21.92
Average parameters	70.86	1.08	7.18	21.05	21.96

Table 7.3. Physicochemical characteristics of Eurasian beaver fat, %.

Fat, title	Fusion temperature, °C		Acid value	Iodine value	Refraction coefficient
	beginning	finish			
External: - range	13.7–15.2	19.3–22.8	1.2344–1.7952	90.4–106.2	1.4363–1.4852
- on average	14.5	21.1	1.447	98.3	1.4657
Paranephric - range	15.4–19.3	22.9–25.5	1.7952–2.1322	84.8–98.1	1.4712–1.4821
- on average	17.4	24.2	1.9637	91.45	1.4766

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Workshop on beavers in Sundsvall, Sweden.
Photo: Göran Sjöberg

Chapter 8: The beaver as a resource for tourism business and education

Göran Sjöberg

Ecosystem services

Among the ecosystem services that the beaver provides, some can be classified as cultural services, e.g. recreation and ecotourism. Beaver can also provide good opportunities for nature education.

Tourism

Nature tourism has been described as responsible travel to natural areas, based on the natural attractions of these areas, which conserves the environment and improves the welfare of local people (TPW 2017). Ecotourism on the other hand implies more strict demands for sustainability, sometimes with positive net benefits for the area visited, and will generally require adaption to a national or international certification or accreditation programme (Gössling and Hultman 2006). Hunting tourism is consumptive, since it involves killing of animals, usually with a rifle. Hunting tourism may nevertheless coincide with ecotourism, although only a minority of hunting tourism enterprises tend to be certified for ecotourism (Gunnarsdotter 2006, Bell et al. 2007, Damm 2008). Wildlife tourism means any tourism which interacts with local animal (and possibly plant) life, and may be either consumptive or non-consumptive.

For successful entrepreneurship in any of these kinds of tourism, many skills are necessary, such as knowledge of the market and about business in general, good education about the subject area, and a correct attitude to service for customers. It also takes time to build up a good reputation and knowledge about customers (Matilainen and Keskinarkaus 2010).

Tourism business will in the long run need to be economically, ecologically, and socially sustainable. For the economic sustainability it will be important to reach potential markets both in the national and international perspective. This includes being part of the business fairs in respective parts of the trade, presenting the products and tying bonds with agents and customers. For ecological sustainability, knowledge of the landscape and the animal populations is crucial. Experience of the particular area is often decisive. Planning with other actors and good relations with landowners and other land users is basic for the social sustainability. Some studies show that the good reputation of tourism trade will stand or fall with the entrepreneurs' ability to make local people benefit from tourism activities, such as purchases of goods, renting of cabins, hiring local hunting / nature guides etc (Matilainen and Keskinarkaus 2010). Without these good relationships, it may prove impossible to continue activities, and the local community may have become reluctant for a long time to cooperate even with new entrepreneurs. Also, pedagogy and training in nature-based education are important skills for any tourism entrepreneur.

Summing up, many requirements are similar for both hunting and non-hunting tourism entrepreneurs such as knowledge in ecology and contacts with landowners. In addition, hunting tourism entrepreneurs need to know hunting traditions of both local communities and of the customers, as well as arms and ammunition, and current legislation.

Hunting tourism entrepreneurs need to combine e.g. beaver hunt with opportunities to hunt other species, also combining with other activities for family members.

Possibilities and the means to get training and counselling for tourism entrepreneurs will differ between countries. However, in many places there will be availability for education in tourism and entrepreneurship in both secondary school and tertiary training. In addition, there are both national, regional, and local authorities, NGOs and companies giving counselling. There are also specific nature guiding courses.

The availability and conditions of use of land for beaver tourism activities will vary between countries, and between categories of land ownership, such as private or state-owned forest or water, and national parks, Natura 2000 areas or nature reserves. For hunting tourism, national hunting legislation and regulations will apply.

Educational use

Beaver is an ideal species for education in nature and ecology, and it has charismatic qualities. It shows interesting adaptations for semi-aquatic life, and for herbivory including felling of large trees. It may at times be easily visible even for groups of visitors. (Combining hunting with beaver watching in a given area might not work since beavers will become shy; Rosell and Pedersen 1999.) The beaver leaves characteristic traces in the landscape such as dams, lodges, and felled tree stems. It affects ecosystems and species communities in a way that facilitates understanding of biodiversity, including ecological processes.

For these reasons, educational use of beavers is common in many areas, and is directed toward both the general public and children's schools. This has a positive effect on the attitudes towards beaver in nature and also creates an understanding for the beavers' living conditions. It also contributes to a general understanding of the need for nature conservation.

"Beaver safaris" as a non-consumptive attraction is now common in many countries in Europe (Rosell and Pedersen 1999). Where beavers have been recently introduced, such as Scotland and Denmark, education activities have often been an important part of the introduction programmes. The presence of beavers may also be seen as an economic resource for landowners and entrepreneurs (Campbell-Palmer et al. 2016).

SWEDEN

Göran Sjöberg

Nature-based tourism (NBT), especially based on forest, lakes, and streams, is of fairly large extent in Sweden, which is easily understood since there is wide access to natural areas in the whole country. The legal right to move freely in Swedish nature (Right of Public Access) is very important not only to the individual visitors, but also to the NBT enterprise. However, many companies also rely on agreements with landowners. The total annual sales of the Swedish NBT-sector was estimated to at least 3,6 BSEK (ca 380 M€). Most of the NBT providers are small local companies. Of 500 companies that answered a question on dependence on animal species for their activities, 17,4 % classified beaver as a very important species, and 11,6 % as somewhat less important. Only fish, birds, and moose were of higher importance (Fredman and Margaryan 2014). This means that there is apparently a large interest for visitors to natural areas to experience beavers and the constructions and landscape they create.

Around 22 % of NBT companies in Sweden cooperate with the Swedish Ecotourism Association which has over 400 member organisations. The environmental certification brand of the association, together with the marketing organisation Visit Sweden's, Nature's Best, has approved about 70 companies (naturesbestsweden.com). Several of these, in the counties of Västernorrland, Värmland and Västmanland, offer beaver watching.

A common format for beaver watching is so-called "beaver safari". This is a common offer at many tourism destinations, in combination with building and navigating timber rafts, canoeing, sport fishing, lighting camp fires and other similar events. It may be either a one day excursion or a combined trip of 2–4 days. The cost for a one day beaver safari is 1250 SEK (ca 130 €) and for two days, including cabin lodging, 1750 SEK (ca 180 €). The combined tours are connected to living in cabins, shelters, or tents in environments with forest and water landscapes. It is usually organized in small groups with a guide. It is informed that there are chances of observing other wildlife such as roe deer, moose, fox and badger.

Organizers boast that over several years of beaver safaris, beaver have almost always been sighted, and sometimes during the whole trip. Sometimes beaver sightings are a part of the combined wildlife experience during night-time canoeing together with also chances of hearing wolves.

Nature schools
A common activity connected to Swedish schools is Nature School. Some of these are run by municipalities, others by NGOs. The purpose for these is both to learn more about nature, but also to promote nature as an arena for learning in general. There are today 90 members of the Swedish Nature School Association (www.naturskola.se). Many of these visit beaver settlements with groups of school kids. One group from third grade reported this on the class website, with even a photo of the beaver:

We were all silent walking along the river and stopped to search. First, nothing happened, but just when we were thinking of giving up, we saw the beaver. It was on the shore, and then it went down in the water and started to swim.

Observations like this will connect learning about wildlife, nature, and ecology with a positive experience and a sense of wonder at nature. Most likely this will lead to the school childrens' understanding of the need for nature conservation.

ESTONIA
Nikolai Laanetu and Elve Lode

In Estonia, the beaver is becoming more desirable for hunting due to its furs, meat and castoreum. It can be seen also in the increasing interest of hunting tourism, especially during the spring season while hunting is stopped for other species.

Several tourist farms have included beaver hunting on their service list, especially in the picturesque landscape of Southern Estonia, where there is relatively good access to beaver habitats.

As the beaver's activity is exceptionally unique and interesting, has extensive influence on the design of the environment, and promotes biodiversity, it has received great attention from nature lovers and school children.

With the purpose to serve the tourism, several stationary beaver study trails have been created in national parks all over Estonia, e.g. in Soomaa National Park in the South-Western part of Central Estonia, and in Lahemaa National Park in North Estonia. However, due to widespread distribution of beaver and due to the dynamic changes of habitat locations, it is not meaningful to create stationary beaver-habitat-oriented demonstration areas in all habitat locations. Instead, temporary observatory screens or stands with beaver activity information are installed close to the small places of country side tourism accommodation (e.g. Elistvere Lake observation point in the South Estonia), where access to the beaver places is guaranteed. However, the best sites for introduction of the beaver's life could be installed close to well-accessible water bodies where the activity of the beavers is high and the impact of hunting and human activity on the beaver settlements is small.

The beavers' activities and accompanying changes in the nature, as well as the growth of biodiversity in beaver habitats, deserves widespread introduction in society. Unfortunately, at present there is a negative attitude in Estonia towards the beavers and their habitats because of the wide range of damage caused by the species to forests and areas of human economic exploitation.

LATVIA
Jānis Ozoliņš

Beaver is offered as a game animal to guest hunters visiting Latvia but it is not a target species they arrive for. A higher demand for beaver hunting tourism is hardly imaginable. The most usual targets for hunting trophies are wild boar, red deer or elk.

Hunting tourism in Latvia is organized by the company "Latvia's State Forests", as well as individual local hunters and hunter clubs.

There is a special temporal permit for the foreign hunters to visit Latvia. It is issued by the State Forest Service on the base of invitation by a local owner of hunting right.

Non-consumptive use of beaver for tourism is not applied so far. There is no special policy applied regarding tourism for the beavers and other wildlife. Canoe traveling, however, is a popular branch in both local and international tourism and that could be combined with watching beavers and their signs of activity. For tourism related infrastructure government advice and support is available to a certain extent.

Beavers are generally not used for educational purposes. There is one example when assessment of beaver population on a local scale was used for public monitoring to teach the volunteers encounter nature and dynamics of natural processes. This was organized by North Vidzeme (Livonia) Biosphere Reserve, for local inhabitants of all social groups.

LITHUANIA
Olgirda Belova

Beaver tourism

Forest recreation and cognitive tourism are highly developed in Lithuania. Each State Forest Enterprise has implemented a recreational programme. There are more than 2 052 recreational facilities in forests, of which 254 are adapted for disabled visitors. These facilities include informative, educational and recreational paths, scenic lookouts and resting points. Foresters do not limit themselves solely to developing recreational framework. They also direct attention towards public relations, ecological educational programmes and working with young forest friends. NGOs such as the Young Friends of the Forest Association are the most enthusiastic group that helps foresters to maintain the outdoor recreation. Many cognitive paths in forests include wetlands where visitors can observe beaver activities.

