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of the Environmental Board of 18.02.2022.

Conservation and management plan for large carnivores: wolf, lynx and brown bear

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Summary

Large carnivores are species characteristic of Estonian landscapes that have high ecological and cultural value. All three species - the wolf, the lynx, and the brown bear - can be considered the flagship species of nature conservation in Europe, whose examples perfectly illustrate various problems and conflicts related to nature conservation. The distribution ranges of the wolf, lynx, and brown bear is recovering in Europe after a long period of persecution, but the need of these species for large home ranges inevitably leads to many conflicts with humans in today's urbanized Europe. The main concerns regarding large carnivores in many parts of Europe are the low abundance and genetic diversity of their populations, the reduction or fragmentation of their natural habitats, overhunting, poaching, and selective hunting, the still insufficient cross-border cooperation to conserve the populations, and among the most important problems, the very persistently declining unfavorable public opinion towards large carnivores. Fortunately, there is a growing belief that today, instead of artificial management boundaries for large carnivores, the focus should be on monitoring, managing, and conserving populations according to the natural structure and integrity of their populations.

The wolf, lynx, and brown bear are included both in the Red List of Threatened Species in the category of species in favorable status (LC) and in Annexes II and III of the Bern Convention. In the list of species covered by the CITES convention, the wolf, lynx, and brown bear are Annex II species that are not currently in danger of extinction but whose uncontrolled trade may threaten their conservation status. The Estonian wolf and lynx populations are excluded from Annexes II and IV of the Habitats Directive and included in Annex V. Estonia has the right to continue hunting these species, but the status of the species must be monitored. The Estonian bear population was excluded from Annex II of the Habitats Directive but remained in Annex IV, which means that special nature areas do not need to be created to protect the bear, but after joining the European Union, the bear is a protected species that can only be hunted in exceptional cases to prevent damage.

Compared to many Western European populations, large carnivores in Estonia are in a relatively favorable status. The total post-hunting season wolf population in spring has ranged from 100 to 200 adults in recent years, and the number of litters in 2020 was estimated at 31. According to the steering group of the Red List of Estonian species, the status of the population is in the "*vulnerable*" category. In 2020, there were approximately 400-450 lynxes and 63 reproductions in Estonia. Due to the poor status of the population in recent years, it has not been allowed to hunt lynx since the 2016 hunting season. The lynx population is currently in an unfavorable status, and according to the steering group of the Red List of Estonian species, it is in the "*vulnerable*" category. The brown bear population in Estonia has steadily increased. In 2020, 89 reproductions and 900-950 individuals were estimated in the population. The population is in very good status. According to the criteria of the IUCN Red List, the status of the brown bear population in Estonia has been assessed in the "*Least Concern*" category.

This action plan for the conservation and management of wolves, lynxes, and brown bears provides guidelines and an action plan for the years 2022-2031 in order for Estonian society to function and develop peacefully with natural, viable, and ecologically functioning large carnivore populations. This plan is a continuation of the action plans for the years 2002-2011 and 2012-2021 that directed the organization of the conservation and management of large carnivores in the past two decades, during the implementation periods of which the foundation was laid for systematic monitoring of large carnivores and hunting management.

The action plan has six central goals/directions:

A sustainability of large carnivore populations in accordance with EU biodiversity conservation rules;
B a clear and functional zoning and implementation system for large carnivore conservation and management areas;
C an effective damage prevention and compensation system;
D scientific basis, clarity, and recognition of management and conservation decisions;
E scientific monitoring and research of abundance and status of the populations;
F public awareness and professional competence of the parties and stakeholders.

Among other tasks, the updated plan sets the goal of forming a cooperation council for large carnivores, which brings together the views and expectations of various interest groups and will be one of the inputs in making decisions related to large carnivores. It is considered very important to continue the existing monitoring and damage prevention system and to constantly improve it. The plan is to pay more attention to increasing people's knowledge and competence in order to improve the unfavorable public opinion towards large carnivores.

The criteria for the favorable status of the large carnivore population were corrected; if these criteria are achieved or maintained, the plan can be considered effective: the number of wolf packs with offsprings under one-year-old remains between 20-30 before the hunting season and the number of lynx females with offsprings is over 80, and brown bear females with cubs-of-the-year is over 70. In addition, the base population, i.e., the number of individuals of reproductive age in the spring, will be assessed. It was agreed separately that lynx hunting will not start until the number of family groups is at least 100. The goal is that the frequency of damage either remains at the same level or decreases.

The total cost of the implementation of management and conservation measures planned for the years 2022–2026 is 2,133,000 euros (including the total cost of first priority activities is 1,505,000 euros and the total cost of second priority activities is 332,000 euros).

1 Introduction

The action plan provides guidelines based on the information collected during the preparation of the action plan (expert assessments, inventories, monitoring reports, etc.) to ensure a favorable status for the wolf, lynx, and brown bear. It is an organizational material aimed at institutions dealing with the conservation and management of wolves, lynxes, and brown bears, which does not directly limit the rights of non-administrative persons or impose obligations on them. The guidelines and principles of conservation and management of the wolf, lynx, and brown bear presented in the action plan are taken into account by the relevant authority when exercising the right of discretion provided for in the legislation, but the purpose of drawing up the action plan is not to make case-based preliminary decisions.

According to § 49 of the Nature Conservation Act, the conservation and management action plan (including the species action plan) is the basis for organizing the conservation and management of species. The conservation and management action plan provides recommendations to the conservation and management organizer on the best ways to achieve the conservation and management goals but does not create rights or obligations for third parties. The action plan for conservation and management is approved by the Deputy Director General of the Environmental Board. Information about the approval of the plan is published on the website of the Environmental Board and the Ministry of the Environment.

Large carnivores are a very important part of ecosystems everywhere on earth, but they are also among the most endangered species (Ripple *et al*., 2014). They face many anthropogenic threats, such as persecution, livestock-related conflicts, hunting, and loss of prey (Ripple *et al*., 2014, Wolf & Ripple, 2016). The unique biological characteristics of large carnivores (predators' relatively long gestation period, large home ranges, gregarious lifestyle in some species) make them particularly vulnerable to threats related to the increase in the human population (Cardillo *et al*., 2004; Chapron *et al*., 2014). The ecological importance of large carnivores has been described in many scientific articles.

Large carnivores are important species *per se*, as well as from the point of view of the integrity of ecosystems, worthy of extensive conservation. Therefore, some large carnivore species (including the wolf, but also the lynx and the bear) are the so-called flagship species of nature conservation, which can be used to inform the public about the necessity and solutions of nature conservation. Many other species living in the same ecosystems are often protected through the mediation of flag species and the protection of their habitats. It is widely recognized that due to the ecological role of large carnivores, their value, and the critical status of their populations, large-scale carnivore conservation is a global priority (Ray *et al*., 2005), which has implications for other species as well (Newsome *et al*., 2016, Ripple *et al*., 2014). Large carnivores are very important influencers of food chains, being able to influence both herbivorous species, mainly various ungulates (Jędrzejewski *et al.*, 2002, 2012; Valdmann *et al.*, 2005; Nowak *et al.*, 2011; Mattioli *et al.*, 2011; Zlatanova *et al.*, 2014), as well as the number of medium-sized predators and their behavior (Dalerum, 2013).

In Europe, all large carnivores have developed a similar distribution pattern, which mostly correlates with genetic diversity - due to the pressure of human activity after the ice age, the western populations are more fragmented, and their numbers are affected by one or more previous bottlenecks (a period of very low abundance), whereas the eastern populations are more coherent, more stable and more numerous (Kaczensky *et al.*, 2012; Pilot *et al.*, 2014; Hindrikson *et al.*, 2017; Lucena-Perez *et al.*, 2020). The return of large carnivores to human-dominated European landscapes in recent decades is technically, socially, and politically one of the most difficult tasks in nature conservation. In addition to the low numbers and genetic diversity of large carnivores in Europe, the most important concerns are the reduction and fragmentation of natural habitats due to the lack of cross-border cooperation in the conservation of populations. Next to the destruction and reduction of habitats, hunting (including over-hunting, poaching, and selective hunting) has been one of the most important reasons for the disappearance of large carnivores or a sharp decline in their numbers all over Europe (Chapron *et al.*, 2014; Hindrikson *et al.*, 2017; Kuijper *et al.*, 2019). To date, the former total culling is being replaced by a scientifically justified sustainable hunting management. At the same time, one of the most important activities in the conservation of large carnivores is the formation of science-based and favorable public opinion. The goal is to preserve viable populations and expand the distribution of species, as well as the peaceful coexistence of humans and large carnivores.

The draft of this plan was compiled by OÜ Rewild, Jaanus Remm, and Maris Hindrikson. The proofreading of the draft plan was done by the employees of the Environmental Board, the Environment Agency, and the Ministry of the Environment (including the species protection committee). During the preparation of the plan, two working meetings and two public discussions (including engagement) meetings were held.

From the compilers of the plan, a huge, huge thank you to all of you!

2 Species biology, distribution, and abundance

2.1 Wolf

The wolf (also gray wolf) belongs to the canine family (*Canidae*) of the carnivores (*Carnivora*). Phylogenetically, the closest species to the wolf are the coyote (*Canis latrans*), the golden jackal (*C. aureus*), the Ethiopian wolf (*C. simensis*), and the African golden wolf (*C. lupaster*; Gopalakrishnan *et al.*, 2018). In Eurasia, wolves are divided into different subspecies, the subspecies *C. lupus* is mainly found in Europe, but the Apennine wolf (*C. l. italicus*; Montana *et al.*, 2017) lives on the Apennine Peninsula, and the Iberian subspecies (*C. l. signatus*; Torres & Fonseca, 2016) on the Iberian Peninsula. The wolf and the domestic dog (*C. l. familiaris*) are considered sister taxa, and various studies confirm a clear divergence between modern dog and wolf lineages (Freedman *et al.*, 2014; Skoglund *et al.*, 2015; Frantz *et al.*, 2016).

2.1.1 Distribution and abundance

The wolf had one of the most extensive historical geographic ranges of any mammal (Ripple *et al.*, 2014; Szewczyk *et al.*, 2019), but as a result of systematic persecution and extermination of the species during the 19th and 20th centuries, the species today occupies only 68% of its historical range (Ripple *et al.*, 2014). Particularly intense and large-scale persecution in Western and Central Europe led to the retreat of the species mainly to remote and sparsely populated areas, and fragmented populations survived only in Portugal, Spain, Italy, Greece, and Finland, and as larger and more coherent populations in the Eastern part of Europe (Baltic, Dinaric-Balkan and Carpathian populations; López-Bao *et al.*, 2017). Only in the last five decades in Europe the persecution of wolves has been replaced step by step by their conservation, which has prevented the complete extinction of several populations since the 1970s (Chapron *et al.*, 2014; Hindrikson *et al.*, 2017). Therefore, in the last few decades, the range of the wolf in Europe has increased again, both due to the expansion of the range of existing wolf populations in different countries, as well as due to the restoration of former distribution areas and the emergence of new populations (for example, the population of the Central European Plain) (Kuijper *et al.*, 2019). However, there is still widespread hostility and negative public opinion toward the wolf, making it difficult to conserve the species in Europe (Chapron *et al.*, 2014; López-Bao *et al.*, 2017).

The **Baltic wolf population** is a part of the Eurasian metapopulation, the range of which includes Estonia, Latvia, Lithuania, and the north-eastern part of Poland within the European Union (Figure 1) and outside the EU Belarus, the northern part of Ukraine and Leningrad, Novgorod, Pskov, Tver, Smolensk, Bryansk, Moscow, Kaliningrad, Kursk, Belgorod and Orel oblasts and its size has been estimated at 3600 individuals (Linnell *et al.*, 2008). The size of the EU part of the Baltic population is estimated to be around 1700-2240 individuals (number of individuals in breeding age; Boitani, 2018; LCIE[1]). Among our immediate neighbors, there are about 400-500 wolves in Latvia (Šuba *et al.*, 2021), about 300 in Lithuania (Hindrikson *et al.*, 2017) and about 267 (in 2012) to 1040 wolves (in 2018) in the northern part of Poland (Diserens *et al.*, 2017; Boitani 2018). In Russia, in our neighboring areas, between 2012 and 2019, 222-446 wolves have been counted in the Pskov region[2]. In the long term, the fate of the Estonian wolf population depends on the situation in Russia (Hindrikson *et al.*, 2017), where the main part of the population of the wider region is located. Therefore, it is important to

[1] https://www.lcie.org

[2] https://priroda.pskov.ru/vidy-deyatelnosti/vidy-deyatelnosti/ohrana-okruzhayushchey-sredy/ezhegodnyy-doklad-ob-ekologicheskoy-situacii-pskovskoy-oblasti

monitor and take into account the population processes taking place in Russia when assessing and managing the status and the perspective of the Estonian population. Based on official data, an average of 206 wolves are hunted in the Tver and Pskov regions per year, which is 22.6% of the total population (Korablev *et al*., 2020). A recent genetic study of wolves conducted in Tver and Pskov region confirmed the results of previous, smaller studies and showed that the wolf population there is genetically homogeneous, without spatial structure, and diverse (Korablev *et al.*, 2020). The estimated size of the entire wolf population in northwestern Russia has varied between 4,100 and 5,900 individuals between 2013 and 2017 (Kolesnikov *et al*., 2017).