According to The Law of the Republic of Lithuania on the Protected Areas (December 4, 2001 No. IX-628, Vilnius) and Regulations of each National and Regional Park, cognitive tourism is a trend of tourism oriented towards the purposeful knowledge of the country's natural and cultural heritage complexes and objects (values), towards the knowledge of landscape and history, as well as intended for science and educational purposes. National and regional parks are responsible for arrangements for recreation, first of all for the cognitive tourism, and development of education on environmental protection.

The main purpose of the national parks is to preserve naturally and culturally valuable landscape complexes and objects; to maintain the stability of ecosystems; to restore destroyed and damaged natural and cultural complexes and objects; to develop scientific research; and to promote and support the ethno-cultural traditions of the Lithuanian regions.

Figure 8.1. Plateliai lake is part of NATURA 2000 territory called "Žemaitija national park".

In Lithuania, demonstration areas on beaver activity are established in the National Parks (e.g. Žemaitija National Park; Fig. 8.1). These areas allow free public access and are used for educational and non-commercial purposes. The Park has spent a lot of time for the development of eco-tourism, to encourage people to come closer to nature, giving them a chance to discover answers to their questions, and substantiate nature conservation. The scale of the existing demonstration areas differs from stream to the catchment. In Žemaitija National Park, there are 26 post-glacial lakes and 32 streams. There are watersheds of three rivers: the Minija, the Bartuva, and the Venta, and a lot of large and small bogs. The bog of Šarnelė in the Wetland Reserve of Paparčiai is a classic example of Žemaitija's raised bogs. Examples of transition mires and alkaline fens are found at Siberija, Šeirė and Stirbaičiai. All these watersheds are suitable for beaver. The educational walking trail Šeirė was established for visitors of different interests. Some part of the trail is adapted to mobility-impaired visitors and to bikers, and the entire trail for all hikers. The trail includes the Šeirė forest, the Gaudupis Bog, lake Piktežeris, and Lake Plateliai, most of which are inhabited by beaver. Visitors can observe beaver floodings, channels, lodges and measurements on preservation (Figure 8.2) of valuable tree species from beavers.

Figure 8.2. Stanislovas Vyšniauskas, a head officer at the Žemaitija National Park, works with protection of valuable trees in the Park against beaver felling. Photo: Olgirda Belova.

Hunting tourism is a consumptive form of nature tourism. In the European Charter on Hunting and Biodiversity (2007), hunting tourism is conducted by hunters who travel considerable distances from their home and/or own hunting grounds in order to hunt. These hunters differ from hunters who mostly hunt in the area where they reside.

Hunting tourism

Hunting tourism includes beaver hunting with dogs or traps in the professional hunting territories within state forest enterprises. Forest Enterprises organise commercial hunting trips on these professional hunting grounds for both local huntsmen and huntsmen from abroad. The organisation of hunting trips is a continuation of ancient and deep-rooted hunting traditions in Lithuania.

All activities of hunting tourism are regulated by the local and European legislation on hunting including the Law on Hunting of Lithuania, the Rules on Hunting in the Territory of Lithuania, and the Law of Wildlife.

POLAND

Michal Wróbel

In Poland, the beaver is an animal that is quite mysterious for most people, and not noticeable in everyday life, so people are encouraged to know about their life. Institutions of national parks, landscapes or forest districts create educational paths in order to show people the life of beavers. Paths are used by individual tourists as well as by organized school trips. Nature amateurs visiting these places can study the biology and ecology of the species. Visitors' paths are guided so that you can see the beavers, their lodges and the impact on the surrounding ecosystem. They have a chance to see the animals themselves, in peace and quiet, which is a unique event. In addition to entities subordinated to the Ministry of the Environment, private companies also organize tours to view beavers.

Tours are sometimes organized during night hours in combination with field trips. In order to bring people closer to the world of beaver life, educational campaigns, conferences, seminars, and meetings for beaver-loving people are organized.

Beavers are associated with strong and healthy teeth, which is used in dental education for children.

The beaver was used by literary writers and children's storytellers as a symbol of hard work, family, care and cooperation.

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Beaver site at Torringen, Sweden, after dam removal. Photo: Magnus Martinsson

Chapter 9: Prevention of beaver damage to economic interests

Alius Ulevičius

The beaver is considered as a problematic species, causing damage to forests and adjacent agricultural lands. Beavers change their environment profoundly by felling trees along watercourses, digging burrows and building dams which can result in flooding of large areas, especially in landscapes with flat topography.

The main aspects of beaver damage are:
1) flooding negatively affects soil conditions in agriculture and forest land, which may result in plant death;
2) destroying the function of artificial drainage system;
3) destroying man-made infrastructures like embankments etc.

All these aspects allow us to assess beaver damage financially by accounting lost production, investments to infrastructure construction. There are many other losses from beaver activity hard to evaluate monetarily but important for human wellfare and aesthetic needs (cutting valuable trees, messing up recreation sites).

Beaver damage management aims to reduce the level of damage caused to forestry due to engineering and foraging activities of beavers but may also need to optimize the benefit for biodiversity. The management includes three basic and inseparable points as
a) quantitative (i.e. number control via hunting)
b) qualitative (i.e. sex and age control in the local populations considering species social structure and behaviour)
c) territorial (habitat) management.
(See Chapters 3 and 6.)

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. Protection of roads, dams on man-made impoundments, levees, drainage ditches would benefit ecosystem and human society.

Use of flow devices is a worldwide acknowledged practice to prevent beaver-caused flooding. However it should be applied professionally to be efficient. This is one of the reasons (simultaneously with relatively high costs) why this method is very rarely used in the Baltic Region.

Before beginning any beaver control action, it should be assessed fairly and objectively whether beavers are really causing damage or creating hardship requiring control.

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 (See Chapters 3 and 6). Despite these activities, dam removal is the simplest and widely used method to protect forest and watersheds. Several Baltic countries have implemented this method into legislation.

Setting of acceptable abundance of a beaver population should be based on damage evaluation and the beaver's role in the ecosystem. One of the simplest approaches could be the inventory of problematic beaver sites ("unallowable") which should be harvested first.

Figure 9.1. Restoration of forest road after beaver damming. Bäcksjön, Umeå, Sweden. Photo Göran Sjöberg, SLU.

SWEDEN

Göran Sjöberg

Beavers are regularly causing damage in Sweden, damming agricultural and forest land, creating (perceived) obstacles to migrating fish, and damaging infrastructure. This is, however, not seen as a major problem to society as the problems can be handled by landowners, hunters and wildlife managers. There are, therefore, no estimates made of the economic costs for beaver damage in Sweden.

For larger landowners – forest companies etc. – the damage to forest by damming and tree felling is seen as marginal, and balanced by the beavers' contribution to biodiversity, since a second objective of Swedish forest legislation is nature conservation, besides timber production. For smaller landowners the beavers' activities may be of comparatively larger consequence, and may result in the landowner removing dams and having the beavers killed.

One not uncommon problem for forestry is the threat caused by beavers damming in culverts of forest roads (Fig. 9.1). Forest companies therefore need to keep vigilance over beavers to remove beaver colonies that are a risk factor for the maintenance of forest roads. The problems are handled by the companies' district officers, when they occur and there is no particular policy for beaver management in Swedish forest companies.

City beavers

The city beavers are a special case. Beavers are now seen in several towns and cities in Sweden. Beavers were e.g. established in Stockholm at least as early as 1996. In 1999 there were still only a handful of individuals observed in the capital (Gothnier et al. 1999) but numbers have recently increased dramatically and media report on numerous beaver sightings in Stockholm and adjacent municipalities (Fig. 9.2). Trees that are partly felled may pose risks for the general public passing through wooded areas. This may make it necessary for the city's wildlife managers to kill certain beaver individuals (svt.se 2015). Beavers also have created problems for train traffic by felling trees over power supply lines. A beaver was also reported, in 2015, to physically attack and bite a person who attempted to photograph it at a bus stop in greater Stockholm (Owen 2016).

Beavers are also seen as threat to fish migration, in particular to valuable sea-migrating trout populations in central Sweden. Dams are routinely removed in some of these streams, although there is little documentation of the actual effects of the dams on trout populations.

Landowners who experience damage to forest land or other property are encouraged by the authorities to monitor the beavers' activities closely during the whole year, to protect exposed and valuable trees with fencing, and to utilise the general landowner rights. If problems are severe,

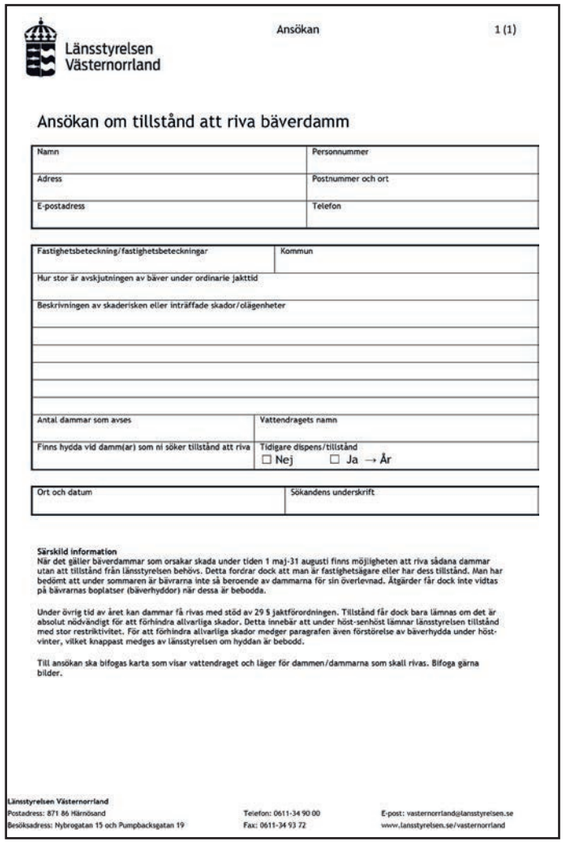
hunting is recommended. The regular hunting season for beaver, as stated by the Game Regulation (Jaktförordning /1987:905/), is from October 1 to May 10 or 15 (depending on county). During this period, any landowner with a hunting permit, or a hunter that the landowner contracts, may shoot any number of beavers on the property. For less severe problems, dam removal may be enough. The landowner may remove beaver dams during the period May 1 to August 31. After this period, the landowner may apply to the County Administrative Board for removal of dams, according to the Game Regulation (Jaktförordning /1987:905/), but this will be permitted only if it is judged necessary for avoiding severe damage. When permitted, dam removal outside of the spring–summer period may be combined with hunting or trapping of beavers (ATL. nu 2016). The Swedish Environmental Protection Agency (2017) has permitted the use of two brands of killing traps for beavers. Beaver lodges may in rare cases also be removed after permission from the County Administrative Board (but during autumn and winter only to avoid serious damage; Fig.9.3).

The general hunting method permitted is shooting. For trapping of beavers, special training and permission is needed.

Figure 9.2. Beaver is now a part of the city fauna. Vinterviken, Stockholm, March 2019. Photo: Peter Sjöberg

Fencing of trees against beaver felling and use of flow devices to reduce effects of damming are not commonly used in Sweden. The reason is most likely that these are costly measures, and landowners can more easily solve problems by hunting and removal of dams.

For the same reasons, there are no management plans for beavers in Sweden, on national, regional or local level. It is considered on all levels that decisions taken by local landowners, forest managers, and hunters are sufficient for fulfilling management of beavers in protecting land, and infrastructure while at the same time maintaining a sustainable beaver population. There is no monitoring of the beaver population in Sweden; so, the estimates of the populations size are very approximate. The Swedish Association for Hunting and Wildlife Management keeps annual statistics of harvested beavers and these figures are relatively stable between years (Viltdata.se).



Länsstyrelsen Västernorrland

Ansökan 1 (1)

Ansökan om tillstånd att riva bäverdamm

Namn	Personnummer
Adress	Postnummer och ort
E-postadress	Telefon

Fastighetsbeteckning/fastighetsbeteckningar	Kommun
Hur stor är avskjutningen av bäver under ordinarie jakttid	
Beskrivningen av skaderisken eller inträffade skador/olägenheter	
Antal dammar som avses	Vattendragets namn
Finns hydda vid damm(ar) som ni söker tillstånd att riva	Tidigare dispens/tillstånd ☐ Nej ☐ Ja → År
Ort och datum	Sökandens underskrift

Särskild information
När det gäller bäverdammar som orsakar skada under tiden 1 maj-31 augusti finns möjligheten att riva sådana dammar utan att tillstånd från länsstyrelsen behövs. Detta fordrar dock att man är fastighetsägare eller har dess tillstånd. Man har bedömt att under sommaren är bävrarna inte så beroende av dammarna för sin överlevnad. Åtgärder får dock inte vidtas på bävrarnas boplatser (bäverhyddor) när dessa är bebodda.

Under övrig tid av året kan dammar få rivas med stöd av 29 § jaktförordningen. Tillstånd får dock bara lämnas om det är absolut nödvändigt för att förhindra allvarliga skador. Detta innebär att under höst-senhöst lämnar länsstyrelsen tillstånd med stor restriktivitet. För att förhindra allvarliga skador medger paragrafen även förstörelse av bäverhydda under höst-vinter, vilket knappast medges av länsstyrelsen om hyddan är bebodd.

Till ansökan ska bifogas karta som visar vattendraget och läger för dammen/dammarna som skall rivas. Bifoga gärna bilder.

Länsstyrelsen Västernorrland
Postadress: 871 86 Härnösand
Besöksadress: Nybrogatan 15 och Pumpbacksgatan 19
Telefon: 0611-34 90 00
Fax: 0611-34 93 72
E-post: vasternorrland@lansstyrelsen.se
www.lansstyrelsen.se/vasternorrland

Figure 9.3. Form for application to a County Administrative Board to remove beaver dams outside of the regular period. Information about the nature of the damage, and about hunting of beavers during the hunting season, is requested.

FINLAND

Kaarina Kauhala

During the monitoring count in 2017, there was a question to hunters about damage caused by beavers. Reported damage by the Eurasian beaver constituted an area of 8 496 ha, mainly in Satakunta, and that by the North American beaver 8 863 ha. Sixty-five percent of areas (hunters' associations) inhabited by Eurasian beavers reported that beavers caused some damage, the corresponding figure for North American beavers being 52 %.

Besides hunting (see Chapter 6), beaver dams are sometimes destroyed to prevent damage from flooding. Removing dams is allowed from 16 June to 15 September – 30 October, depending on the area, but permission from the landowner is needed (Suomen riistakeskus; The Finnish Wildlife Agency). In other times of the year permission is demanded also from Suomen riistakeskus.

ESTONIA

Nikolai Laanetu and Elve Lode

From the environmental and economic point of view, waterbodies are considered as promising or acceptable beaver habitats, if the beaver activity involves little economic damage, and there is a significant increase in environmental values and a recovery of the ecosystem.

The beaver's activities in drained woodlands can lead to extensive flooding and increased moisture conditions in the soil, accompanied by damage in the tree stands. There are also additional problems and high financial costs for the maintenance and restoration of damaged drainage systems (see Chapter 3).

In order to prevent the beaver-caused damage, it is necessary to have an adequate overview of the state of the beaver habitats and the economic and environmental values of the areas of interest to the beavers. Although the patterns of occurrence and utilisation of beavers in Estonia in different water bodies are planned according to the beaver management plan (see Chapter 3), these principles have not been applied at national level, nor by hunters or landowners.

In order to prevent beaver-caused damage or to mitigate the damage that has already been encountered, the main methods are intensive hunting and removal of dams.This activity does not usually produce the expected results, since some animals will stay in the same place and restore the dams quickly so that the negative effect will persist.

For the same purpose, extensive drainage regeneration techniques are also being used to remove dams and the accumulated sediments behind them, and to remove the tree stands growing on the shores of the water bodies of interest to the beavers. Such work is more common in drainage systems of the state forests. Capturing of beavers, paid by the government, is also ordered on the state lands. On private land, however, intensive hunting is widespread.

Reduction of pond water levels with culverts installed in the beaver dams has not been used in Estonia due to the complexity of these works, and the low efficiency and relatively high installation costs.

LATVIA

Jānis Ozoliņš

An inquiry of 75 hunter clubs in season 2016/2017 reveals that 67 % of all repondents have participated in hunting aimed at prevention of damage done by game animals. In total, the respondents performed 1 596 such hunts which is on average 13 hunts per person within this season. Only 2014 animals were hunted during these activities. However, the most frequent animal taken to reduce economic damage was the beaver – 38.8 % of the total number.

Figure 9.4. Installation of pipes against road flooding in beaver site in Lithuania. Photo: Olgirda Belova.

LITHUANIA

Alius Ulevičius

According to The Ministry of Agriculture, there were 4.7 thousands of beaver dams in drainage ditches in 1998 in Lithuania. The total impact comprised about 24 thousands ha of drained land, which was fully or partially excluded from further exploitation.

In 1997, beaver dam removal and ditch restoration have reached 1.6 million litas (nearly 464 thous euro).

In 2004, 25.4 % of the beaver sites (2 116 of 8 333) were regarded causing collapse of underground drainage and damage to agriculture land or meadows (Report..., 2004).

In Žemaitija NP (North Western Lithuania), floodings caused by beavers comprised 3.6 % of total forest cover in 1998. The total beaver damage to the state forests of Lithuania comprised about 2800 ha or 0.14 % in 2010 (data of the State Forest Service).

In 2004, 25.7 % of beaver sites (2 146 of 8 333) were regarded causing floodings of forest and other damage for the forest (Report..., 2004).

Solutions used

The management of the beaver population is based on the determination of allowable and unallowable dams, of which the latter have to be removed on the ground of the decision of Regional Environment Protection Department by application from foresters or other holders (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).

The Law of Hunting defines:
1) The order of compensation of damage caused by beaver to lands and hydrotechnical facilities;
2) The order of population regulation based on damage caused by game to land and forest holdings;
3) The order of decision on removal of beavers on the ground of application from holder of hunting ground unit, landowners, forest owners, water or other holders.

Implementation of these regulations allowed to mitigate flooded areas in the forests from about 2000 ha in 2009 to about 250 ha in 2014 (State Forest Service).

Techniques and regulations for beaver dam removal and hunting

Three legal techniques of beaver hunting are used in Lithuania.

1) Stand hunting is the most used method. However, such method required more experience as a part of hunted animals could be not taken from the water.

2) Conibear traps are used as the method allowed within the European Union. However, traps could be more selective towards otters, which are common visitors of beaver sites.

3) Using of trained dogs to drive out animals from shelters. This is effective to eliminate nuisance beavers. There is a problem as shortage of well working dogs, severe invasion into habitat by destruction of beaver dams, burrows, lodges.

The most used is dam removal and draining of beaver ponds. Beaver dams are destroyed using mechanical tools, but the use of explosives is forbidden.

Predicting beaver behaviour in cases of damage prevention.

There is lack of the special research on how beavers react to dam destruction (Belova 2001, 2012, 2013); however, few studies (Belova 2006, 2012, 2013; Belova et al. 2017) and personal observations show that beavers as rule, rebuild destroyed dams. Thus, dam destruction should be combined with animal removal and other preventive measures (e.g. fencing).

Use of flow devices to reduce water levels.

Fencing of culverts, and installation of beaver pipes to reduce the water level, etc., is used in Lithuania insufficiently (Fig. 9.4).

Reasons:
- expensive and practically no experience;
- time and work consuming;
- they could be effective, when installed professionally and properly maintained;
- hardly expected to be promoted by the private business, at least in the nearest future.

Setting population levels for balancing economic damage and value of beavers.

Considering the fact that about 50 % of beaver sites are regarded economically problematic in agriculture and forestry, the beaver population should be reduced to half to set an economically reasonable abundance level of about 40 000 – 50 000 of individuals. These numbers were given in official statistics by the Ministry of Environment last year. However, earlier assessments (Ulevičius 2008) showed official census was underestimated as much as 2–2.5 times.

POLAND

Michal Wróbel

In Poland, conflict situations caused by beavers affect both agricultural and forest areas. Most often, the land is flooded, culverts are blocked, causeways are destroyed, and trees are felled (Boczoń A. et al. 2009, Święcicka N. et al. 2014). In addition to damage to agricultural and orchard crops, there is also a problem with destruction of old trees, which are particularly valuable in nature and are impossible or very difficult to replace. In the case of water management, the most important damage is the excavation of pond flood embankments etc. There is also blocking of drainage ditches and culverts. Concerning communication routes, trees are occasionally felled, blocking roads or railway lines. In the case of damage to agricultural land, the owners of the farms report a noticeable loss and demand compensation from the government. To claim compensation for beaver damage, the land owner should apply to the Regional Directorate for Environmental Protection.

Ways to reduce the damage according to Czech (2010):

Flooding of land:
- Damage analysis, possible dedication of fields to beavers and tolerance of beavers.
- Prevention of colonization of new areas.
- Water level control in beaver stations: fence guarding the culverts, pipes protecting the culverts, pipes passing through beaver dams, trunk drainage.
- Placing new buildings, roads and other structures on embankments or natural elevations.
- Proper design of bridges and embankments.

Destruction of embankments due to digging of burrows and corridors by beavers:
- Damage analysis, possible ”field dedication” and tolerance of beavers.
- Laying out meshes on embankments.
- Digging nets and walls in the embankments.
- Preventing colonization of new areas.

Cutting down valuable trees:
- Moving agricultural crops further away from watercourses and reservoirs.
- Protection of individual trees by wire mesh wrapping at a distance from the trunk and other materials difficult to chew for beavers.
- Use of metal fences about 1 meter tall, or electric fences 30 cm above the ground.
- Feeding on crops, digging canals to facilitate food transportation, digging holes below the ground:
- Moving agricultural crops further away from watercourses and reservoirs.
- Creating a 20 m wide buffer zone without trees for beavers along the banks of water bodies.
- Electric fences.