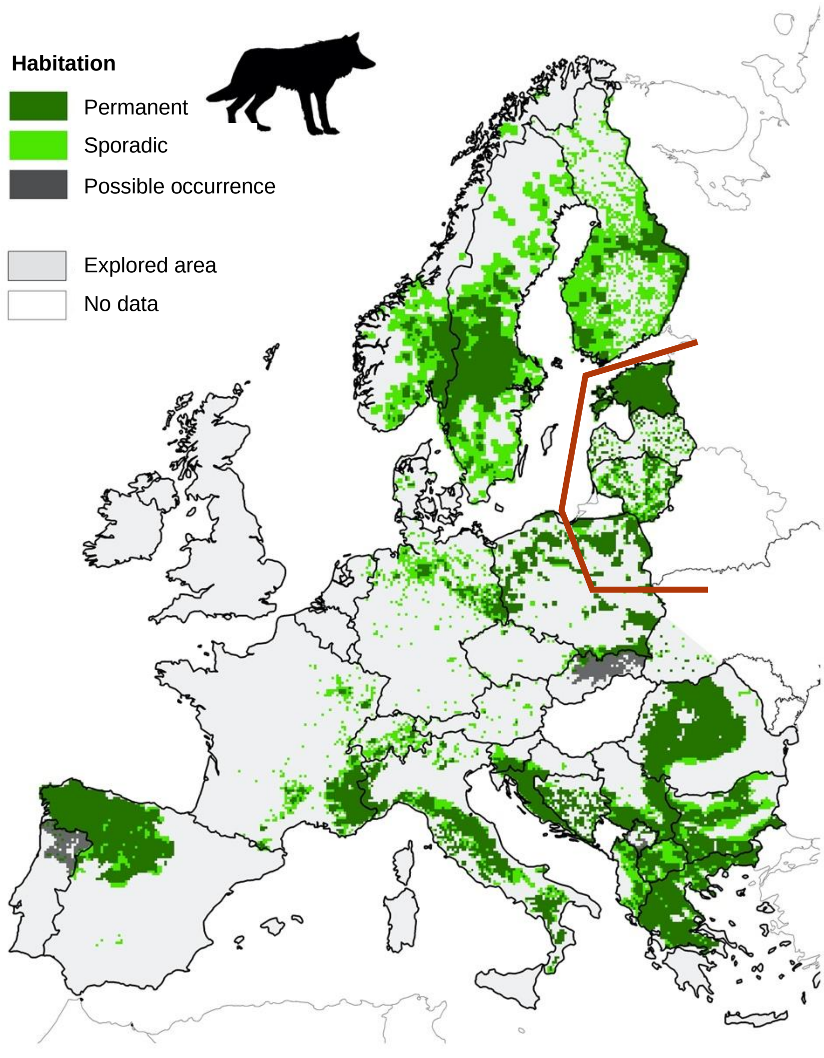
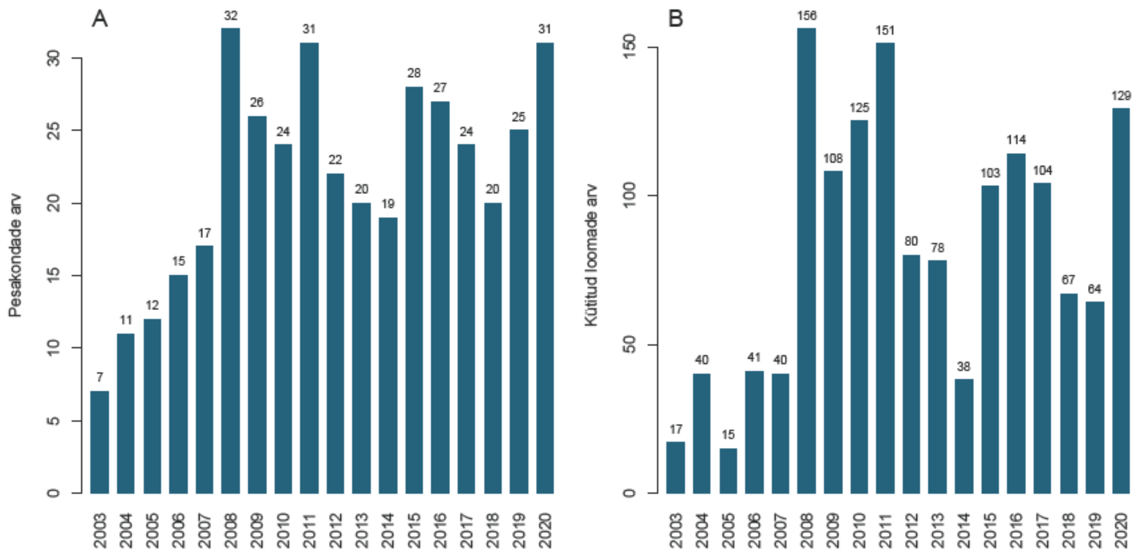


Figure 1. Wolf distribution in Europe (indicated in green and dark gray) according to LCIE estimate in 2016[3]. The EU part of the Baltic population is marked by the red line.

In **Estonia**, the number of wolves has fluctuated greatly since the beginning of the last century. The biggest lows were in the 1930s and 1960s when only 10-20 individuals were counted in Estonia, and the highest peak was in the mid-1950s when as many as 1,000 wolves were counted (Kaal, 1983). The next peak in the number of wolves was in the mid-1990s when about

[3] https://www.lcie.org

700 wolves were counted, and this was followed by another low at the beginning of this century. In 2002 and 2003, there were only nine wolf breeding packs in Estonia, three of which lived in the border areas of Latvia, so the autumn population of wolves (i.e., adult animals and pups) can be estimated at about 75 individuals. The applied hunting restrictions led to an increase in the number of wolves until the number reached the highest level in the period in 2008 when the number of breeding packs was estimated at 32, and the number in autumn could reach almost 300 individuals. Since that year, the number has slightly fluctuated, and in 2019 the number of breeding packs was estimated at 25, while 65 wolves were shot in Estonia during the 2019/2020 hunting season. In Latvia, on the other hand, for example, 280 animals were hunted in the same season, i.e., in the 2019/2020 hunting season. (Veeroja *et al.*, 2020). In 2020, the number of breeding packs was estimated at 31 (Veeroja *et al*., 2021), and in the same hunting season (2020/2021), according to official statistics, 129 wolves were hunted (Figure 2). But in addition to them, there were 2 cases when the animal was wounded but not caught, and one nuisance individual hunted with a special permit.



A Number of breeding packs

B Number of hunted individuals

Figure 2. Determination of the number of wolf breeding packs (A) and the number of hunted individuals (B) in the years 2003-2020 (source: KAUR).

In the winter of 2018/2019, a genetic study of the wolf population in mainland Estonia was carried out by the Environment Agency (KAUR) and Tallinn University of Technology (TalTech).[4] . A total of 329 wolf excrement samples were collected from wolf habitats. In addition to excrement samples, 58 tissue, 13 blood and saliva samples, and hair samples from 32 sheep presumably killed by wolves were also tested. DNA samples isolated from excrement and saliva samples were tested in five replicates, and blood and tissue samples in three replicates. Samples in which at least 11 of the 17 investigated microsatellite loci were amplified

[4] https://www.keskkonnaagentuur.ee/et/eesmargid-tegevused/projektid/elme/hundi-arvukuse-geneetiline-uuring

were used to calculate the frequency of alleles and to identify individuals, as described by Granroth-Wilding *et al.* (2017). Of the tested samples, 11 or more loci were detected in only 25.2% of the samples (109 in total) and only in 19.1% of the excrement samples (63 samples). During the identification of individuals, 12 samples were found with a complete overlap of genotypes and 7 with partial overlap (the difference between the two loci was in one or two positions). All samples with overlapping genotypes were derived from excrements. A total of 88 wolves (individuals) were distinguished according to the aforementioned criteria.

Taking into account only the results of excrement samples and assuming that the specimens are included in the sample according to the Poisson distribution, it is possible to calculate the number of specimens not included in the sample and the total size of the population. According to a more conservative estimate (19 repeated observations), the size of the wolf population was at least 65 individuals (95% confidence interval: 59–78), and according to a more optimistic estimate (12 repeated observations), at least 122 individuals (95% confidence interval: 96–202; see Annex 1). It is important to note that the confidence interval for these estimates is quite wide (29-87% compared to the mean value). Considering that, in addition to the 43-50 individuals identified on the basis of excrement samples, 45 more individuals were distinguished from tissue, blood, and saliva samples, it is clear that the conservative approach obtained from the repetitions of excrement samples clearly underestimated the total population size, and the estimate of 122 individuals is most likely an underestimate because a part of mainland Estonia (the territory of 3–4 wolf packs) was not covered during the collection of excrement samples and it is known that the collection of samples was somewhat aggregated (compared to random distribution). It is also not yet clear whether the ratio of successful (at least 11 loci detected) and failed samples was similar across regions or not.

2.1.2 Population structure

The demographic structure of the wolf population in Estonia can currently be described based on hunting samples. On average, 51.8% (37.4–64.7%) of the individuals hunted in 2006–2020 were under one year old, while 47.6% (37.7–57.7%) of those were hunted in 2012–2020. The average proportion of pups in the hunting sample has also been similar in Latvia - 47.1% (Šuba *et al.*, 2021), somewhat lower in Finland - 42% (Ronkainen & Kojola., 2005). The proportion of female wolves in the hunting sample in Estonia in 2006-2010 was 46% among juveniles and 35% among older individuals; in Finland, the proportion of females among radio-collared wolves that participated in the study (1998-2013) and whose official cause of death was hunting was 45% (Suutarinen & Kojola, 2017).

2.1.3 Habitat and home range

The wolf is a highly adaptable species that inhabit all natural terrestrial biotopes in the Northern Hemisphere (Ripple *et al.*, 2014). In the European forest area, wolves inhabit a wide variety of habitats, avoiding larger human settlements and roads if possible (Ordiz *et al.*, 2015; Kuijper *et al.*, 2019). In Estonia, when the number of wolves is low, only larger natural massifs have been inhabited, but during periods of high numbers, areas with a larger proportion of cultural landscapes have also been inhabited. The habitat choice of the wolf in Estonia, as everywhere within the range of the wolf, depends to a great extent on the location of prey animals and their population density (Zlatanova *et al.*, 2014). In the European and North American literature review (42–66 °N) prepared by Jędrzejewski et al. (2007), it can be seen that the size of home ranges of wolf packs varies greatly throughout the range, depending mainly on latitude and prey biomass. At similar ungulate biomass (100 kg/km²), wolf territories were, on average, 140 km² at 40°N latitude, 370 km² at 50°N latitude, and 950 km ^{2} at 60°N latitude. The habitat studies of the wolf carried out in South-West Estonia between 2004 and 2020 show that the size of the home range varies in the order of 800-1200 km² (Wolf habitat use and nutrition, 2004-2020; KAUR[5]). By combining the aforementioned latitudes and the corresponding home range sizes in the regression equation, we get the expected average home range size in Central Estonia (58.5 °N) to be approx. 900 km².

2.1.4 Reproduction and sociality

A wolf is a territorial animal with a pack lifestyle. A wolf pack usually consists of a breeding pair and their pups of the same year, and older packs also include some of the pups of the previous year. In addition to packs, the population also includes territorial pairs that have not yet had time to breed and single wolves, which are mostly young individuals that disperse from their parents' territory (Mech *et al*., 2003). In case of wolves, as in many other social predators, most of which are territorial, population density patterns are influenced not only by prey but also primarily by the home territory, as well as the size of the group (Jędrzejewski *et al.*, 2007). In the range of the wolf, these two parameters show a significant geographical difference - the territories of wolf packs can range from less than a hundred square kilometers to several thousand square kilometers (Ballard *et al.*, 1998), being larger in the northern areas of the wolf's range (see also chapter 2.1.3).

Wolves are monogamous animals, pairs are permanent, and both parents take part in raising the pups. The wolf's mating season is usually at the end of January and February, and pups are born in May (Kaal, 1983). The generation time of wolves is 3–4 years (Skoglund *et al.*, 2015; Mech *et al*., 2016). It has also been found that a large proportion of young female wolves do not breed, and the peak breeding age occurs at 5-7 years of age. The exception is populations colonizing new areas, where breeding age arrives at a younger age (Mech *et al.*, 2016). Sexually mature wolves of both sexes usually leave the natal pack, form a pair with the opposite sex and dispersers from other packs, choose a territory, and have offspring (Mech, 2020). In Finland, the average number of pups at the beginning of winter in the first breeding has been 3.4, and in repeated breeding, 5.1 (Kojola, 2004). In Estonia, since 2008, the Environment Agency has monitored the reproductive performance of the wolf population in Southwest Estonia and tried to explain as accurately as possible the number of offspring in different litters and, in parallel, the size of the individual composition of the packs. The number of offspring in the litter was determined during various field observations, mainly using trail cameras, and placing them in the nesting territories of different wolf packs. In addition to trail cameras, other commonly accepted field observation methodologies were used. Currently, the Environment Agency has collected data on 43 dens where it was possible to determine the annual number of wolf pups in the litter. The annual average number of offspring born in the same year in wolf packs in the late summer period of August-September is 5.35 (range 3-8 offspring; observation area 7 500 km2; observation years 2008-2021; n = 43 dens). Dispersal of young wolves studied in Finland (migrations from the place of birth in search of new habitats) showed that, although 53% of radio-collared wolves moved more than 800 km, new territories were mostly settled less than 200 km from the former home territory (Kojola *et al.*, 2009). Based on a European study, wolf populations can genetically influence each other (through the dispersal and migration of individuals) over a distance of up to 850 km (Hindrikson *et al.*, 2017). The wolf packs located closer to each other are generally genetically directly related. The Estonian wolf population is connected to Russia through migration, but the connection is relatively weak due to obvious movement barriers (Lake Peipus and Lake Pskov) (Hindrikson *et al.*, 2013; Plumer *et al.*, 2016). There are few direct reports of the movement of wolves across the Estonian-Russian border - however, in 2021, a wolf radio-collared in Estonia was hunted in the Leningrad oblast.