Beginning in the 1990s, the need for local reduction of beaver began to increase in Poland. It was proposed to start the exploitation of beavers in the areas of the provinces where the distribution is continuous (Dzięciołowski 1996). In the face of dispersed populations in the rest of the country, it was proposed to maintain their protective status. The acquisition would be consistent with the principle of sustainable use of renewable resources as adopted by the International Union for Conservation of Nature. Tools for local reduction of beaver numbers could be trapping and relocation, or hunting (see Chapter 6). The Regional Directorates for Environmental Protection issue permits for hunting at the most conflicting places, taking into account the size of the local population of these animals (see Chapter 6). Under Polish conditions, the reduction should be carried out in areas with a very high density of beavers and in the case of the need to remove animals considered a problem (Janiszewski and Misiukiewicz 2015).

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Beaver site in Lithuania after dam removal. Photo: Joel Segersten

Chapter 10: Management of beavers for water quality

Karin Eklöf

The waters in all European Union (EU) countries should be mitigated to reach good chemical and ecological status according to the EU Water Framework Directive (WFD) implemented in 2000 (2000/60/EG). The WFD aims to protect and improve the water quality of all waters in the EU. A good water quality status is characterized by water bodies that deviate as little as possible from their pre-industrial reference conditions (Törnblom et al. 2011). It is likely that beaver activities had a large influence on the water quality and hydrological regimes during these reference conditions. The re-introduction of beavers beginning in early 20th century in many EU countries may thereby have been a good strategy to reach the goals in the WFD (Törnblom et al. 2011). However, if beavers should be considered as a way to mitigate water quality, we need to fully understand how beaver activities influence the hydrological regimes and the alteration of biogeochemical cycles. In this chapter we will present today's knowledge about influences of beaver activities on hydrology, geomorphology and water quality. We will furthermore discuss whether or not beavers could increase the chances of reaching the WFD goals. Finally, we will present some national examples of the management of beavers in some Baltic Sea Region countries.

Hydrological and geomorphological effects of beaver activities

There are strong interactions between hydrology, geomorphology, water chemistry and temperature in water courses. All of these may be influenced by beaver activities. Beavers can influence the accumulation, distribution and availability of elements by altering hydrological regimes that can change biogeochemical pathways. Beavers may also mobilize elements from the terrestrial vegetation to sediments during flooding (Naiman et al. 1994). Conversion of a lotic water system (stream) into a lentic system (pond) decreases the velocity and changes the typical annual discharge pattern. Beavers can transform a stream into series of small slow-flowing water ponds, and in some places into running-water swamps. During high flows the beaver pond may store water and thereby decrease the flow rate compared to before impoundment. Consequently, the flow may be higher during low flow seasons such as during late summer (Rosell et al. 2005). Beaver systems may contribute to ecosystem services such as flow regulation and conservation of waters in dry areas. Beaver activities may not only store water in impoundments, but also result in elevated groundwater tables in the surrounding areas (Johnston and Naiman 1987). Although most studies suggest that beaver impoundments stabilize the stream flow, the hydrological alteration is dependent on location and age of the beaver pond. Older beaver ponds usually reduce the stream flow more compared to young ones, possibly due to less permeable beaver dams in old systems (Meentemeyer and Butler 1999). In slow-moving shallow waters, where surface areas have increased since before impoundment, water temperature often increases. However, the water temperature effect can vary greatly depending on site-specific characteristics such as topographic shading, groundwater inflow and stream volume (Rosell et al. 2005).

Hydrological alteration will influence the channel morphology. Slow-moving waters in the beaver impoundments may cause higher sedimentation rate. The function of the beaver impoundment as a sediment trap, in combination with the addition of dead terrestrial vegetation and possible erosion after flooding, causes sediment layers in the impoundment to increase over time (Butler and Malanson 1995). Sediments within the beaver impoundments usually consist of finer sediments compared to upstream and downstream (Ecke et al. 2017). The alteration of bottom substrate composition can influence the biotic community structure and the biogeochemical status in the sediments.

Effects of beaver activities on water chemistry

Usually only a minor part of the chemical elements from vegetation, which decomposes after flooding of terrestrial land, are transported downstream or returned to atmosphere (Naiman et al. 1994). Thus, sediments in the beaver impoundment accumulate considerable standing stocks of elements that will have long-lasting effects on the characteristics of the local environment. A single beaver impoundment may only have minor ecological effects on a larger scale, but if beaver activities are frequent in the area, the beaver-induced changes in physicochemical characteristics may be widespread in both space and time.

Flooded vegetation that eventually dies and falls can act as a long-time source of nutrients and organic carbon to the beaver pond systems. Photo from a beaver dam in Poland: Joel Segersten

Soils that become flooded can shift from oxidized to reduced environments. Anaerobic conditions are common in the sediments of the beaver impoundments, where stream velocity is low, and the decomposition of accumulated organic matter consumes oxygen. This may change the chemical speciation of many elements such as mercury (Hg), iron (Fe), manganese (Mn), sulfur (S), nitrogen (N), and phosphorus (P), as well as various cations influencing the acid neutralizing capacity (ANC), the soil structure development and organic matter accumulation. More reduced conditions in sediments after beaver-induced impoundments have been suggested to be the primary reason for alteration of biogeochemical pathways (Naiman et al. 1994).

Organic matter and nutrients. Even if large amounts of organic matter (OM) and particles are trapped in the sediments when velocity decreases in the beaver ponds, altered mineralization of recently flooded soils and bank erosion may also increase the export of OM and nutrients from the beaver ponds to downstream. Whether or not the beaver pond increases the export of nutrients downstream, large amounts of nutrients, N and P, are accumulated in beaver pond sediments. The enrichment of nutrients in the sediments may increase the primary production in the beaver pond. The N and P input is from upstream terrestrial (allochthonous) sources, flooded forest materials and soils as well as from fallen wood materials from vegetation that died after flooding. Considerable amounts of N input also originate from N fixation, associated with sediment microbes. N fixation is favored by high P concentrations in the sediments and sometimes also in water bodies downstream of beaver ponds (Francis et al. 1985). Whether beaver ponds act as a source or a sink for N and P differs between study sites. If OM concentrations increase downstream of a beaver pond, total N and P concentrations may also increase. N fixation within the pond and downstream can further cause the pond to act as a source of N. Whether or not the beaver pond increases the P concentrations downstream can be related to differences in redox conditions in sediments which influenced the biogeochemical cycling of P (Klotz 1998). A meta-analysis evaluating data from studies published until 2016, found no net effect of beaver dams on N and P retention (Ecke et al. 2017). That study also compared newly established beaver ponds with old ones, and found young systems to be a source of P whereas old systems retained P. The differences between young and old beaver systems, in how they influenced N and P concentrations, may be related to age-dependent sediment properties and solidity of the beaver dam (Ecke et al. 2017).

Methylated mercury and methane. There are several studies that have detected elevated exports of highly neurotoxic and bioaccumulative methyl-Hg (MeHg) downstream of beaver ponds (Driscoll et al. 1995, Driscoll et al. 1998, Roy et al. 2009). Methylation of Hg from inorganic Hg (HgII) to MeHg is a microbial process mediated by some members of sulphate-reducing bacteria (Compeau

Over time the beaver dam structure gets more solid causing stronger hydrological effects and greater possibility for nutrient retention. Photo from a beaver dam in Sweden: Joel Segersten

and Bartha 1985, Gilmour et al. 1992), and iron-reducing bacteria (Fleming et al. 2005) among others. Formation of MeHg in the beaver ponds is favoured by low oxygen conditions and the release of labile carbon sources working as electron donors for Hg methylators as well as sulfate (SO_4) and iron(II) and other electron acceptors, from terrestrial material and flooded soils. MeHg formation has been found to be higher in recently formed beaver systems and pioneer systems compared to older and re-colonized systems, indicating favourable redox conditions and access to labile organic carbon sources in these newly flooded environments (Roy et al. 2009, Levanoni et al. 2015, Ecke et al. 2017). The characteristics of the organic carbon can influence the Hg methylation rate. The composition of organic matter in recently established beaver ponds has been found to be more humic-like and less processed compared to that in older ponds (Catalán et al. 2017).

Moreover, flooding-induced changes in organic carbon composition, by the release of fresh humic susbstances from flooded soils and the enhanced algal production in nutrient rich waters, have been found to fuel microorganisms capable of methylation of Hg (Ortega et al. 2018).

Anaerobic sediments with high supply of labile organic carbon sources may also favour methane production, and 33-fold greater methane emissions in beaver ponds compared to upstream and downstream have been detected in Quebec, Canada (Ford and Naiman 1988).

Beavers and EU legislation

In summary, some beaver-induced changes in hydrology and water chemistry may be beneficial for the environment, such as stabilization of stream flows, water storage capacity, increased nutrient retention and reduced sediment transportation downstream. However, other effects can be negative, such as increased Hg mobilization and methylation as well as increased methane production within the impoundments.

According to the available knowledge summarized above, beaver activities could both mitigate and worsen the situation for some of the main issues within the WFD. Beavers may increase the heterogeneity of the landscape and create a mosaic-type landscape with beaver-induced open water ponds and wetland forests mixed with terrestrial land. This may supply a variation in e.g. flow rates, water temperatures, occurrence of dead wood, nutrient conditions and sediment substrates along a stream channel that may increase the diversity of many groups of flora and fauna. Ground water recharge that could possibly be improved by beaver activities is also included in the WFD to ensure good quantitative status of groundwater.

One important feature of beavers is the possibility of beaver ponds to retain sediments and nutrients. Beaver ponds that retain nutrients could improve the ecological and chemical status of the waters by decreasing the risk of eutrophication. In this regard, old beaver ponds may be more favourable than younger ones as they have been found to retain P to a larger extent than young ones.

Minimizing the concentrations of hazardous substances in surface waters is one main issue in the WFD. In beaver ponds that retain sediments there is a high risk that pollutants attached to organic particles settle in the sediments. However, as noted above, there is a risk of increased formation of bioavailable MeHg in the sediment of the beaver ponds. As fish Hg concentrations are well above the Environmental quality standard set by the WFD (0.02 mg kg^{-1} wet weight, Directive 2008/105/EC) in large parts of the northern hemisphere, this needs to be taken into account when considering whether beavers could mitigate water quality or not. The lower risk of old beaver ponds to form MeHg (Roy et al. 2009, Levanoni et al. 2015, Ecke et al. 2017) again speaks in favour for preserving old and re-colonized beaver ponds.

An important point to make in this discussion is that the possible increase in exports of MeHg and nutrients may not be that persistent. Generally, waters that suffer from low oxygen conditions within the beaver ponds are completely oxygenated again within a short distance downstream of the pond (Rosell et al. 2005). When oxygen conditions change, MeHg is likely to be demethylated to less bioavailable inorganic Hg(II). The composition of nutrients may also change within a short distance from the beaver pond. More research is needed on the persistence of the chemical effects of beaver ponds, to understand the importance of these effects on a larger spatial scale and thereby be able to balance the positive effects against the negative effects.

Beaver ponds may come in conflict with other interests such as timber production, recreation or urban systems such as roads or railways. This may cause the beaver dam to be removed. It is thereby important to consider ecological and economic trade-offs to implement the WFD (Törnblom et al. 2011).