[5] https://www.keskkonnaagentuur.ee/et/suurkiskjad

The connection with the Latvian population is significantly closer on the basis of the genetic structure of the populations (Hindrikson *et al.*, 2013), and according to KAUR wolf telemetry monitoring, every year several packs are known to move in the territory of both countries.

2.1.5 Diet

The wolf is a highly adaptable and broad-spectrum predator (Newsome *et al.*, 2016), being the most important predator of cervids in the Northern Hemisphere (Ripple *et al.*, 2014). In Europe, almost everywhere, the wolf's main prey species are different ungulates: red deer (*Cervus elaphus*) is the wolf's most preferred prey species over roe deer (*Capreolus capreolus)*, and wild boar (*Sus scrofa*) and moose (*Alces alces*) are the wolf's main prey species in areas where neither red deer nor roe deer spread or where their population density is low, as for example in northern parts of Italy and Sweden (Jędrzejewski *et al.*, 2002b; Mattioli *et al.*, 2011; Sand *et al.*, 2012; Špinkytė-Bačkaitienė & Pėtelis, 2012). Specialization of the wolf on ungulates follows a geographic pattern in Europe: moose and reindeer (*Rangifer tarandus*) in Scandinavia, red deer in central and eastern Europe, and wild boar in southern Europe. In addition to heavier prey, wolves feed on roe deer in almost every region with relatively similar frequency (Zlatanova *et al.*, 2014).

Wolves are opportunistic and mainly use two ecological adaptation strategies: (a) in natural habitats and areas with high ungulate abundance, they feed mainly on wild ungulates; (b) in anthropogenic landscapes and areas with low abundance of natural large-bodied ungulates, wolves feed on livestock, plants, smaller prey (small ungulates, rodents) and food waste (Zlatanova *et al.*, 2014). In Estonia, the wolf's main prey species have been roe deer, wild boars, and moose. Prey preference seems to depend mainly on the availability, i.e., abundance and location of these species (Valdmann *et al.*, 1998; Valdmann *et al.*, 2005). In Latvia, deer and wild boar make up 69.7% and 22.6% of the wolf diet (part of biomass), respectively, and beaver (*Castor fiber*) is the next important prey species after ungulates and was found in the stomachs of 8.6% of hunted wolves, making up 6.4% of the consumed biomass (Žunna *et al*., 2009).

In Estonia, applied research on the wolf's diet and habitat lasted from 2004 to 2020 on a land area of 600 to 2,000 km² in southwestern Estonia, in the periphery of Viljandi and Pärnu counties. This long-term study shows that since 2018, roe deer have come to dominate in wolf diet in the researched area, and the share of moose has decreased significantly (Kübarsepp, 2018). Therefore, since 2010, a significant change has taken place in the wolf's diet. In 2011 and 2012, the roe deer in the wolf's diet did almost not exist due to serious decrease in the roe deer population at the beginning of 2010s, 50-65% of the food consisted of moose and 30-35% of wild boar. After drastic decrease in wild boar population due to the African swine fever that started in 2014 the proportion of roe deer in the wolf's food base has steadily increased since 2013 (Kübarsepp, 2018). The analysis of wolf excrements collected in 2017-2018 and comparison with data from 1998 showed that, although ungulates still made up the majority of the wolf's food in the sample, the proportion of moose, wild boar, small rodents, and hares has decreased significantly (Valdmann & Saarma, 2020).

2.1.6 Mortality

The main mortality factor for wolves in Estonia is undoubtedly hunting, followed by traffic accidents and certainly by poaching. In the years 2009–2018, 18 traffic accidents involving wolves were known to have occurred on Estonian roads (Remm & Remm 2019). In the years 2015–2020, 8 misdemeanor proceedings have been initiated in connection with the wolf on the basis of § 50 of the Hunting Act (hunting without a hunting permit, i.e., illegal hunting). The annual non-hunting mortality of the population is previously estimated to be around 20%

(Männil & Kont, 2012). Among the causes of death of wolves studied in Sweden, it appeared that out of 20 wolves found dead, seven deaths were caused by traffic, four by Sarcoptic mange, and four by poaching (Mörner *et al.*, 2005). Studies in Finland have shown that as many as 50% of 28 radio-collared wolves died in the first year after leaving their natal territory (Kojola *et al.*, 2009). A later study, focusing mainly on illegal hunting, found that wolf mortality in Finland is very largely anthropogenic, with wolf survival rates ranging from 11–24% (high levels of illegal hunting) to 43–60% (no illegal hunting; Suutarinen & Kojola, 2017). Quite similar results have also been found in a study (2001-2012) conducted on the wolf population in western Poland and in the recently emerged wolf population in Central European Plain, where it was found that 65% of 28 wolves died in traffic, 35% by poaching and 7% by diseases (see also ch. 2.4.3) and due to other natural factors (Nowak & Mysłajek, 2016). In Estonia, the wolf hunting pressure was 32% in 2018 and 26% in 2019, while the potential increase rate has been estimated at 40% over a longer period of time (the autumn population has been taken into account, i.e., old animals with pups; Veeroja *et al.*, 2020). In Latvia, the average mortality rate of 37.2% in the last 20 years due to legal hunting has been lower than the reproductive potential of the population, and the number of wolves has increased (Šuba *et al.*, 2021).

2.2 Lynx

The lynx (Eurasian lynx) belongs to the feline family (*Felidae*) of the order Carnivora. In addition to the Eurasian lynx, we can find in Europe also the endangered Iberian lynx (*Lynx pardinus*), whose population has increased from less than 100 individuals to 360 individuals in 2015 as a result of species protection programs in the last 20 years[6] and up to 855 individuals in 2020[7] .

2.2.1 Distribution and abundance

The result of the increasing pressure of human activity during the Holocene was the emergence of genetically structured, impoverished, and isolated lynx populations in Europe (Lucena-Perez *et al.*, 2020). As a result of the persecution and eradication of large carnivores, the number of lynx populations in southern and western Europe fell drastically in the 19th century so that by the beginning of the 20th century, the species was extinct in central and southern Europe, surviving only in the Carpathians and the Balkan Peninsula (Breitenmoser *et al*., 2000; Rueness *et al.*, 2014; Lucena-Perez *et al.*, 2020). In the second half of the 20th century, thanks to population recovery and reintroduction programs, the number of the species gradually increased, and the area expanded, and now the lynx is widely spread in Northern and Eastern Europe as well as in the forested regions of Southeast and Central Europe (Carpathians, Balkans, Dinaric Mountains, Alps, Jura, and Vosges Mountains; Rodríguez-Varela *et al.*, 2016). Between 1971 and 2018, there have been 16 attempts to reintroduce lynx in Central Europe, but most of these times have been unsuccessful (Mueller *et al.*, 2020). A recent genome-wide study (n = 80) points out that European lynx populations are isolated from Asian populations, and to strengthen the populations, it would be reasonable to restore the connection of the lost populations (Lucena-Perez *et al.*, 2020).

The Baltic lynx population is a part of the Eurasian metapopulation, which is relatively evenly distributed in Estonia, Latvia, Belarus, and in Leningrad, Novgorod, Pskov, Tver, and Smolensk oblasts in Russia, and as fragmented sub-populations in Lithuania, north-eastern

[6] http://www.iberlince.eu/images/docs/3_InformesLIFE/Informe_Censo_2017.pdf

[7] https://www.theguardian.com/environment/2020/oct/25/the-lynx-effect-iberian-cat-claws-its-way-back-from-brink-of-extinction

Poland, northern Ukraine, and Kaliningrad oblast (Linnell *et al.*, 2008; Kaczensky *et al.*, 2012; Figure 3). According to Linnelli et al. (2008), the population size is about 3400 individuals. Kaczensky et al. (2012) estimated that the European Union (EU) part of the Baltic population zone consisted of approx. 1,600 animals of breeding age in 2012, the majority of which live in Estonia and Latvia, the EU part of the Baltic population was estimated to be slightly smaller in 2015 by Boitani et al. (2015) – 1,200 -1,550 individuals. According to the official census, more than 900 lynxes live in Latvia (Bagrade *et al.*, 2016) and about 162 lynxes in Lithuania (Balčiauskas *et al.*, 2020). In a recent, as yet unpublished study, 561 Estonian-Latvian lynx (including 290 from Estonia) were studied using genetic methods, using 11 microsatellite loci, and the results show that the Estonian lynx population is very closely related to the Latvian population and there are no obstacles to gene flow between the populations of these countries (Tammeleht *et al.*, manuscript in preparation).

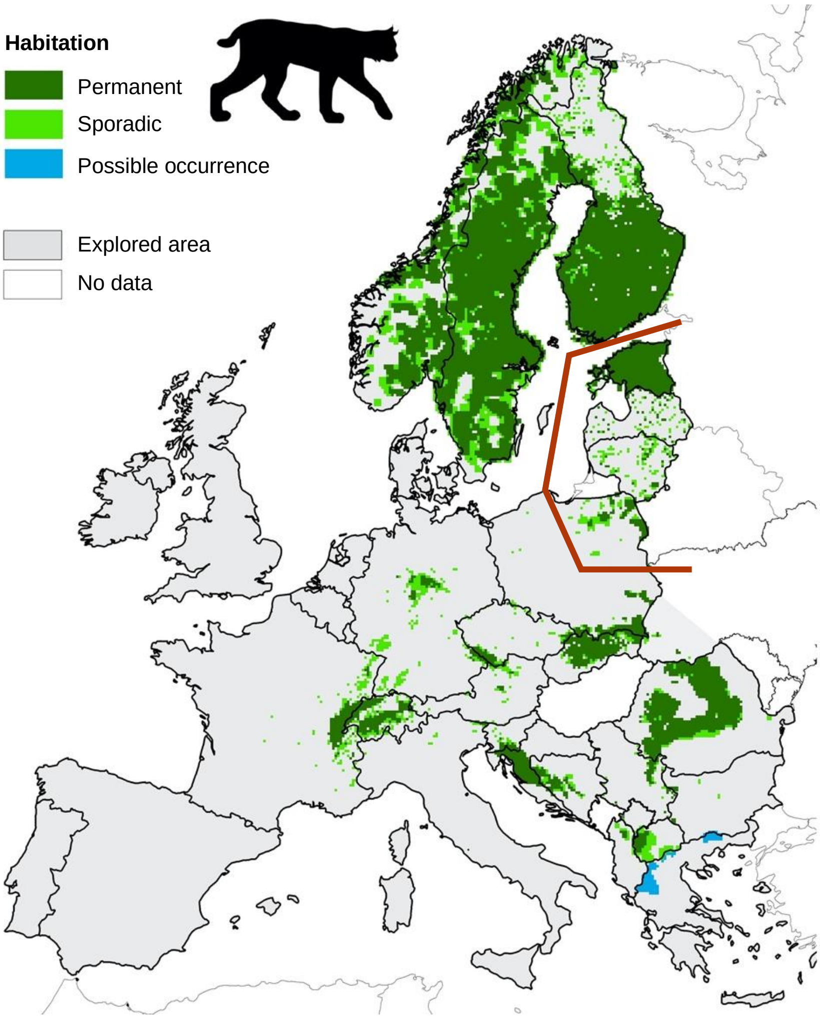
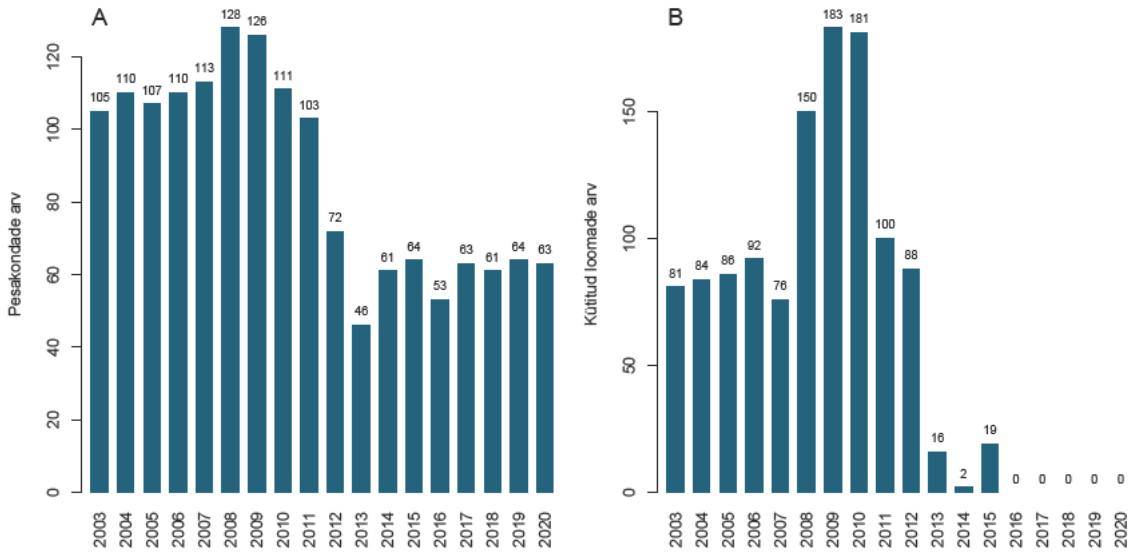


Figure 3. Range of lynx in Europe (marked in green and blue) according to LCIE estimate in 2016[8]. The EU part of the Baltic population is marked by the red line.