Measurements of Hg in Scandinavian and Baltic beaver ponds

As Hg concentrations in inland fishes are far above the Environmental quality standard and beaver activities may further increase these concentrations, Hg is a prioritized substance when evaluating possible negative effects of beaver activities. The high concentrations of Hg in fish are of concern in Scandinavia, and quite a lot of monitoring activities have been carried out in Sweden, Norway and Finland. There is, however, a lack of Hg data in general from the Baltic region, including in Latvia, Lithuania and Poland. Within the WAMBAF project, data of total Hg and MeHg in sediments, surface waters and biota have been collected upstream and downstream (and, for sediments, within) beaver ponds in Latvia, Poland, Lithuania and Sweden. The results show that the concentrations of Hg in biota, sediments and water from the beaver ponds in Latvia and Poland are in the same range as the concentrations in Sweden. The concentrations in the Lithuanian beaver pond are lower, probably due to site-specific variations between different sites and not due to generally lower concentrations in Lithuania. The WAMBAF results indicate that high Hg in biota is not only a Scandinavian issue, but may be of concern in the other Baltic countries as well. Higher concentrations of MeHg in sediments within the beaver pond and/or downstream compared to upstream, indicate that the beaver pond acts as a source of MeHg. Within the WAMBAF project beaver dam removal was carried out in both Sweden, Latvia, Lithuania and Poland. WAMBAF results showed that the Hg burden downstream of a beaver dam decreased when the beaver dam was removed. However, as Levanoni et al. (2015) identified higher MeHg concentration in water downstream young pioneer beaver ponds compared to old recolonized beaver ponds, we suggest the removal of beaver dams to be more efficient in decreasing the Hg burden downstream in young pioneer systems compared to old recolonized systems.

Whether or not the beaver impoundments improve the water quality depends on site-specific characters in the local environment but also on the specific environmental concerns in the region. Below follow examples of national perspectives on how to manage beavers for water quality in Sweden, Finland, Estonia, Latvia, Lithuania and Poland.

SWEDEN

Karin Eklöf

In Sweden, beavers are acknowledged for contributing to heterogeneity in the landscape and providing habitat for many plant and animal species. However, beavers can also cause damage on forests, roads and railways. With approximately 55 % of Swedish land cover made up of productive forest land, forestry is an important export-oriented industry in Sweden. Catchment activities that interfere with timber production may thereby be a concern. Hunting beavers outside of the open season and beaver dam removal are thereby sometimes permitted to protect sensitive areas from flooding.

In an ecological perspective, ponds and wetlands have been recognized in Sweden to mitigate droughts and floods. In 2017 the Swedish government therefore allocated 200 mSEK over the coming three years for county boards, municipalities and local organizations to restore wetlands. This indicates the political commitment to preserve or restore wetlands and ponds in the landscape.

As Hg concentrations in freshwater fish in Sweden are not only above the Environmental quality standard set by the WFD (0.02 mg kg^{-1} wet weight, Directive 2008/105/EC), but also above the levels that the World Health Organization (WHO) deems potentially harmful for human consumption (0.5 mg kg^{-1}) in half of Sweden's inland waters (Åkerblom et al. 2014), possible increases of MeHg as a consequence of beavers have been of great concern. Studies in Sweden have found elevated MeHg concentrations downstream of beaver dams, with greater effects in pioneer systems (Levanoni et al. 2015).

FINLAND

Leena Finér

In Finland, more than 70 % of the 30 Mha land area is covered by boreal forests, most of which are managed. Typical for Finland is also the abundance of mires. Originally the mire area was 10 Mha and half of it is drained for forestry. Drainage has reduced the number of wetlands. Currently the activities of beavers are considered to create new riparian wetlands with high value for fish and game populations as well as for terrestrial and aquatic biodiversity (Nummi 1992, Nummi et al. 2011, Nummi and Kuuluvainen 2013, Nummi and Holopainen 2014, Vehkaoja and Nummi 2015, Vehkaoja 2016). Around 10 000 North American and Eurasian beavers live in Finland (Kauhala 2015). According to the beaver inventories 1 900 beavers have flooded 590 ha of land in SW Finland (Kauhala 2012), which might indicate that in the whole Finland beavers flood about 3 000 ha. Therefore at national level their importance in creating wetlands is small. Beavers and flooding are unwanted phenomena, because they kill trees, and consequently beavers are often hunted and dams are

destroyed. However, at the same time Finland has committed to increase the number of wetlands by artificial means (Juvonen and Kurikka 2016).

Beavers live in streams and lakes. There are no studies on the effects of beaver dams on the water quality of forest streams in Finland, but beaver dams are considered to have a similar effect as constructed wetlands on stream water quality (Kattainen and Nummi 2012). Constructed wetlands can effectively retain sediments and nutrients if they are large enough (Nieminen et al. 2015). The impact of flooding on water quality has been studied in small head-water lakes inhabited by beavers (Vehkaoja et al. 2015). Flooding has increased the concentrations of dissolved carbon in lake water for 1–3 years, but it has not affected the nutrient concentrations (Vehkaoja et al. 2015). In general, beavers are regarded to create biogeochemical hot spots and hot moments in the Finnish boreal landscape (Vehkaoja et al. 2015).

ESTONIA

Nikolai Laanetu and Elve Lode

Under Estonian conditions, the water bodies impounded by the beavers regulate the surface water discharge, improve and increase the recovery of local ground- and surface water resources, and impede the sediment transport to downstream. These ponds also significantly enhance biodiversity locally as well as the potential of the hunting economy and the environmental value.

Such beaver habitats should be maintained and protected as permanent sites, especially in order to preserve the reproductive potential of the beavers and ensure biodiversity, as well as to improve the water quality and to restore or maintain the groundwater level and storage capacity.

According to the Estonian beaver conservation and management plan (see Chapter 3), the occurrence of the species in such permanent habitats is permissible and its distribution should be maintained only within certain limits of population increment, in order to ensure the continued activity of beavers in these habitats.

The improving and maintaining effects of beaver ponds on water resources and their quality is not regulated by law in Estonia. However, according to the beaver management plan, pond areas should be preserved, as important habitats for amphibians, fish fauna and other water-related species, as well as for natural reduction of sediment loads and water quality improvement in surface water bodies.

LATVIA

Zane Lībiete

Reintroduction of beaver in Latvia was started in 1927. However, for a long time the population growth was slow, and hunting of beaver was again permitted only in 1981. In 1986 the number of animals registered by the responsible authority had reached 11 025 but the total population size estimated by scientists was 17 300 beavers (Balodis 1990).

According to extensive field observations carried out in the 20th century after the reintroduction of beaver, it was concluded that beaver activity significantly improves ecological conditions in human-impacted landscapes by decreasing eutrophication and increasing the self-purification capacity of streams (Cimdins and Balodis 1980, Balodis 1981, Balodis et al. 1982, Balodis 1990). This was, however, mostly a qualitative assessment, and quantitative data on changes of water quality parameters are very limited. The only available study from 1980 has analyzed biological oxygen consumption in water and upper sediment layer, specific conductivity, dissolved oxygen and concentrations of nitrates, ammonia and phosphates in two beaver-impacted rivers. Water quality parameters above and below the dam were compared, and it was concluded that concentrations of organic and mineral nutrients below the dam are slightly higher than above the dam (Cimdins and Balodis 1980). In the same publication, it was assumed that beaver activity in polluted streams might decrease leaching of nitrogen and phosphorus downstream, by lowering flow rate and facilitating sedimentation.

Still, the situation has changed dramatically until the present day and become rather controversial, mainly due to the expansion of the beaver population size, reaching almost 90 000 recorded animals in 2010. By flooding the adjacent forests, beavers may cause increased export of sediment and nutrients to streams, especially in cases with fine-textured soils. Using grey alder trees, a frequent species on the riverbanks, as material for the dams and buildings, especially on former agricultural lands, beavers may cause reduction of the dissolved oxygen content, as the decomposition of grey alder is very fast (Urtans A., pers. comm.). Beaver activity in drainage systems raises the water table and causes a growth decline or even dieback of adjacent forest stands. It is often the case that repeated human intervention, to limit the beaver activity by taking down the dams, is needed in commercial forests, which facilitates further leaching of sediment and nutrients. No data on Hg and MeHg transport has been gathered in Latvia before the WAMBAF project.

LITHUANIA

Olgirda Belova

The status of beaver is quite ambiguous in Lithuania. In general, the beaver role in local ecosystems is considered as positive because beavers reconstruct natural streams and create habitats for many other mammal, bird and amphibian species (Lamsodis 1999, 2000a, 2000b, 2001; Lamsodis and Ulevičius 2012a, 2012b; Samas and Ulevičius 2015). Simultaneously, there is most often indication of damage caused by beavers. Beaver-induced habitat changes may be unacceptable to humans as beaver ponds may flood forest and agriculture land.

In Lithuania, studies were performed on how morphological and hydrochemical changes effect water chemistry in beaver ponds, and how these migrate nutrients through a fluvial network (Lamsodis 1999, 2000a, 2000b, 2001), including measurements of:

- ground water levels;
- water temperature and insolation;
- soil 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;
- movements and forest disturbance level.

Concentrations of NO_3-N, NH_4-N and PO_4-P were found to decrease when drainage ditches were dammed by beavers (Lamsodis 2000b). However, these studies are mostly related to “forest – open land” ecotones (mostly agricultural land). Only few studies were performed in the forests (Ruseckas 2011) ascertaining that beaver dams caused damage to forests on the territories of all enterprises and the number of dead trees depends on the tree species and the depth of groundwater. It was found that Norway spruce is most sensitive to flooding among the tree species (Belova 2006, Ruseckas 2011).

POLAND

Michal Wróbel

Beaver ponds in Poland have been noted for the positive influence of floodplains for improving water quality. Decreasing flow rates and elevated water levels affect the physico-chemical conditions and the hydration of the soil, as well as the species composition of flora and fauna. Giżejewski and Goździejewski (2016) found that beaver ponds can act as water treatment plants, where various pollutants may be subjected to sedimentation, sorption and other physicochemical changes. Beaver ponds can provide good conditions for the development of aquatic and marsh plants that may improve the mechanical filtration and sedimentation of various elements (Brzuski and Kulczycka 1999, Janiszewski and Misiukiewicz 2012). Studies on the water quality in Polish beaver ponds mainly concern nitrogen, phosphorus, chlorine and sulfur compounds (Kukuła and Bylak 2010, Szpikowska and Szpikowski 2012).

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Benthos sampling at a WAMBAF demo site near Jaunkalsnava, Latvia. Photo: Joel Segersten

Chapter 11: Assessment and mitigation of beaver impacts - the Beaver Tool

Frauke Ecke

Background

As the previous chapters have illustrated, the environmental and ecological impact of dam-building beavers is multifaceted and complex and can from an ecosystem service perspective be beneficial or detrimental. In addition, the direction and extent of the impact of beavers is scale-dependent – in both space and time. While dam-building has generally a more profound impact in flat areas, where large areas can be flooded by a single dam, such impacts are generally less pronounced in topographically more complex systems. From a temporal perspective, potential beneficial responses of beaver dams for nature conservation last generally over several decades, potential negative effects related to e.g. mercury methylation in beaver ponds are generally temporary and any potential damage to infrastructure (e.g. flooding to roads) is mostly associated with the colonization phase of beavers.

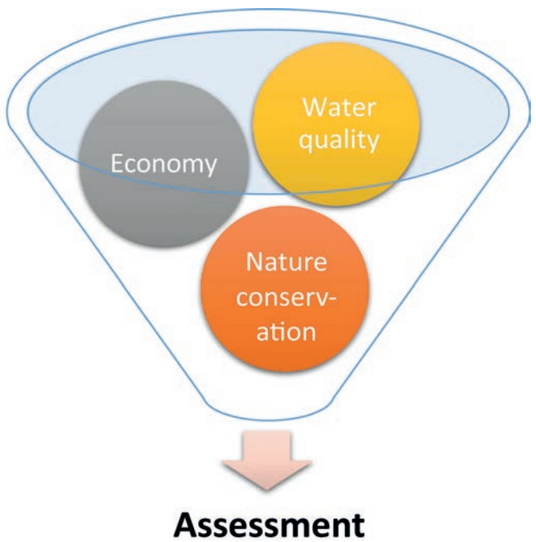

Figure 11.1. Three main sectors impacted by beaver systems: economy, water quality, and nature conservation values in beaver systems. A beaver system can have high values for several sectors, for example in terms of both water quality and nature conservation. Economic values are rather expressed as economic losses, e.g. due to loss of productive forest and/or damage to infrastructure.

Table 11.1. Variables (selection) included in the assessment of the value of/damage caused by beaver dams. For details (complete protocol, instructions etc. see Beaver Tool Protocol[1].

Sector and variable	Explanation
Water quality and hydrology	
Water transparency	Water transparency upstream and downstream of the beaver dam and in the beaver pond
Oxygen	Oxygen concentration upstream and downstream of the beaver dam and in the beaver pond
Nitrogen	Nitrogen concentration upstream and downstream of the beaver dam and in the beaver pond
Phosphorus	Phosphorus concentration upstream and downstream of the beaver dam and in the beaver pond
Mercury	Mercury concentration upstream and downstream of the beaver dam and in the beaver pond
pH	pH upstream and downstream of the beaver dam and in the beaver pond
Water quantity	Contribution of the beaver dam to flood prevention
Nature conservation values	
Freshwater pearl mussel or other protected mussels	Species that are protected according to national law or international directives occur upstream and/or downstream of the dammed area and/or in the beaver pond
Coarse dead wood	Occurrence and amount of coarse dead wood
Spawning grounds for migratory fish	Occurrence of important spawning grounds for migratory fish upstream and/or downstream of the dammed area and/or in the beaver pond
Beaver dams as barriers	Is the dam a significant barrier for migratory fish
Amphibians	Occurrence and reproduction of amphibians upstream and/or downstream of the dammed area and/or in the beaver pond
Snags (standing dead trees)	Number of snags (> 2 m height with diameter > 20 cm)
Floating-leaved vegetation occurs	Occurrence and cover of floating-leaved vegetation in the beaver pond
Economic values	
Loss of arable land	Extent to which arable land is affected by beaver-induced flooding
Forest loss	Extent to which productive forest is affected by beaver-induced flooding
Impact on infrastructure	Extent to which infrastructure is affected by the beaver-induced flooding

1) The Beaver Tool including instructions for data sampling, protocol, assessment and examples is available at: https://www.skogsstyrelsen.se/en/wambaf/beaver-dams/

Sectors affected by beaver dams and their assessment

Due to the complexity of beaver impacts and environmental responses, there is a need to assess the potentially beneficial and detrimental, respectively, effects of beaver in a standardized and objective way. Here, we present the Beaver Tool that can be used as a decision support and/or assessment tool. As a decision support tool, it can be used to make a recommendation whether a beaver dam should be removed or kept based on information on water quality, nature conservation and/or economic values that are either gained or lost by removing and keeping the dam, respectively. As an assessment tool, it helps to identify and quantify water quality as well as nature conservation and economic values of beaver systems. Basically, the tool considers three sectors: economy, water quality and nature conservation (Fig. 11.1).

The quality (accuracy and precision) of the outcome of an assessment of the three sectors relies on the quality of the input data. Preferably, the assessment is based on a combi-

nation of field-based assessments and measurements. The more reliable the input data, the more reliable the assessment and/or recommendation.

In case infrastructure is threatened or already affected (e.g. flooding of road or railway), the recommendation should be to remove the dam in case no other mitigation measure (e.g. drainage of dam) is possible. When removing a dam, it is crucial to consider national legislation e.g. related to animal welfare issues. It is also important to account for the risk of beavers almost instantly rebuilding a dam. Hence, in some cases, culling needs to be considered to minimize the risk of rebuilding dams.

How does the Beaver Tool work?

The questions in the protocol (for some examples see Table 11.1) are partly detailed and might be experienced as even far too detailed. Here, it is important to have in mind that not all information is necessary to make an assessment and/or recommendation to either keep or remove a dam. Information that is asked for relates to variables that have been shown to either increase or decrease the value of a beaver system at local and/or catchment level (e.g. concentration of methylmercury in water, occurrence of red-listed species and damage to infrastructure). We are aware of that information might be unavailable for some or even many of the listed variables. However, the more information that is available, the more reliable the assessment/recommendation.

The final assessment of the values of and damage caused by beaver dams, respectively, based on the protocol is done in a matrix using color codes for the respective variables (grey: missing data, green: beaver system has a positive impact, red: beaver system has a negative impact). From experience, we know that in many beaver systems, the benefits for nature conservation prevail (all fields for nature conservation are green and no red fields for either water quality and/or affected economic values). In other cases, one red field (e.g. damage to productive forest) might be sufficient to motivate dam removal. Hence, the Beaver Tool provides only guidance. The actual decision to keep or remove a beaver dam needs to be based on the pros and cons provided by the assessment and by balancing the values of the different sectors against each other.

ACKNOWLEDGEMENTS

Linnéa Jägrud, Joel Segersten, Göran Sjöberg, Magnus Martinsson, Alius Ulevičius, Zane Lībiete, Olgirda Belova, Daniel Thorell, Timo Hiltunen, Edward Pierzgalski, Dovilė Čiuldienė, Kamil Mank, Arta Bardule & Karin Eklöf provided input to the development of the Beaver Dam Tool.

Beaver site at Torringen, Sweden, before dam removal. Photo: Magnus Martinsson

Chapter 12: Good practices for management of beavers in the Baltic Sea Region

Göran Sjöberg, Alius Ulevičius and Olgirda Belova

PREFACE

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

The purpose of the good practices report is to suggest a number of useful management practices and methods according to experiences made in the participating and other countries that may be suited for beaver management and improving water quality in the Baltic area. We hope to present options for beaver population management, to serve as inspiration for developing national, regional and local management, as well as national legislation and guidelines, within the Baltic Sea region. However, before implementing any of the measures proposed, make sure that the measure complies with national legislation, forest certification standards etc.

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

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

Good practices for ditch-network maintenance and management of riparian forests prepared within the WAMBAF-project are available on:
www.skogsstyrelsen.se/en/wambaf/drainage/
www.skogsstyrelsen.se/en/wambaf/riparian-forests/

BACKGROUND

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

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

There is presently a lack of:

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

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

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

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

A Beaver Tool has been developed which aims to classify beaver sites to these categories (see Chapter 11).

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

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

TERMINOLOGY

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

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

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

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

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

Beaver damage: The flooding caused by beaver dams can result in extensive forest damage. When the flooding occurs next to infrastructure, it can cause widespread damage

by washing out tracks and roads. Beavers also cut down various species of trees for both food and the building of dams and lodges. Beavers can destroy infrastructure by digging burrows.

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

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

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

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

AIMS AND SCOPE

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

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

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

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

There is presently a lack of:

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

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

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

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

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

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

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

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

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

INTRODUCTION

Extinction of the Eurasian beaver
Beaver was abundant throughout the Baltic Sea Region from early postglacial times, and an important game animal since the Palaeolithic period and on. Intensive hunting and capture, together with changes in human land use, led to the total extinction of the species in the watersheds of the Baltic Sea basin (see Table 12.1), even if beavers still occurred within the borders in some of today's countries – Russia and Germany.

Reintroduction
In the late 19th and early 20th century there was a spread of conservation ideals in general, and a realization about the need for measures for preserving and re-establishing the beaver. Beavers from the remaining populations in Europe were used for re-introduction in the Baltic Sea region (Table 12.1).

Successful reestablishment
Reintroduction, further translocations, natural spread together with species protection and regulated hunt has led to strong growth in beaver populations and high densities in the BSR. The species' number in the region today is well over 600 000 (Table 12.1). Beavers are also increasingly becoming a part of urban wildlife, which creates both assets and drawbacks.

Density of beaver populations
The density is moderate to high in the countries of the region (Table 12.1). In some areas beavers are still increasing their distribution and abundance. In the larger countries, as Russia, Sweden, Finland and Poland, there is considerable variation in distribution, depending on variable landscapes and incomplete recolonization by beavers. In some parts, there is an active effort to keep populations at a target limit.

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

Table 12.1. Chronology and abundance of beaver occurrence in the WAMBAF project area. Timeline mainly according to Halley et al. (2012) and Belova et al. (2017).

Country/ Region	Year of extinction	Year of first reintroduction	Population number 2015 (approx.)	Area of country/region (km²)	Density - ind./100 km²
Sweden	1871	1922	130 000	447 435	29
Finland	1868	1935	12 000*	338 449	4
Estonia	1841	1957*****	12 000	45 226	27
Latvia	1870's	1927	125 000	64 573	194
Lithuania	1938	1947	102 000	65 286	156
NW Region, Russia	Around 1868, possibly 1920's ***	Leningrad province 1952** Vologda province 1949**** Pskov province 1951*****	160 000**	1 677 900	10
Poland	1844	1948	100 000	312 679	32

* Including 10 000 North American beavers
** Including ca 15 000 North American beavers
***Danilov et al (2011). *C. fiber* spread into Karelia 1967; *C. canadensis* spread into Karelia from Finland already 1961
****Zavyalov (2011)
***** Chapter 5; Simultaneously spread from Russia

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

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

Beaver transformation of landscapes and ecosystems
Through damming and felling, beavers open up the forest canopy and create lying and standing dead wood. Beaver dams increase the wetted area of the forest landscape. Sunlight and heat will reach the water environment and, together with changes in the stream bed, this will change the microbial environment and the processes. The dams also slow down the stream velocity and create stretches of still water along streams, thereby increasing stream habitat diversity. Dams will act as sediment traps and increase retention of carbon in lower stream orders of watersheds. The dynamics of nutrients and toxic compounds in beaver impoundments are complex and depend on the conditions. By felling trees, adding organic material to the stream, and defecating, beavers increase the exchange between land and water environments. As herbivores, they are also exerting an influence on the species and age composition of woody plants, and also on herbal vegetation. When beavers move on and desert dams and lodges, various successional paths are possible depending on local conditions.