The number of lynxes **in Estonia** has been at a low point since the end of the 19th century, and since 1937 the lynx has been under protection. In 1966, only 60 individuals were counted in Estonia. Since then, the number of lynxes had increased continuously, reaching its maximum in 1998, when the number of hunted individuals was about 220 animals per year. The decline after 1998 reversed to an increase again from 2005, from which the autumn number of the population until 2010 was about 700-850 individuals. In 2013, however, the number of lynx family groups (females with kitten) dropped to 46, and since 2014, the number of family groups has been between 53 and 64 (Veeroja *et al*., 2020; Figure 4). As of autumn 2020, there are 400–450 lynx and 63 family groups in Estonia (Veeroja *et al*., 2021). Due to the relatively poor status of the population in recent years, lynx hunting is not allowed in the 2016/2017 to 2020/2021 hunting seasons. In 2020/2021, however, one lynx was shot as it had been mistaken for a wolf and another lynx was found illegally hunted. Besides hunting, the dynamics of the lynx population in Estonia are very closely linked to the abundance of the lynx's main prey species, the roe deer. Here, however, it is important to note that changes in the number of roe deer are reflected as changes in the number of lynxes with a significant time delay. In Estonia, the range of roe deer is close to the northern border, so the abundance of the species has

[8] https://www.lcie.org

fluctuated to a very large extent depending on the winter weather conditions. This fact must also be taken into account when planning the target level and hunting quotas of the lynx population.



A Number of females with kittens

B Number of hunted individuals

Figure 4. The number of lynx family groups (A) and the number of hunted individuals (B) in Estonia in the years 2003–2020 (source: KAUR).

2.2.2 Population structure

The structure of the lynx population in Estonia has not been thoroughly studied in the sense of basic science, and the following figures reflect the knowledge obtained from monitoring data. While in the years 2006–2011, juveniles accounted for an average of 30% (25–37) of the individuals hunted in Estonia, in 2012, the proportion of juveniles (animals under one-year-old) had dropped to 15%. In Latvia, in the period 1998–2006, 33.7% of the hunting sample consisted of juveniles, 12.4% of 1-year-olds, and 53.9% of adult animals (Ozolinš *et al*., 2007), but in a later study (2006–2015) the number of 1 - year-old lynxes out of 1188 animals is very small (3.2%), the proportion of juveniles, on the other hand, is 29.8% (Bagrade *et al*., 2016). It should be noted here that hunting can be selective and the age distribution among the hunted animals is not necessarily the same as the population.

2.2.3 Habitat and home range

The Eurasian lynx is the most widely distributed feline in the world; its range extends from Central Europe to the Far East, and it covers a variety of habitats (forest, scrub, desert, rocky areas, and grassland) and climate zones (Mediterranean, temperate, boreal, 5,500 m above sea level; Lucena-Perez *et al*., 2020). Lynxes avoid areas with intensive land use and choose different forest types with a sufficiently high density of ungulates (Breitenmoser *et al.*, 2000; Müller *et al*., 2014; Magg *et al*., 2016). In Estonia, the lynx lives in all forest habitats.

The lynx is a territorial animal with a solitary lifestyle. The permanent groups of the lynx consist of the mother and her cubs under one year old. In a large meta-study comparing home ranges of lynx in ten European regions, it was found that it was, on average, 625 km² for males and 319 km² for females and that the size of the home range of lynx in Europe is mainly influenced by the population density of prey species (Herfindal *et al.*, 2005). As a rule, the home ranges of same-sex adults do not overlap or overlap to a small extent, but the home ranges of different-sex adults can overlap to a significant extent (Kowalczyk *et al*., 2015).

In Estonia, the home range of the lynx was studied between 2006 and 2017, when it was revealed that the home range of the lynx varies between 124 and 676 km². The largest home ranges were found in 2014 when the average size of the home range for males was 676 km^2 and for females 492 km² (Kont *et al.*, 2015). The increase in home ranges was probably due to the marked depletion of the food base and the low number of lynxes, the first of which creates the need and the second gives the opportunity for territorial individuals to move over larger areas.

2.2.4 Reproduction and sociality

The Eurasian lynx is a polygamous solitary species that breed seasonally - pairs form only for the breeding season, and only the female is engaged in raising the cubs. The mating season of the lynx in Estonia usually starts at the end of February and the beginning of March and lasts about a month. Cubs (1–4, usually 2–3) are usually born in May and usually stay with the mother until the mother's next mating season, when the cubs are about 10–11 months old (Basille *et al.*, 2009). The mortality rate of cubs during the first year of life is very high (*ca.* 50%; Breitenmoser-Würsten *et al.*, 2007), and natural causes (starvation, diseases; Andrén *et al.*, 2006) mainly play a role in this. Just under a year old, kittens start dispersing from their natal area, future habitats are found, and the home territory is usually occupied during the following year (mainly up to 1.5 years of age; Samelius *et al.*, 2012). Although about half of female lynxes are sexually mature at the age of less than a year, they are not yet physically fit to raise cubs and as a rule, breed for the first time at the end of their second year of life (Breitenmoser-Würsten *et al.*, 2007). In Estonia, the average number of lynx cubs in a litter has fluctuated between 1.7 and 2.1 in winter.

In Estonia, in the winter of 2008, out of two male lynx cubs (Kont et al., 2009) radio-collared at Tipu Game Research Area (Pärnu mk, Saarde parish), one was hunted in the following winter 33 km from the marking site, and the other one was seen in May 2011 115 km from the marking site in Tartu County. Its last coordinates were also obtained from the same area before the transmitter stopped working in October 2008, and the animal was hunted in the same area in January 2012. At the same time, a 1-year-old female lynx equipped with a radio collar was hunted in the winter of 2011 at a distance of 43 km from the marking place in Latvia, and her last location points were obtained from the same area in September 2008. In Norway, the dispersal range (distance from the center of the mother's home range to the center of the new home range) of young lynxes is, on average, 47 km (3-215 km) for females, and in males an average of 148 km (32–428 km; Samelius *et al.*, 2012).

2.2.5 Diet

The lynx is the most carnivorous of Estonia's large carnivores. It is a large opportunistic carnivore whose main food objects in most of Europe are small to medium-sized ungulates (mainly roe deer), accounting for 52-92% of the prey consumed in winter (Valdmann *et al.*, 2005; Molinari-Jobin *et al.*, 2007; Krofel *et al*., 2011). Chamois *Rupicapra rupicapra*) and red deer can also be the main prey species instead of roe deer (Odden *et al*., 2006; Molinari-Jobin *et al.*, 2007). In Scandinavia, it has been found that the proportion of sheep (*Ovis aries*) in the lynx diet in summer can increase significantly (Herfindal *et al.*, 2005; Odden *et al.*, 2006), which has led to major conflicts in Norway. Variation in the proportion of ungulates from region to region depends on the presence of alternative prey species, mainly hares (*Lepus spp*.), whose proportion in the lynx's diet increases from south to north (Jędrzejewski *et al*., 1993). The results of the analysis of the stomach contents of individuals hunted in Estonia also show the dominance of roe deer in the lynx diet, followed by hares and foxes (*Vulpes vulpes*; Valdmann *et al.*, 2005). Based on the dietary studies of collared lynxes in Estonia, the main prey species of the lynx is the roe deer (Kont *et al.*, 2016); among other species, they have also preyed on the mountain hare (*Lepus timidus*), Eurasian beaver (*Castor fiber*), hazel grouse (*Tetrastes bonasia*), fox, common crane (*Grus grus*) and moose.

2.2.6 Mortality

The main cause of mortality in lynx in Europe is anthropogenic - legal and illegal hunting and traffic accidents (total 54-97%; Ryser-Degiorgis, 2011). In Estonia, hunting was the main mortality factor for lynx for a long time, but since 2013, lynx have been legally hunted very little or not at all due to their low numbers. In Latvia, about 20–30% of lynxes are hunted every year (Bagrade *et al.*, 2016), which is slightly more than, for example, in the Bohemian Forest ecosystem, where the rate of illegal lynx hunting is 15–20% (Heurich*et al.*, 2018). The annual non-hunting mortality of the population in Estonia is estimated at an average of 13% (KAUR assessment for the first decades of the 21st century). In Sweden, Norway, and Switzerland, poaching is the main mortality factor for adult lynx - in Scandinavia, lynx mortality due to poaching is estimated to be 32-74% of the total mortality (Andrén*et al*., 2006); in Poland, it was found between 1991 and 2011 that poaching accounts for lynx mortality caused by human activities 67% (Kowalczyk*et al.*, 2015). There is no data on the frequency of poaching in Estonia, but since 2015, four misdemeanor proceedings have been initiated in connection with illegal lynx hunting (EB supervision department). In the years 2009–2018, 28 lynxes killed in road traffic were recorded in Estonia (Remm & Remm, 2019), and in the years 2010–2020, according to KAUR,14 lynxes are known to have died of sarcoptic mange (see also chapter 2.4.3).

2.3 Brown bear

The brown bear (hereinafter simply bear) is the most widespread species in the family of bears (*Ursidae*) belonging to the order of carnivores and is in a favorable status (LC) based on the IUCN red list of threatened species due to populations in North America, Eastern Europe, and some Asia (McLellan *et al*., 2017).

2.3.1 Distribution and abundance

In Europe, the brown bear is the flagship species of nature conservation, whose example perfectly illustrates the problems and conflicts related to the conservation of large carnivores. The economic backwardness of rural areas, the reduction of direct persecution of the species, and planned conservation strategies have halted the overall decline of the species and led to the recovery of most populations. At the same time, the willingness of social groups to co-exist with bears is reduced by emotions related to damage to livestock and property on the one hand (Bautista *et al.*, 2017) and on the other hand to rare but still occurring attacks on people (Bombieri *et al.*, 2019).

While during the last Ice Age, the brown bear inhabited the entire continent of Eurasia, today, the brown bear inhabits only some isolated areas in the European part of the continent (Chapron *et al.*, 2014). Human land use and direct persecution of the species have played a key role in the spread of the bear, but as a lesser-known factor, climate warming in the Holocene has also played a key role (Ripple *et al.*, 2013; Albrecht *et al.*, 2017). The brown bear's current range is about 68% of the historical range of the species (Ripple *et al.*, 2014). To date, the bear has spread as a more or less uninterrupted large population in Scandinavia, Finland, Russia, and Estonia. Larger but isolated populations are in the Carpathians and the Balkans, and in addition to them, there are some small, isolated populations in Europe (Figure 5). In recent years, brown bears have been repopulating the areas where they have historically been present, and the expansion of the brown bear's range into currently uninhabited areas continues. This is especially the case for the Alpine, Cantabrian, and Iberian populations (58%, 36%, and 35% of suitable uninhabited habitats, respectively), but less so in the Carpathian and Central Apennine populations, where there are few suitable uninhabited habitats (6% and 15%, respectively; Scharf & Fernández, 2018).

The brown bear is the most numerous large carnivores in Europe, whose population reached 17,000 individuals of breeding age in 2012 (Kaczensky *et al.*, 2012). Despite their large numbers, some populations are small, isolated, and easily affected by threats caused by genetic and demographic factors (Chapron *et al.*, 2014; Boitani *et al.*, 2015). Conservation and management of the brown bear are extremely difficult in many parts of Europe for several reasons: (1) there are few large areas suitable for the species in the wild in Europe, and (2) the species is distributed in 22 countries with very different conservation measures and regulations (Boitani *et al.*, 2015). The vast majority of the EU part of the **Baltic brown bear population** is in Estonia, and the bear also spreads to a small extent in northern Latvia. The main part of the Baltic population is located in Russia (Leningrad, Novgorod, Pskov, Tver, Smolensk, Kaluga, Moscow, Kaliningrad, Bryansk, Tula, Kursk, Belgorod, and Orel regions), and the population size has been estimated at 6,800 individuals (Linnell *et al.* 2008).