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

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

Beaver may also be seen as a game resource which results in recreation value for hunters, but the species may be also used for production of meat, fur, castoreum and other products. A non-invasive recreational use of beavers is beaver tourism such as "beaver safaris", and beavers may serve educational purposes e.g. in ecology teaching of schools and children's nature clubs.

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

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

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

Mercury in forest land is released into surface waters and may create health and environmental problems at least in parts of the BSR. This concerns in particular methylated mercury, since it is more available for uptake in the food

chains. Methylation of mercury may under some conditions occur in environments created by beavers, in particular where sediments are anaerobic. The processes of methylation and demethylation are complex and depend on microbial dynamics, but research results show that pioneer beaver systems increase the risk for methylation. In combination with the tendency of older dams to retain phosphorus, the lower risk for methylation there should favour the preservation of older and recolonized dams, in contrast with new, pioneer, dams.

APPROACHES FOR THE IMPLEMENTATION OF GOOD PRACTICES IN BEAVER MANAGEMENT

Adaptive management
We suggest the use of an adaptive management method (Organ et al. 2012). This is a decision process that promotes flexible decision-making. It leads to increased learning from management. However, to function properly it needs to be carefully designed and follow certain processes. A simplified picture of the steps in the process is presented in Fig 12.1.

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

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

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

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

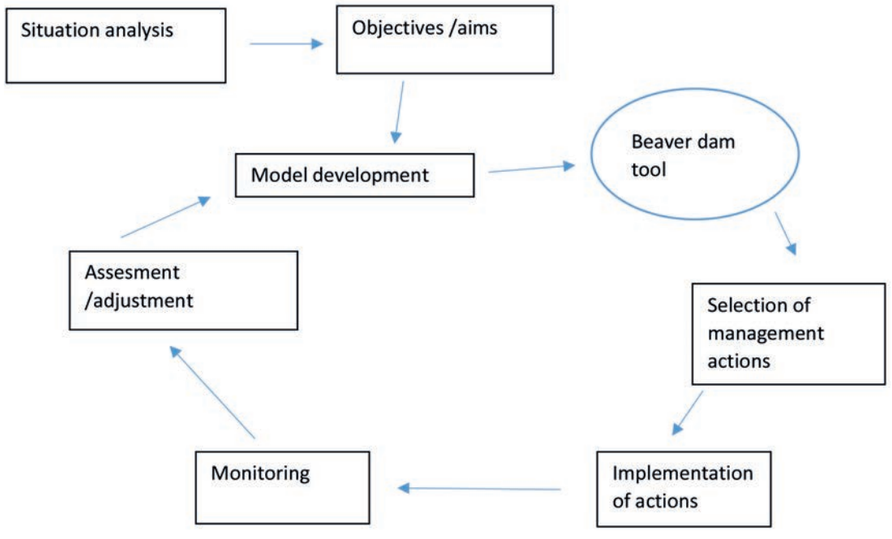

Figure 12.1. Simplified diagram over the process of adaptive beaver management – with a suggestion of the use of the WAMBAF beaver tool (see Appendix 1).

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

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

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

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

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

Implementation of management actions
For beaver management, there are many possible kinds of management actions, and they may be arranged on a scale of intensity or intervention with beavers. In the diagram below, options are listed from non-invasive (left) to hunting /trapping for local eradication (right). Depending on the damage situation, the latter may be less (left) or more (right) justified or desired by stakeholders (Fig. 12.2).

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

- *Inform* landowners, hunters and other stakeholders about EU, national and regional legislation and policies. This is an important framework and sets the limits for other management actions of the population.
- *Educate* stakeholders about the role of beaver in the natural communities and ecosystems. This may create an understanding of the broader perspective of the role of beaver. The educational situation may also give feedback from experienced stakeholders to managers about the actual situation in beaver habitats.

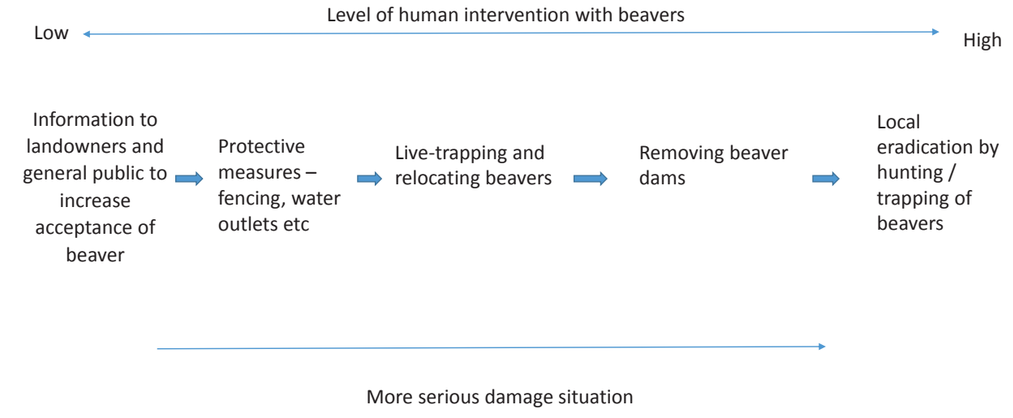

Figure 12.2. Management options for beaver colonies.

- *Show* how to protect forest and agricultural land, infrastructure, and individual trees. There is a large number of techniques for protection of land, trees, crops and infrastructure. They need, however, to be carefully designed for each specific situation.
- *Increase* the value of beavers in the eyes of landowners and hunters. This may include watching beavers for touristic or educational purposes, or using beaver meat for cooking, beaver furs for dressing or castoreum for perfumes etc.
- *Help* to make decisions about beaver management and reaching management objectives including protection of water quality. The use of the WAMBAF Beaver Tool is promoted to achieve this purpose.

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

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

Fencing. Fencing is used to protect individual trees or prevent beaver from access to undesired areas. Usually a wire mesh is used. Poles may be made from metal or wood, but in the last case fresh and not debarked poles should be avoided. Special attention should be paid to how the underneath of a mesh is attached to the ground. Is recommended to put the underneath part of the mesh into the ground ca. 20 cm, or attach a horizontal strip of mesh (50 cm width) on the surface of the ground from the outside of the enclosure in the fashion of the letter "L". Other fencing techniques serve to protect single or groups of valuable trees against beaver felling in forests, parks or housing areas. Tree trunks are usually enveloped by mesh of about 1 m high. Mesh should be applied not tightly by leaving enough space between bark and mesh to allow the tree trunk to thicken.

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

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

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

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

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

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

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

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

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

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

- *allowable* beaver sites have to be maintained to persist as long as possible, applying minimal harvesting within limits of annual increment;
- *unallowable* beaver sites are managed to completely remove beavers with subsequent prevention from repeated habituation;
- in *allowable* beaver sites, hunting limits should not exceed annual increment, whereas in unallowable sites full harvesting is recommended;
- in *allowable* beaver sites, "silent" and non destructive-to-habitat methods (hunting from hides and legal Conibear traps) are recommended;
- in *unallowable* beaver sites, all legal methods, including beaver dam demolition and using trained dogs to drive out beavers from burrows, can be allowed.

Implementation

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

Monitoring

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

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

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

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

- **aerial** (or remote-sensing-based) counts, or
- **land-based** counts.

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

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

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

1. A **weak beaver site** is inhabited by 1–2 beavers (mean 1.5). Tree and shrub cuttings in autumn are concentrated in one or two places, one or two beaver trails going from water to cutting places; usually one beaver dam, and no branch cache.
2. A **moderate beaver site** is inhabited by 3–5 beavers (mean 4). Tree and shrub cuttings in autumn are concentrated in 3–5 places with the same number of beaver trails. Beaver lodge (if present) is usually big and intensively maintained by beavers; usually more than one beaver dam, the main dam is significantly larger than others; presence of branch cache.

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

Samplers of beaver monitoring data may be local stake holders, e.g. hunting ground units or landowners. Experts are involved in subsequent data processing and analysis. Regularity of beaver monitoring may be once a year, or at least once in three years (three years is the approximate duration of a beaver generation).

Economy. In order to judge effects on economy, various expertise is needed. To evaluate areal extent of beaver impoundments, again time-series of remote-sensing data will be needed, and GIS-trained persons to make measurements. To judge actual costs of damage from damming or tree-felling, more complicated remote-sensing technology, or careful field work, will be needed, in combination with knowledge of forest (or agricultural) economy. For costs of infrastructure damage from beavers, surveys may need to be made to companies and / or municipal authorities. Separate statistics for beaver damage will most likely not be available.

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

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

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

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

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

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

Interactions with the other WAMBAF themes

- **Riparian forests.** This is the main habitat of beavers and they will transform them while adding some values but at the same time creating what may be perceived as problems. For management of riparian forests, beaver may generally be considered an asset, if the objective is to optimize biodiversity. Implementation of policies for riparian forests need to be flexible enough to allow for the activities of beaver, which are not quite predictable. Beavers may fell forest buffers that have been left after forestry activities, in particular if the species left standing are palatable ones.

- **Drainage systems.** The activities of beavers directly counteract the objectives of forest drainage activities which is to increase runoff from forest soil and wetlands. Beavers strive to impound streams and wetlands and keep the water level high and stable. This implies that it will be necessary to make priorities for a given area or watershed. Should beavers be allowed to restore the ecosystem or should drainage systems be protected? Preferably, this should be decided in advance of an actual conflict situation so that is immediately clear for managers and stakeholders what action, if any, will be taken.

BEAVER MANAGEMENT WITHIN THE BALTIC SEA REGION

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

Country/ Region	Purpose of national beaver management	Target for national beaver management	Methods for beaver management	Present population status
Sweden	Generally, to provide a sustainable population; more specifically the landowners' benefit.	None. No monitoring of the beaver population.	Hunting, dam removal. Certain killing traps, after special permission.	Database for voluntary reporting of localities of observations. No official standpoint on beaver numbers but it is placed in category of "least concern". It is not a controversial species.
Finland	Partial protection of Eurasian beaver in relation to North American. North American beaver should be prevented to spread into range of Eurasian beaver in Finland, and into Sweden.	None. Beaver numbers are monitored by hunters' organizations.	Hunting. License required for hunting of eurasian beaver.	North American beaver - considered too high. Eurasian beaver is listed as "near threatened".
NW Region, Russia	Limiting damage to forestry and agriculture.	No exact figures.	Trapping.	Beavers in Russia have almost completely reconstructed their previous habitat. Numbers of both species today considered too high in NW region. Harvest needs to increase.
Estonia	To keep the beaver abundance within permitted limits, in accordance with needs of species protection and the impact of beaver activity on environment and economy.	Optimal abundance from 10 000 to 11 000 individuals, according to the Action Plan for Protection and Use of Beaver.	Trapping (mainly state lands) and hunting (private lands); Expanded period in beaver-damaged sites. Removal of dams.	Abundance is presently brought down to optimal numbers.
Latvia	Favourable conservation of beaver, and protection of drainage systems and other resources. Also providing hunting oppurtunities.	Ambition to bring down population numbers.	Trapping and hunting. Hunting clubs contracted to protect drainage systems on state forest company land. Special management strategy for Riga city beavers, with use of protection for trees and other measures.	According to official estimates, population was brought down from maximum 90 000 to 58 000 individuals. Actual figures may be higher.
Lithuania	Provide a sustainable beaver population; Limiting damage.	About 40 000 – 50 000 individuals.	Determination of "allowable" and "unallowable" dams. Trapping and hunting.	Much too high (over 100 000) – should be reduced with at least 50 %.
Poland	Protecting the beaver population, but also avoiding excessive damage for landowners.	None. National inverntories during 2006 – 2007.	After special permission, shooting, livetrapping with relocation, or destruction of dams and burrows. Also, protective measures for forests, fields and infrastructure.	No national exemption from species protection in EU Habitat directive. Population numbers appear to stabilize at relatively high level.

EU-level

The Bern Convention (ratified 01/06/1982) gave the beaver protective status (Appendix III) in EU.

Beaver is included into the lists of EC Habitat Directive 92/43/EEC: Annexes II, IVa (21/05/1992) species of "Community interest EC Habitat Directive 92/43/EEC, and Annex V (21/05/1992) derogation for beaver management from strict protection for Sweden, Finland, Latvia, Lithuania and Estonia.

Sweden

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

Finland

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

NW Russia

An order on approval of norms of permissible use of game resources and norms of their permissible numbers approves the norms on beaver hunting: 50 % of the local population number on 1 April based on the state monitoring of game resources and their habitats.

The Hunting Regulations in the Russian Federation approve the hunting season for game species, hunter responsibilities, order of hunting and selection of hunting method, prohibited hunting methods, transportation, hunting limits on the protected areas, requirements of the certain game species including beaver. During the hunting, removal/destruction of the beaver dams is prohibited (except for arrangement of traps).

In Russia, the main harvesting method is using killing traps.

The numbers of beavers in Russia generally, and in the northwest region, are considered to have been restored to historical levels.

An increased trapping is now needed to protect agriculture and forestry.

The outcome of the competition between North American and Eurasian beavers is difficult to predict. There is no specific measure to protect Eurasian beavers in North-West Russia.

Estonia

The Hunting Act contains general regulations for regulation and use of game species.

The list of game monitoring data and regulation for data collection, and authorised institution for monitoring arrangement defines monitoring of game species and principles of its arrangement.

The Action Plan for Protection and Use of Beaver requires to keep the beaver abundance within permitted limits. This implies a quality assessment of the beaver habitats and planning of the beaver occurrence in accordance with the needs of species protection and the impact of beaver activity on environment and economy. Beaver habitats are defined in three categories of protection and use:

1) water bodies, where the beavers are allowed (the environmental impact of beaver activity is positive) – beaver hunting is allowed during hunting season depending on increment of population,

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

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

In Estonia, various methods for harvesting are permitted but killing traps is the most common. Hunting, sometimes after capture by dogs or net, is also used, and in addition bow and arrow.

According to the Estonian Hunting Rules and the Hunting Act, beavers may be hunted: 1) from August 1 March 15, with hunting trap, scoop-net, or certain hunting dogs; 2) from October 1 to April 15 with all type of hunting dogs; 3) ambush and stalking hunt with certain dogs from August 1 to April 15. Hunting may be combined with removal of dams. The hunting bag size is not limited.

In the cases of beaver-damaged sites, beaver hunt is permitted the year around as ambush and stalking hunt with certain dogs, with the permission of the Environmental Board.

Latvia

Guidelines for monitoring of beaver areas in the state forests are developed. Monitoring means annual survey of beaver sites dividing all beaver sites into 2 groups:
1) to be managed (preserved);
2) to be removed.
The Hunting Law determines the right to hunt and procedure to obtain this right as well as territories, where hunting is allowed, and prohibited means of hunting. The Hunting Regulations determine the special regulation of the management: open season, reporting to surveillance authorities, use of traps. Several methods are permitted for harvesting: Sit-and-wait-hunting, killing traps and chasing by dogs. Hunters have to report the numbers of hunted beavers to the local authority of the State Forest Service. Beavers can be hunted regardless of estate size. There are no restrictions in cull numbers, but there is a closed season from 16th April till 14th July.

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

The company “Latvia’s State Forests” has an agreement system with the hunter clubs. The company maintains and renovates historical forest drainage systems as well as provides recreation and hunting services. Major part of the woodlands is leased for hunting to the local hunter clubs. If a renovated drainage system is present in a hunting ground, the hunters have to sign a written agreement about beaver management to prevent ditches from damming. Guidelines for monitoring of beaver areas in the state forests are developed. Monitoring means annual survey of beaver sites dividing all beaver sites into 2 groups: 1) to be managed (preserved); 2) to be removed.

Beaver numbers need to be balanced for both positive and negative effects on biodiversity and species protection (trout and pearl mussels vs carnivores).

Lithuania

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

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

Allowable sites are important for the local biodiversity, causing no or negligible damage, are potential centres for beaver distribution, important to maintain the local beaver populations, and are key landscape components of woodlands or belong to protected areas. There are, as a rule, old sites, which occupy large extensive wetland areas. Annual harvest should not exceed 15–20 %, and still hunting (1st August–15th April) and trapping (1st August–15th April) are recommended. Unallowable sites risk causing damage or conflict situations today or in the near future, contain low habitat and food supply for beavers. Such sites have to be removed on the ground of the decision of the Regional Environment Protection Department by application from foresters, forest owners, or other holders. Here it is recommended to hunt all beavers using the legal hunting methods during the whole hunting season. About 50 % of beaver sites in Lithuania are regarded economically problematic in agriculture and forestry.

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

Poland

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

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

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

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

Conclusions

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

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

APPENDIX 1 - BEAVER TOOL

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

Allowable beaver sites:

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

Unallowable beaver sites:

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

From the WAMBAF project perspective, the focus on water quality and its influence to forest hydrological conditions prevail during classification of beaver sites. Usually the most hydrologically and ecologically positive beaver impacts appear after long habituation of beavers with consequent formation of so called „beaver wetlands“. Thus, many of old and extensive beaver wetlands should be regarded as allowable beaver sites (Table 12.2).

Table 12.2. Interference matrix between beaver activities in new and old beaver sites, WAMBAF preferences, habitat diversity and biodiversity using expert evaluation scores (-1 – negative, 0 – indifferent, 1 – positive impact) in the forest streams.

Beaver activities	**WAMBAF aspects**					**Formation of wetlands**	**Habitat diversity**	**Biodiversity**	**Total score**
	Drainage function	**Water quality SS, N, P**	**Methyl-Hg**	**Buffer zones**	**Riparian forest**				
New beaver sites									
Damming	-1	1	-1	-1	-1	1	1	-1	-2
Burrowing	-1	-1	-1	-1	0	1	1	1	-1
Cutting	0	0	0	-1	-1	1	1	1	1
Total score: new	-2	0	-2	-3	-2	3	3	1	-2
Old beaver sites									
Damming	-1	1	1	1	-1	1	1	1	4
Burrowing	-1	0	0	0	0	1	1	1	3
Cutting	0	0	0	1	-1	1	1	1	3
Total score: old	-2	1	1	2	-2	3	3	3	9

APPENDIX 2 - LEGISLATION AND REGULATION CONCERNING MANAGEMENT OF BEAVER AND BEAVER DAMS.

Country	Laws, Decrees and Acts	Rules and Regulations	Intructions, Orders, Lists etc.
Sweden	Game Act: 1987 (1987:259), latest update 2014 (SFS 2014:698)	Game Regulation (1987 (1987:905), latest update SFS 2016:125). Species Protection Regulation (2007 (2007: 845), latest update 2014 (SFS 2014:1240))	The Swedish Environmental Protection Boards' instructions and General advice on hunting and the State's Game (2002 (NFS 2002:18), latest update 2013 (NFS 2013:14))
Finland	Hunting decree 666/1993 (updated 11.4.2013)		Forestry environment guide [Metsähallituksen ympäristöopas, 2011]
Estonia	Hunting act, 01.03.2016		List of game monitoring data and regulation for data collection, and auhorised institution for monitoring arrangement, 16.01.2016. The Action Plan for Protection and Use of Beaver
Latvia	Hunting Law (updated 02.12.2015	Hunting Regulations (Regulations by the Cabinet of Ministers No. 421 - updated 22.07.2014)	
Lithuania	The Law of Hunting (No. IX-966; 20.06.2002; updated XII-372 18.06.2013)	The Hunting Rules on the Territory of the Republic of Lithuania (No. 258, 27.06.2000, updated 2011.11.12, No. 135-6429. 2015, 2014, 2013, 2016)	Order "Concerning change in the Order of LR Minister of Environment of 29 May 2003. No 265 "Beaver Population Regulation, No D1378 11.05.2010
Russia		Hunting Regulations in Russian Federation (2010; updated 04.09.2014 No 383; 2016)	Order on approval of norms of permissible use of game resources and norms of their permissable numbers (No. 138 of 30.04.2010)
Poland	The Act on Destruction of beaver dams	Regulation of 6 October 2014 "On the protection of species of animals (Dz. U. No. Pos. 1348)" Regulation of The Minister of Environment of 10.04.2001	

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Acknowledgements

The authors wish to thank Drs John P Ball, Bodil Elmhagen, Fyodor Fyodorov, Göran Hartman, Sauli Härkönen, and in particular Alexander Saveljev, for information or comments, as well as the photographers and game cooks contributing to the book, all WAMBAF colleagues, and participants in WAMBAF beaver seminars and training courses.

The graphic design was made by Ms Andrea Jonsson, Swedish Forest Agency.

Drs Duncan Halley, Alexander Saveljev, and Frank Rosell kindly permitted the use of the European distribution map in Chapter 5.

WHY ANOTHER BEAVER HANDBOOK?

The beaver populations in the Baltic Sea region are quite dense, and often pose new challenges for sustainable management. At the same time, management of beaver populations may be seen as an important tool for management of water quality.

The content of this book includes:

- General information on beaver populations and management needs around the Baltic Sea.
- Country-specific legislation and policy concerning beaver management, damage control and hunting/trapping.
- Examples of raising the value of beaver as a resource for various purposes.
- Presentation of a "Beaver Tool" for facilitating management decisions.
- Good practices from seven countries.
- Results on the beavers' role for water quality.
- Suggestions for reduction of leakage of nutrients and hazardous substances to watersheds and the Baltic.
- Help in implementing EU directives and other conservation, environmental and water protection documents.
- Suggestions for national / regional species management plans.

The book will be of use for policy makers, landowners, managers of forests, watersheds, and wildlife, as well as hunters and sport fishers. It may be used in training courses and in the communication with target groups to support management decisions. One purpose is to contribute to transnational learning on beaver management and use in the countries of the EU Interreg Baltic Sea Region.

The book has been produced by the project Water Management in Baltic Forests (WAMBAF) in 2016–2019, funded by the EU and national sources. The authors together have a broad and diverse experience of beaver, water, and management issues.

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