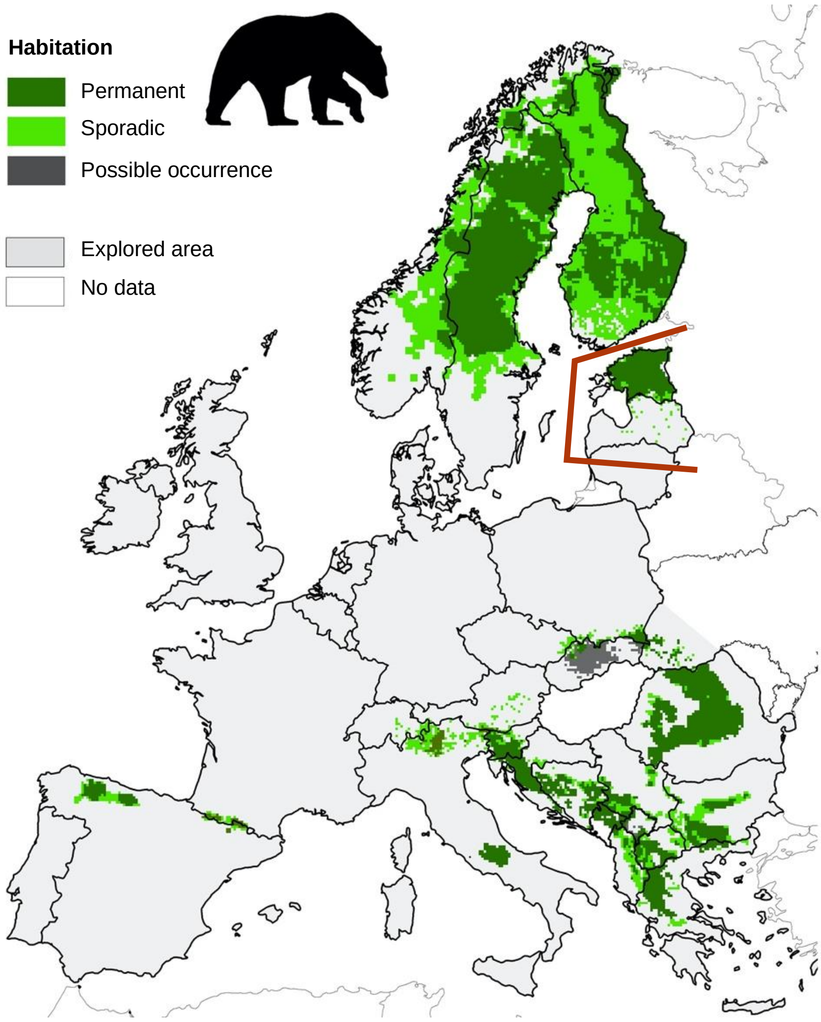


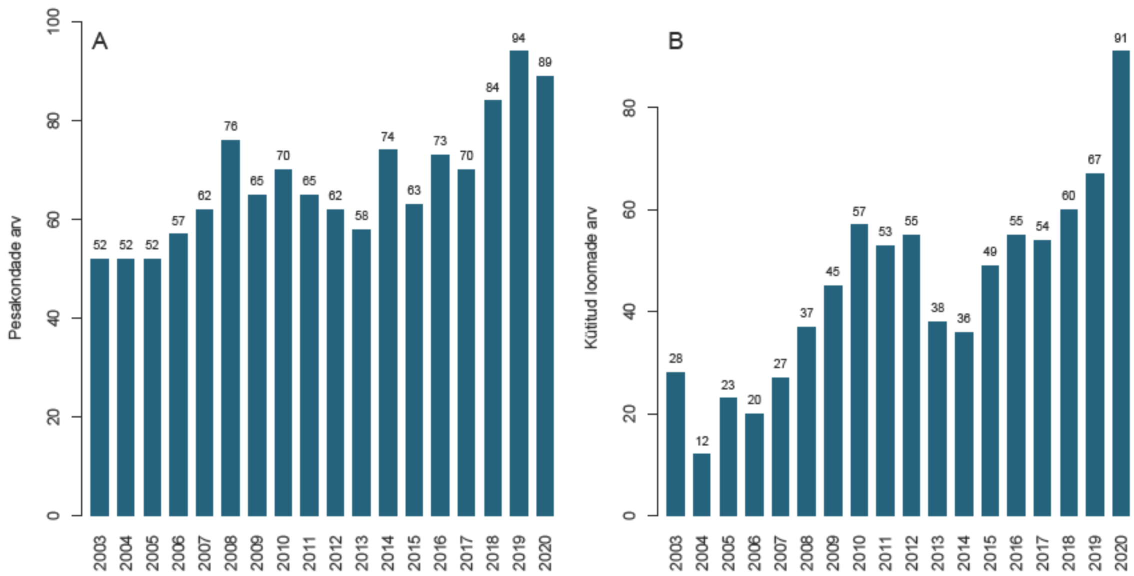
Figure 5. Bear range in Europe (indicated in green and dark gray) according to LCIE estimate in 2016[9]. The EU part of the Baltic population is marked by the red line.

In **Estonia**, the bear is spread over the entire continental area, and the population size is considered to be 900–950 individuals (including old and young animals, in 2020; Veeroja *et al*., 2021). Estonian bears are part of the larger Holarctic brown bear clade and are genetically related (although not very strongly) to Latvian and Russian populations (Korsten *et al.*, 2009; Tammeleht *et al.*, 2010; Keis *et al.*, 2013; Anijalg *et al.*, 2020). The size of the entire Baltic population is estimated at 6,800 individuals (Linnell *et al*., 2008).

In Estonia, the number of bears began to decline from the middle of the 19th century and went through a very strong demographic bottleneck between 1890 and 1940 (Anijalg *et al.*, 2020). In the years of low abundance (the 1920s), the bear population was preserved at 20-30 individuals (Kaal, 1980). Bear protection began in 1934, after which the population started to grow: In the 1950s, about 40 individuals were counted, and in 1980, about 250 individuals. Since 1954, there have been regular hunting statistics with census data, based on which the number of bears shows a continuous upward trend from 1957 until 1990 when the population reached an estimated 800 individuals (Valdmann *et al.*, 2000). Since the 1990s, the abundance of the species has been relatively stable until today. Between 2002 and 2010, the number of bears varied between 500 and 700 (including young and old animals). Currently, bear is

[9] https://www.lcie.org

common in all counties of mainland Estonia, and the number of bears was estimated at 900-950 individuals as of the summer of 2020 (Veeroja *et al.*, 2021). According to official statistics, 91 bears were hunted in 2020 (Figure 6). In addition to them, one specimen was illegally hunted (mistakenly identified as a wild boar), and one specimen was wounded but not caught (EB, KAUR).



A Number of females with cubs of the year

B Number of individuals

Figure 6. The number of brown bear females with cubs-of-the-year (A) and the number of hunted individuals (B) in Estonia in the years 2003–2020 (source: KAUR).

In a recent genetic population study of Estonian brown bears, it was revealed that the Estonian bear population is divided into three genetic clusters, two of which are probably founded by post-bottleneck individuals. Several brown bear contact areas along the Russian border can be identified, and in addition, there is a north-south movement corridor of male animals in the forest area of Central Estonia (Anijalg *et al.*, 2020).

2.3.2 Population structure

In Estonia, based on random observations in 2020, the average number of cubs in a litter was 2.48, while the average for the previous four years (2016–2019) was 2.33 (Veeroja *et al.*, 2020). The change in average litter size has probably been influenced by the improvement in the quality of observations. Thus, radio telemetry studies carried out in Sweden have shown that, based on such studies, the number of cubs in a litter is higher than the number of cubs in a litter determined by random observations (a less scientific method) (2.26 *vs.* 2.02). Litter sizes determined by observations varied (spring observations determine the litter to be larger, winter observations to be smaller), but no such variation occurred using scientific methods (Zedrosser & Swenson, 2005).

Little is known about the age structure of the Estonian bear population because, due to selective hunting, the hunting sample does not reflect it as well as the wolf and lynx. In the 2016-2017 application study of bear age, there are more or less equal numbers of female and male animals in the hunting sample (37 females, 39 males), 36 of them adult specimens (from 3 years of age) and 30 sub-adult specimens aged 1-2 years. Seventeen of the females were fertilized, i.e., this individual would probably have given birth in the upcoming season (this was shown by the embryos found in the animal's uterus and/or the corpora lutea of pregnancy in the ovaries).

2.3.3 Habitat and home range

Plasticity in habitat selection (Luvsamjamba *et al.*, 2016) and nutrition (Vulla *et al.*, 2009; Bojarska & Selva, 2012), and good mobility limit the bear's habitat use during periods of activity significantly less than specialist species (Tammeleht *et al*., 2020). Bears inhabit diverse habitats in Europe that offer a sufficiently good food base and shelter conditions and are also suitable for hibernation (Swenson *et al.*, 2000), and high-quality habitats are characterized on the one hand by productive habitats and low human-caused mortality (Peters *et al.*, 2015). As a result of modeling, it has been found that continental Europe has > 1 million km² of potentially suitable habitat for brown bears, of which 37% is uninhabited, while the most unused habitat is in the range of the Alpine population (58%), the least unused habitat is in the Baltic brown bear population (only 4%; Scharf & Fernández, 2018). In addition to the food base, shelter conditions are also very important, as bears generally avoid the proximity of human activities, such as cities and recreation centers (Nellemann *et al.*, 2007). Hibernating bears also avoid the proximity of major roads (Tammeleht *et al.*, 2020).

In southern Sweden, which is relatively close to our natural conditions, the mean home range size (95% MCP) of bears is 1,055 km² (314–8,264) for adult males, 217 km² (81–999) for adult solitary females and 124 km² for females with cubs under one year of age (46–478). Home ranges are significantly smaller in areas with higher bear population density and in more food-rich habitats (Dahle & Swenson, 2003). In Slovenia, average bear home range sizes have been measured at 350 km², and males have home ranges four times larger than females (Jerina *et al*., 2012). There have been no studies of the bear's home range in Estonia.

2.3.4 Hibernation

From late fall to spring, bears hibernate, which is related to their adaptation to the winter period of food scarcity (Swenson *et al.*, 2000). In Estonia, bears usually hibernate in November and leave their winter dens from March to May of the following year. Adult male bears are the first to abandon winter dens, and female bears with her cubs of the year are the last to abandon them. Female bears give birth to cubs in their winter dens and usually spend the next winter with them. In the southernmost parts of the brown bear's range, bears are active year-round (Swenson *et al*., 2000). The brown bear has definite preferences regarding the hibernation site. Based on the spatial model, the suitable hibernation sites are fairly evenly located on the mainland of Estonia, being the most suitable in Lääne and Ida-Viru Counties and confirming the importance of the ground height of large forest areas when choosing a hibernation site. Based on the spatial model of hibernation sites, it would be possible to better plan the preparation of forest management plans and the protection and management of the bear in order to ensure the sustainability of the Estonian population, taking into account the bear's preferences when choosing a hibernation site. The probability of a brown bear choosing a place for a winter den is significantly higher in areas with a higher proportion of spruce and a somewhat younger stand (Tammeleht *et al.*, 2020).

2.3.5 Reproduction and sociality

The bear is a non-territorial polygamous animal with a solitary lifestyle; one male tries to impregnate several different females in the same season, pairs are formed only for the mating season, and only the female is engaged in raising cubs. The home ranges of individuals of both sexes overlap with the home ranges of other individuals of both sexes (Dahle & Swenson, 2003).

Compared to our other large carnivores, the bear's reproductive potential is low due to its late sexual maturity and longer interbreeding cycles. The bear´s mating season in Estonia usually lasts from the end of May to the beginning of July. Cubs (1-5, usually 2-3) are born mostly in late December or early January, during the mother's hibernation. As a rule, the cubs stay with the mother until the mother's next mating season, when the cubs are about 1.5 years old. So it follows that bears usually give birth every two years. In Sweden, mother bears give birth to their first litter at an average age of 4.4 years, the average time between births is 2.4 years, and the average number of cubs in a litter is 2.4 (Swenson *et al.*, 2000).

The dispersal of juveniles is gender-specific, i.e., philopatric females tend to establish a home range in or near their natal area, and males disperse from their mother's home range (Støen *et al.*, 2006). Permanent bear groups consist of a mother and her cubs up to 1.5 years of age (Dahle & Swenson, 2003). The brown bear exhibits both short- and long-distance dispersal (Støen *et al.*, 2006), and radiotelemetry studies have shown that there is male-based dispersal, in which young males emigrate more frequently and further than young females (Støen *et al.*, 2006; Zedrosser *et al.*, 2007). It has also been found that maternally related individuals with overlapping home ranges can form temporary groups (Støen *et al.*, 2005). Temporary groups are also formed by breeding pairs between the end of May and the beginning of July.

2.3.6 Diet

The brown bear is an opportunistic omnivore, a typical omnivore that consumes a variety of food, including food of anthropogenic origin, throughout its geographic range but prefers the fruits of various plants. The distribution, availability, and quality of food resources affect the bear's reproductive success (Beckmann & Berger, 2003) and several other life course characteristics (McLellan, 2011), bear population density (Naves *et al*., 2006), and human-bear conflicts. Due to the large local differences in bear nutrition, it is difficult to generalize the feeding habits of bears from region to region.

Although the diet of the brown bear has been extensively studied, most studies have been conducted in the northern part of the species' range and in areas with little human impact (see review in Bojarska & Selva, 2012). In Europe, ungulates are particularly important food objects for the bear in spring, and the share of moose in the bear's diet is very important - in a large-scale meta-study looking at the diet of bears, it was found that the bear was the most important predator of moose, causing on average 23% of the natural mortality of moose populations. A very clear north-south pattern was visible in the bear's diet – the proportion of ungulates in the bear's diet increases with cooler average annual temperatures (Niedziałkowska *et al.*, 2019). Despite the large differences in the feeding habits of geographically distant bear populations, it has been found that bears in most populations consume a significant amount of ants (*Formicidae*; Vulla *et al.*, 2009). Ants seasonally account for one-third of the energy content of food in some European populations (Ciucci *et al.*, 2014; Stenset *et al*., 2016, Keis *et al*., 2019).

Supplemental feeding and waste are becoming important in more and more populations. In Slovenia, it has been found that supplementary feed can be the most important food category for bears, accounting for 34% of the annual energy intake from food (maize 22% and carrion

12%; Kavčič *et al.*, 2015). Bears easily get used to artificial food provided by humans and, in connection with that, to people, which is why such animals can easily become problematic or nuisance animals. Among mammals, domestic cattle (*Bos taurus*), roe deer, domestic pig (*Sus domestica*), wild boar, and raccoon dog (*Nyctereutes procyonoides*; Vulla *et al.*, 2009) have been found in the Estonian bear's diet. At least domestic cattle and domestic pigs were the bear's food in the form of waste.

2.3.7 Mortality

In Estonia, the main mortality factor for bears older than one year is hunting. For example, 67 bears were hunted in the 2019 hunting season, and the hunting pressure in 2017-2019 was nearly 8%. In previous years, the hunting pressure has been overestimated due to the insufficient observation data which lead to the underestimation of bear abundance (Veeroja *et al.*,2020). In 2020, 92 bears were hunted, which makes the hunting pressure a little over 10% (Veeroja *et al.*, 2021). In the years 2009–2018, 22 bears killed in traffic were registered in Estonia (Remm & Remm, 2019), and since 2015, four misdemeanor proceedings have been initiated in connection with the illegal hunting of bears on the basis of § 50 of the Hunting Act (hunting without a hunting permit) (EB supervision department). Diseases and parasites are not known to have been the cause of bear death in Estonia, but it must be taken into account that data on natural mortality and mortality of young animals are incomplete.

2.4 The place and relationships of large carnivores in the ecosystem

All large Estonian carnivores are apex predators whose role in the ecosystem has been studied more or less depending on the species (Valdmann *et al.*, 2005; Herfindal *et al.*, 2005; Jędrzejewski *et al.*, 2007; Elmhagen *et al.*, 2010; Kaartinen *et al.*, 2010; Chapron *et al.*, 2014; Ripple *et al.*, 2014; Nowak *et al.*, 2017; Newsome *et al.*, 2017). This chapter gives an overview of the existing or predicted relationships of large carnivores in the ecosystem, taking into account the conditions in Estonia.

2.4.1 Predator-prey relationships

The wolf, lynx, and brown bear are apex predators in the food chain and have no natural enemies. The effects of large carnivores on their prey have been studied extensively. The most important part of the wolf and lynx's diet is ungulates (Jędrzejewski *et al.*, 2002, 2012; Valdmann *et al.*, 2005; Nowak *et al.*, 2011; Mattioli *et al.*, 2011; Zlatanova *et al.*, 2014; Newsome *et al.*, 2016), and the vast majority of studies on the effects of predation also focus on ungulate populations. In Europe, the proportion of ungulates in the bear's diet is significantly lower (Vulla *et al.*, 2009), although bear predation can still account for a significant part of moose calf mortality in northern regions (Ståhlberg *et al.*, 2017). The lynx mainly affects the number of roe deer, but also that of the fox (Elmhagen *et al.*, 2010; Ripple *et al.*, 2014). See also the descriptions of the diet of large carnivores in chapters 2.1.5, 2.2.5, and 2.3.6.

The status of populations of **prey species** is one of the most important factors on which the state of large carnivores depends (Wolf *et al.*, 2016). The most important prey species for the lynx is the roe deer. The wolf's main prey species are roe deer, wild boar, and moose. The bear's main food objects do not include our game mammals, but moose, roe deer, wild boar, and red deer are less important food objects (Vulla *et al.*, 2009; Keis *et al.*, 2019). In order to ensure the preservation of viable populations of both predators and their prey species in the long term, it is extremely important that predators are taken into account when planning the management and conservation of prey species and that prey species are taken into account when making decisions and goals regarding the management and conservation of predator populations (Apollonio *et al.*, 2017). When defining the growth of ungulate populations and the hunting quota in Estonia, on the basis of existing knowledge, natural mortality outside of hunting, of which predation is an important part, has also been taken into account. Estimates of the status of prey animal populations are presented based on KAUR's 2020 annual game monitoring report (Veeroja *et al*., 2020; Table 1).

In 2020, the **roe deer** population was in a very good status considering the needs of large carnivores. During the 2019 hunting season, a total of 31,032 roe deer were hunted in Estonia, which is the largest number of roe deer ever hunted during one hunting season, accounting for more than 36% of all game hunted in the 2019 hunting season. The number of **wild boars** decreased drastically between 2015 and 2018 due to the outbreak of African swine fever (ASF), but it has stabilized and, as of today, has started to rise again (Veeroja *et al*., 2020). **The moose** population is currently rather in a downward trend, and in 2019 the relative population density of moose decreased by 12.5% compared to 2018 (estimate of the change in abundance; Veeroja *et al*., 2020). Decreasing the number of moose has been goal-based and mainly related to the need to limit the forest damage caused by it. The number of **red deer** is high in Saaremaa and Hiiumaa and is gradually increasing in areas bordering Latvia: Pärnu, Viljandi, and Valga counties, as well as in other counties (Veeroja *et al*., 2020).

Table 1. The abundance of the most important prey species (ungulates) of large Estonian carnivores, according to KAUR.

Species	Population estimate in Estonia, 2020	Population change, 2015–2020
Wild boar	7,000-8,500 individuals	Falling at first, then rising
Moose	*approx.* 11,000 individuals	Falling at first, then stable
Roe deer	130,000-140,000 individuals	Rising at first, then stable
Red deer	*approx.* 8,200 individuals (75% in Saaremaa and Hiiumaa)	Stable, fluctuating

Apart from ungulates, the prey of large carnivores quite often includes beaver, hare, fox, raccoon dog, and other medium-sized and small game. The abundance trends of these species are relatively stable for most species, but there are also species showing strong fluctuations (e.g., small mammals). In contrast to the largest mammals, estimates of the abundance of species with smaller body sizes are much more incomplete.

Regulation of the population of medium-sized predators. The ecological relationships between large carnivores and smaller carnivores are complex, ranging from mutual promotion to direct suppression (including intra-guild predation). *Top-down* regulation of medium-sized predators by large carnivores can take place both as direct killing and in non-lethal ways: competition for the same resources or indirectly by influencing behavior and habitat selection. This, in turn, can slow down the growth of medium-sized predators (Ripple *et al.,* 2013; Prugh & Sivy, 2020).

Analyzing data from North America, Europe, and Australia, it has been found that the impact of apex predators on medium-sized predators increases from the low-abundance fringe areas of top-predator habitats to the high-abundance core areas (Newsome *et al*., 2017). The continued global decline in the range of apex predators may thus promote the increase of medium-sized carnivore populations, change the structure of the ecosystem and contribute to the loss of biodiversity. Another factor that can limit the suppressive effect of apex predators on medium-sized carnivores is human activity, which often changes the social structure and stability of apex carnivore populations (Wallach *et al.*, 2009). Such factors suppress the top-down population control and lead to a change in the ecological status as a bottom-up regulatory system. As a result, the number of medium-sized predators increases (Newsome *et al.*, 2017). For example, it has been suggested that the expansion of the jackal's range into Europe has been triggered by strong hunting pressure on the wolf and regional extermination of the wolf (Krofel *et al.*, 2017a).

In Scandinavia, intra-guild predation, in which large predators prey on smaller carnivores or other large carnivores but do not eat them, is generally low. For example, in Finland, a recent study estimated the chance of wolves dying from intra-guild predation at 1% (Suutarinen & Kojola, 2017). Presumably, the relationships between fox, lynx, and wolf (diet, behavior) are more complex than they appear on a large scale if only data related to the presence of predators are used (Wikenros *et al.*, 2017). The effect of wolf and lynx predation on raccoon dogs has been indirectly studied in Poland, where 27% of the mortality of raccoon dogs was caused by predation, of which 7% (i.e., *approx.* 2% in total) was caused by wolves (Kowalczyk *et al.*, 2009). Based on several observations made in Estonia, it can be assumed that, at least locally, the wolf can significantly reduce the number of raccoon dogs, thereby promoting the growth of many species affected by raccoon dogs. Lower numbers of foxes and raccoon dogs also reduce the spread of canine infectious viral diseases such as rabies, canine distemper virus, and canine parvovirus, and parasitosis such as sarcoptic mange (see also chapter 2.4.3). The lower number of foxes and raccoon dogs also has a favorable effect on protected ground-nesting bird species, for which predation pressure is very high based on current research (Kaasiku & Rannap, 2019).

Large carnivores can also have a favorable effect on the abundance of medium-sized carnivores because often, the carcasses of wolf and lynx prey are an additional resource for several other species. In the course of the lynx studies in Estonia, it has been observed that the roe deer killed by lynx are eaten by wolves, wild boars, foxes, raccoon dogs, pine martens (*Martes martes*), and various birds. Pray animals killed by wolves and lynx can be a vital alternative food for many species during severe winters when the availability of staple food (such as small rodents) is difficult due to deep snow.

2.4.2 Keystone species

Large carnivores are a very important part of Earth's ecosystems. In addition to being species important from the point of view of ecological diversity, they are also very important influencers of food chains, being able to influence both the number of herbivorous species and medium-sized predators and their behavior (Dalerum, 2013).

Large carnivores significantly affect the abundance of their prey species (mainly game ungulates) and, through this, also directly affect the damage of moose and roe deer to forest management. In the case of moose, however, the main population regulator is generally hunting, less so the wolf. The wolf can become an important regulator of the moose population when wolf packs are allowed to achieve a natural ecological structure, and the number of individuals in the pack is sufficient to kill the moose.

In addition to hunters, the lynx and the wolf, as well as the weather, are also important as a limiter of the growth of the roe deer. For example, the winters of 2010 and 2011 were exceptionally snowy, due to which our roe deer population decreased significantly (Veeroja *et* *al*., 2020). Damage to forest plantations caused by roe deer increases during the periods of its high abundance, and between 2014 and 2019, both the number of forest expertise related to roe deer damage and the gradual increase in the size of the damaged area were clearly visible (Veeroja *et al.,* 2020). Wolf and lynx predation significantly affects the growth rate of the roe deer and, as a result, reduces the amount of forest damage during periods of increase in its population.

Hunting has been the main regulator of the number of wild boars, and only the wolf has been locally important at certain times among large carnivores. At the same time, the interest of hunters has been to keep the number of wild boars and their growth rate permanently high. In the last five years, the most important determinant of the number of wild boars has been African swine fever - a viral disease with a very high mortality rate, which spread to Estonia via Latvia from Belarus in 2014.

Based on the observations made in Estonia, both wolves and lynxes can be important as a regulator of beaver abundance and as a reducer of damage caused by it. This effect certainly increases during periods when the main prey species (especially roe deer and wild boar) are in decline, and the predators have a need for alternative prey species.

2.4.3 Infections

All large carnivores carry and spread parasites and other infections that are dangerous for the large carnivores themselves, other species in the ecosystem, and humans.

Sarcoptic mange. Currently, the only parasite that can affect the increase of the wolf population is the sarcoptic mange mite (*Sarcoptes scabiei*), which has been widespread in the Estonian wolf population in recent years. If in 2017 sarcoptic mange was found in half of the wolf packs, in 2019, the frequency in Estonia had dropped to 30%. The main carriers of sarcoptic mange are foxes and raccoon dogs, whose significant increase in numbers coincides with the vaccination of wild animals against rabies (Süld *et al.*, 2014). A sharp increase in the number of foxes and raccoon dogs after rabies vaccination of wild animals has been observed in many European regions (Goszczyñski *et al*., 2008; Bombik *et al*., 2014). Sarcoptic mange does not itself cause the death of the host, but it weakens the organism and thereby create the conditions for other infections. The direct cause of death of an infected individual is a large loss of energy, lack of food, hypothermia, or sepsis, due to which the organs stop working. Sarcoptic mange has also been spreading among wolves in Latvia since the 1990s, and the spread of sarcoptic mange has increased since then (Ozoliņš *et al.*, 2017b).

A rather serious spread of sarcoptic mange in the wolf population has also recently been described in Scandinavia, where 10% of 145 wolves were found to be seropositive (Fuchs *et al.*, 2016). In the Iberian wolf (n = 88), 20% of sarcoptic mange seropositivity occurred (Oleaga *et al.*, 2015). In Estonia, in 2019, compared to the previous year, the spread of sarcoptic mange in the wolf population increased again, and infected individuals have been hunted or killed in approx. 22% of wolves and 31% of packs, but the spread of this disease has not visibly affected the breeding success of wolves so far. It can be concluded from this that, unlike the fox and the raccoon dog, as well as the lynx, it is not important as a mortality factor for the wolf (Veeroja *et al*., 2020).

Sarcoptic mange has been prevalent in the Estonian lynx population for about ten years - the first two infected animals were discovered in 2010, and four more in 2011 (Jõgisalu & Männil, 2011). Since lynxes are animals with a solitary lifestyle, they usually get the aforementioned infectious diseases from foxes or raccoon dogs, not from fellow species. Thus, an increase in the spread of sarcoptic mange occurs due to intra-guild predation (wolves and lynxes kill raccoons and foxes). In Białowieża, Poland, however, it has been found that due to the solitary way of life, infectious diseases do not spread as widely in the lynx population as in animals with a more social way of life (including many dogs; Kołodziej-Sobocinska *et al*., 2014).

Rabies. A significant threat to wolf populations is dogs, which can be carriers of various pathogens and spread diseases. Examples include canine parvovirus, rabies, and canine distemper virus, which can be dangerous to both wildlife and humans (Knobel *et al.*, 2014). In Europe, rabies, a viral disease that was contagious to all mammals, including humans, and fatal to the host, was previously widely spread and was mainly transmitted by foxes (Müller & Freuling, 2018). Despite the fact that rabies has been eliminated in most European countries over four decades thanks to successful oral vaccination of wild animals, the risk of rabies in Estonia has not disappeared because the disease is spreading in Eastern Europe and Russia (Baker *et al.*, 2019). In Estonia, rabies vaccination of wild game was started in 2005, and in recent years only a few cases of rabies in wild animals have been discovered near the eastern border of the country. Since 2013, Estonia has been officially a rabies-free country. At the same time, the risk of a resurgence of rabies remains high in Estonia, as the disease continues to be widespread in Russia (Shulpin *et al.*, 2018).

Canine distemper virus, a virus that is highly contagious and causes disease with very serious consequences for infected animals (harmful to the respiratory, digestive, and nervous systems; Martella *et al*., 2008), is common in dogs and wolves in many European countries, and in Portugal, the disease has been considered a potential threat to the local wolf population (Conceição-Neto *et al.*, 2017). This virus can significantly damage the wolf population, being especially dangerous for pups and young animals. For example, in Yellowstone National Park, USA, there were large-scale canine distemper outbreaks in 1999, 2005, and 2008, during which the survival of pups in local wolf packs dropped to 13%, and the entire population decreased by 30% (Almberg *et al*., 2010).

Parvovirus is another dangerous virus for dogs that is highly contagious, and its presence has been detected in European wolves, mainly in southern Europe - Spain, Portugal, and Italy (Miranda *et al.*, 2017; Oleaga *et al.*, 2018).

Parasitic worms. A total of 13 species of helminths have been found in wolves in Estonia, including the life-threatening echinococcus tapeworm (*Echinococcus granulosus*; Moks *et al.*, 2006). A total of 7 helminth species have been found in lynxes in Estonia (Valdmann *et al*., 2004b) and 6 in Latvia (Bagrade *et al.*, 2003). In Estonia, two species of intestinal helminths have been found in bears (E. Moks & I. Jõgisalu, unpublished data); no helminths were found in 50 bears examined in Sweden and 12 bears in Poland (Mörner *et al.*, 2005; Borecka *et al*., 2013). Trichinella from the genus *Trichinella* has also been found in lynx and bears in Estonia (lynx infection 58–69%; Malakauskas *et al.*, 2007; Pozio *et al.*, 1998).

Leishmaniasis. A newer disease, the spread of which in Europe can be mentioned, is leishmaniasis, whose main host is the domestic dog. For example, in a study conducted in Spain (2008–2012), leishmaniasis was found in 33% of the 102 wolves tested (Oleaga *et al.*, 2018).

2.5 The research on large carnivores in Estonia in the last decade

2.5.1 Research

In the years 2012–2020, basic research has been carried out mainly in (1) brown bear genetics, including population structure, demographic processes, and phylogeography (Keis *et al.*, 2013; Anijalg *et al*., 2018; 2020) and (2) habitat use (Tammeleht *et al*., 2020) and (3) nutrition (Keis *et al*., 2019) and (4) wolf genetics, including genetic diversity, population structure and hybridization with dogs (Hindrikson *et al.*, 2012; 2013; 2017; Plumer *et al.*, 2016). A methodology has been developed for determining the type of predator species in case of killing sheep (Plumer *et al.*, 2018). A complete overview of publications related to large carnivores prepared with the participation of the University of Tartu can be found on the page of the Chair of Teriology at the University of Tartu[10]. In addition to these, data collected from Estonia have been used in other international basic scientific studies and analyses. Among them are reviews of changes in the abundance and range of large carnivores in Europe (Chapron *et al*., 2014), problems related to wolf-dog crosses in Europe (Salvatori *et al*., 2020, Donfrancesco *et al*., 2019), large carnivore and bear damage (Bautista *et al.*., 2019, 2017), the predation of sheep by large predators (Gervasi *et al*., 2021), bear attacks on humans (Bombieri *et al*., 2019) and the status and genetic structure of the Baltic lynx population (Ratkiewicz *et al*., 2012; 2014; Schmidt *et al*., 2021).

Applied research on large carnivores is largely organized by EB and KAUR. Basic research has also been financed by the Estonian Research Foundation and the Estonian Research Council. The following is an overview of the main large carnivore monitoring and applied research conducted in Estonia in the years 2012–2021. They can also be found on the KAUR website[11] and summarized below in this document. Applied research has mainly been carried out in three major areas: (1) wolf and lynx habitat, territoriality, and diet (2011–2017 for lynx and 2013–2020 for wolf), (2) damage by large carnivores, including the share of wolves in killing sheep and zoning the landscape into wolf conservation and management areas, and (3) demography, including various genetic studies that reflect both the population structure of the wolf and the age structure of the hunted large carnivores.

<u>Basic and applied research completed in the years 2012–2021</u>

Habitat, diet

- Wolf habitat use and diet (2013–2020)
- Lynx territoriality and diet (2011–2017)

Damages

Sheep depredation

- Improving large carnivore damage assessment results using predator DNA test (2016)
- The role of wolves and dogs in sheep depredation in Estonia - development, and implementation of a suitable methodology for predator species identification (2013)

Management areas

- Feasibility and possibilities of establishing large carnivore management areas (2014)
- Zoning of the landscape into areas with different wolf management intensity (2013)

Demographic studies

- The use of genetic methods in demographic studies of the Estonian wolf population (2012–2015)
- Ages of large carnivores hunted in 2011 and 2012
- Ages of hunted wolf and bear (2016-2017)
- A genetic study of wolf population size (2020)

<u>In the years 2012–2021, two doctoral theses have been defended on the topic of large carnivores</u>

[10] https://www.zooloogija.ut.ee/et/oppetoolid/terioologia-oppetooli-publikationiand
[11] https://www.keskkonnaagentuur.ee/et/suurkiskjad

- 2013 Marju Keis, *Brown bear (Ursus arctos) phylogeography in northern Eurasia*, University of Tartu;
- 2016 Maris Hindrikson, *Gray wolf (Canis lupus) populations in Europe with an emphasis on Estonia and Latvia: genetic diversity, population structure and -processes, and hybridization between wolves and dogs*, University of Tartu.

In addition, one doctoral thesis has been defended on the topic of parasites of large carnivores:

- In 2016, Leidi Laurimäe, *Echinococcus multilocularis and other zoonotic parasites in Estonian canids*, University of Tartu.

2.5.2 Monitoring

Current monitoring of large carnivores is mostly based on information collected by hunters. Monitoring activities are coordinated, and information is gathered by KAUR, and KAUR also performs data analysis and reporting. If necessary, additional studies are performed or commissioned by a third party. Due to Estonian legislation, the user of the hunting area is obliged to monitor the game within their hunting area every year.

The following information is presented in KAUR's annual monitoring reports: (1) a description of the status of the game population; (2) a change in the status of the game population; (3) a prognosis of the status of the game population and risk factors; (4) recommended hunting quota and structure of the game species. The key parameters monitored are the spread of the breeding population of the species, the trend in abundance, the number of reproductions, the size of the lynx and bear litters, the demographic structure and growth rates of the population, the extent and spread of damage and the spread of infections (especially sarcoptic mange). From the number of reproductions distinguished during the analysis of monitoring data, the population's autumn, i.e., after the breeding season, general population, and, if necessary, spring, i.e., after the hunting season, are derived. The monitoring methodology has followed European, especially Fennoscandian, practice and experience of large carnivore monitoring. The tools of the JAHIS information system developed by the Estonian Hunters' Society (EHS) are widely used to transmit the information collected by hunters (including trail observations, individual and litter observations, photos, etc.) to KAUR, but other channels can also be used (including paper letters, e-mail). When presenting the numerical indicators of the populations, the confidence limits of the determinations have not yet been specified.

A detailed description of the large carnivore monitoring methodology in use is presented in Annex 2.

3 Human-carnivore relations

The relationship between large carnivores and humans has been full of contradictions throughout history, as it is today. It is difficult to find a balance between wolves and livestock in today's changing and increasingly human-influenced landscapes, and the wolf is also a competitor for hunters in terms of ungulates. The bear causes the most problems in beekeeping. In the case of the lynx, direct conflict situations are probably the rarest, but in the case of low numbers of roe deer, competition with hunters and related consequences can emerge. All large carnivores are important game species, as well as valuable objects of nature tourism. All three species of large carnivores have a significant place in culture and folklore.

3.1 A place in culture

Large carnivores have played an important part in folklore; they have also been cult animals. Teddy bears have played an important role in the development of many children. At the same time, large carnivores have been food competitors for hunters, depredated farmers' livestock, and also attacked people themselves (very rarely nowadays), which is why people have been hunting them for centuries and tried to destroy them with all possible means. Only in recent decades, mainly as a result of scientific research, have large carnivores begun to be appreciated as an important component of the ecosystem, as well as to be valued as objects of nature tourism and hunting tourism. In perspective, large carnivores are predominantly seen not only as a natural resource and as symbols of protected landscapes but rather as a real part of our everyday landscapes alongside daily human activities.

In 2018, the wolf was chosen as Estonia's national animal with the participation and support of 26 organizations[12]. With this initiative, attention was drawn to the importance of the wolf in nature and to its role as an indicator of a complete ecosystem. The place of the wolf in Estonian culture and science is also valued and promoted.

3.2 Hunting

Hunting, including both legal and illegal hunting, along with habitat destruction, has been one of the most important reasons for the disappearance of large carnivores from all over Europe. (Chapron *et al.*, 2014; Hindrikson *et al.*, 2017; Kuijper *et al.*, 2019). To date, the former total hunting, which does not take into account the structure and status of the populations, is being replaced by scientifically justified, more sustainable hunting. The goal is to preserve viable populations and expand the distribution of species.

The skins and skulls of wolf, lynxes and bears as hunting trophies are included in the list of hunting trophies valued internationally (CIC - International Council for Game and Wildlife Conservation). A hunting trophy or the income from its sale is an important motivator for hunting large carnivores, in addition to the need to regulate numbers.

Predation is the most important mortality factor for all three large carnivore species. Hunting pressure is the ratio of the number of individuals hunting to the total number of the population, expressed as a percentage. In Estonia, the legal hunting pressure in the years 2016–2020 has been 26–47% for the wolf and about 7–10% for the bear, and the lynx has not been legally hunted in those years (KAUR). Lynx hunting pressure in Latvia is estimated at 20–29% (Bagrade *et al.*, 2016), and wolf hunting pressure at an average of 37.2% (Šuba *et al.*,2021). In Finland, wolf hunting pressure is 4–21% (Suutarinen & Kojola, 2017).

3.3 Nature tourism

Large carnivores are important objects of nature tourism in the increasingly modernizing and urbanizing European landscapes due to their charismatic nature yet hidden way of life. The most frequent tourist object is probably the brown bear, which is attracted to observation sites with artificial bait and other lures, for example, in Croatia, Slovenia, and Finland (Penteriani *et al.*, 2017), as well as in Estonia. On the other hand, out of the three large carnivore species in Estonia, the lynx is probably the most attractive to tourists.

In Estonia, the branch of tourism related to large carnivores has started to develop more vigorously only in the last decade, and its potential has been assessed as very high (Sepp, 2017). The wolf and the lynx can be exhibited to tourists mainly by observing their actions, the wolf also by listening to the response howling induced by nearby wolves by imitating howling. In the case of bears, it is common to observe baited specimens. In Estonia, about a dozen bear-watching huts for tourists have been built.

Nature tourism and its practice also bring with it considerable income, which can exceed many times the profit from hunting. In Western Europe, for example, it has been estimated that tourists visiting the Harz Mountains, largely because of the lynx residing there, bring in an

[12] https://et.wikipedia.org/wiki/Eesti_rahvusloom

estimated £8-13 million per year for the German state[13]. In the Canadian province of British Columbia, it has been estimated that the income from bear watching exceeds the income from hunting by 11 to 12 times[14].

Large carnivore nature tourism has a positive effect on raising human awareness of large carnivores and is also an alternative to hunting tourism. At the same time, nature tourism is associated with possible problems and dangers, such as the bear getting used to additional feed (Kojola & Heikkinen, 2012) and disturbances during the breeding period of wolves and lynx, which must be taken into account in the development and regulation of this economic sector of nature tourism. In order to bring out more positive effects of nature tourism in Estonia, it is important and necessary to train nature guides more in order to avoid possible dangers and problems and to prepare corresponding instructional materials.

3.4 Damages

Conflicts between humans and large carnivores lead to conflicts in carnivore conservation worldwide. At the heart of this conflict is mainly the depredation of livestock by large carnivores, which leads to persecution by humans and even poaching as a response. The main losses associated with large carnivores can be divided into two: (1) the killing of domestic animals, including both livestock and dogs, by wolves, and (2) the killing of domestic animals and ravaging of beehives by bears. In Europe, damages caused by large carnivores are compensated in the amount of around 28.5 million euros per year. Between 2005 and 2012, the average annual cost per individual in the population in Europe was 2,400 euros for wolves, 700 euros for lynxes, and 1,800 euros for bears (Bautista *et al.*, 2017; 2019). At the same time, the corresponding values in Estonia were 595 euros for the wolf, 4 euros for the lynx, and 27 euros for the bear per individual of the population. In relation to damage, however, it should be kept in mind that large predators generally prefer natural prey. In a diet study of 119 wolves in 27 countries, Janeiro-Otero et al. (2020) found that even when livestock is abundant, wolves choose wild animals 65% of the time. A pan-European study (Gervasi *et al*., 2021) found a positive correlation between the abundance of wolves and sheep killed (compensated) by wolves.

In Europe, approximately 3,200 claims for bear damage are made every year, of which 59% are related to killing livestock, 21% to ravaging apiaries, and 17% to agricultural depredations. Most claims are made in Mediterranean countries and Eastern European countries. Estonia is one of the countries with the smallest amount of damage claims, with 0.1 damage cases per bear per year, whereas the largest is Norway (8.5; Bautista *et al.*, 2017).

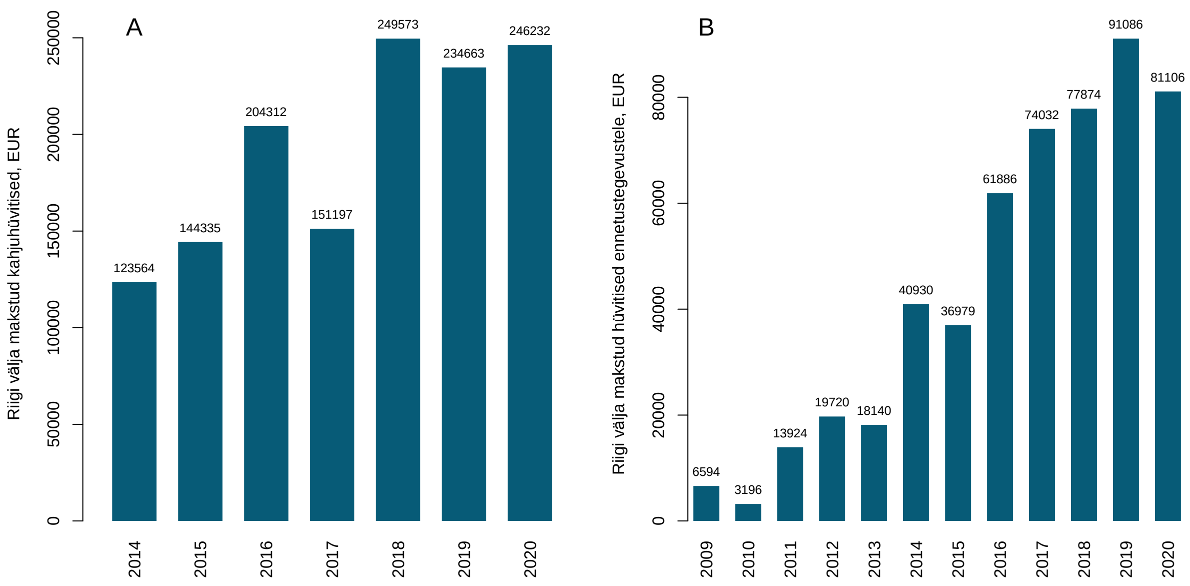
In 2007, Estonia started compensating for the damages caused by large carnivores and subsidizing the costs incurred for damage prevention. In general, in the case of large carnivore damage, it is recommended to support damage prevention measures and compensate for damage only if the owner has taken measures to protect their herd. In the absence of sufficient motivation to implement damage prevention measures, damage compensation is not sustainable either economically or from the point of view of the conservation of large carnivores (Gervasi *et al*., 2021). In 2019, the Environmental Board (EB) received 364 applications from 270 sufferers for compensation for damages caused by large carnivores, and EB compensated the damages caused by large carnivores in a total amount of 234,663 euros.

[13] https://www.northumberlandnationalpark.org.uk/wp-content/uploads/2018/04/Lynx-harz-mountains-AECOM.pdf

[14] https://www.responsibletravel.org/wp-content/uploads/sites/213/2021/03/economic-impact-bear-viewing-bear-hunting-gbr-bc.pdf

In 2020, the corresponding values were 458 requests from 325 claimants, on the basis of which a total of 246,232 euros were paid out (T. Talvi, EB; Figure 7A).

Preventive measures to prevent carnivor damage have greatly increased in the last decade. If in 2009, the state made payments to support prevention activities in the amount of 6,594 euros, in 2019 in the amount of 91,086 euros, and in 2020 in the amount of 81,106 euros (Figure 7B). However, it is worth noting that the cost compensations paid out by the state for preventive activities have been several times smaller than the damage compensations. Even considering that the state reimburses up to 50% of the costs of preventive measures (see also chapter 4.1.3), the total cost of preventive activities, including the animal breeder's own contribution and the state's compensation/subsidy, is expected to have been lower than the compensation payments. Thus, the compensation and prevention of damages by large carnivores are out of desirable proportion.



A Compensation for damages paid by the state, EUR

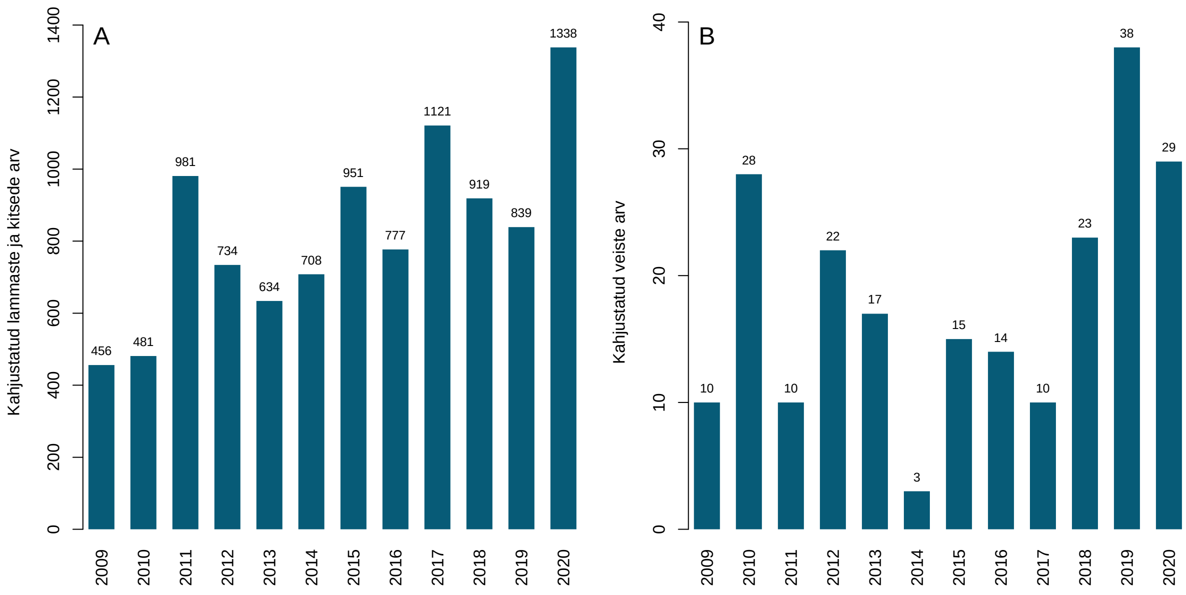
B Subsidies paid by the state for prevention activities, EUR

Figure 7. Compensations for damages caused by large carnivores in 2014–2020 (A) and compensations paid out by the state in Estonia in 2009–2020 to cover the costs of activities to prevent damages caused by large predators (B; source: T. Talvi, EB).

3.4.1 Livestock

At the moment, probably more than 90,000 sheep are kept in Estonia (ARIB). The wolf kills about 0.6–1.1% of them per year. In 2020, according to the data reported to EB, wolves killed or injured 1,338 sheep and goats (in 2019, respectively, 839 animals, according to the consolidated data of T. Talvi; Figure 8A). Almost half of the sheep were killed by wolves in Harju, Rapla, and Järva counties in 2020. Almost 30% of the killings occurred at sheep breeders, whose preventive measures have been assessed as insufficient. In addition to sheep, wolves also damage beef cattle (in 2020, according to EB, 29 pcs.; Figure 8B) and kill dogs (see chapter 3.4.3).

Damage caused by lynx is marginal due to the low population, and there are also very few bear attacks on livestock. However, there is a possibility that livestock may fall prey to all large carnivores as incidental prey.



A Number of sheep and goats damaged

B Number of cattle damaged

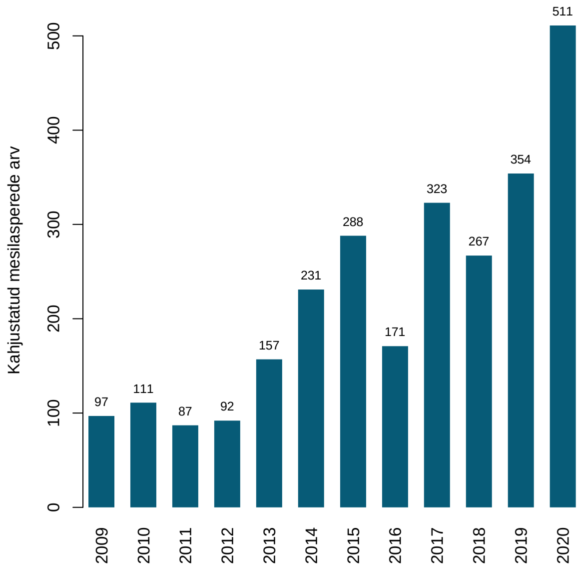
Figure 8. The number of sheep and goats damaged by registered large carnivores (A) and the number of cattle damaged (B) in Estonia in 2009–2020 (source: T. Talvi, EB).

In recent years, golden jackals, which have recently spread here, have also killed livestock in Estonia. The jackal is not considered a large carnivore, and the species is not protected in the European Union in the same way as large carnivores. Therefore, the damages caused by the jackal have not yet been compensated by the state. This, in turn, can lead to cases where the damage caused by a jackal is tried to be shown as caused by a wolf or even a lynx. Unfortunately, such cases can lead to an unjustified loss of reputation for large carnivores.

In addition to large predators (predominantly wolves), sheep can also be killed by dogs. In the years 2008–2015, saliva samples were collected from the wool of 183 predated sheep across Estonia, and predator DNA was isolated from it (Plumer *et al.*, 2018). Out of 143 samples with a positive result, 116 turned out to be killed by wolves (81%) and, in 21 cases, killed by dogs (15%). The attacks took place all over Estonia. Damage caused by dogs must be covered by the owner of the dog, but it is usually very difficult to prove it. So, similarly to the jackal, damage by dogs to livestock may be tried to be shown to be caused by large carnivores, which in turn complicates the organization of objective conservation and management of large carnivores.

3.4.2 Apiaries

The damage caused by bears in Estonia has been mainly related to the depredation of apiaries. In 2020, as far as it is known to EB, brown bears damaged 511 beehives in 179 apiaries on 221 occasions (in 2019, 193 occasions and 354 beehives in 163 apiaries; Figure 9). The average number of honeybee colonies registered as damaged by the bear in recent years is about 300. In addition, the bears damaged more than 230 bales of silage. The number of registered damages caused by bears has increased in recent years, but it must be taken into account that the awareness of the possibility of reporting damages and receiving compensation has also increased. This, in turn, may have increased the activity of damage reporting.



Number of damaged beehives

Figure 9. The number of registered beehives damaged by brown bears in Estonia in 2009–2020 (source: T. Talvi, EB)

3.4.3 Dogs

Depredation of dogs (predominantly by wolves) occurs rather rarely, although, between 2011 and 2020, wolves are known to have injured or killed a total of 152 dogs (including 21 dogs in 2019 and 30 dogs in 2020). The vast majority of them were house dogs, and the share of hunting dogs was less than 10%. In Finland, however, the proportion of hunting dogs killed by wolves is over 60% of all killed dogs (Kojola *et al.*, under review). In the same study, it was found that the killing frequency of dogs (both in Finland and Estonia) was higher when there was a lower abundance of natural prey and vice versa. The killing of hunting dogs has been considered one of the reasons that can promote the development of irrational "wolf hatred" in the hunters' commune and the unwanted consequences that come with it.

3.4.4 Nuisance specimens and repeated damage

Among the large carnivores, there may be nuisance specimens (problem specimens) that have successfully killed livestock or domestic animals and learned to repeat this behavior. As a result, these individuals kill livestock or domestic animals significantly more often than average and cause repeated damage in the same area. In terms of calculation, repeated damage is considered to be situations where similar damage cases occur at least three times within a one-month period within a distance of about 10 km.

In most cases, bears are identified as nuisance specimens, as bee damage is often concentrated in isolated, limited areas. There have been no convincing direct observations of repeated damages in Estonia (e.g., based on DNA) to identify specimens. Thus, the definition of problem specimen has been more of an estimate. Repeated damage can also be caused by wolves, by lynxes probably very rarely. In the case of the repeated killing of livestock, where measures to protect the herd are absent or permanently deficient, the definition of predators as nuisance specimen is not justified.

3.4.5 Attacks on humans

Attacks by large carnivores on humans can today only be talked about in the case of bears. Wolf attacks in Estonia have remained in the distant past, and lynx attacks on humans are not known. Attacks by large carnivores directed at humans are the most dramatic form of human-wildlife conflicts (Støen *et al.*, 2018). Although such cases are rare compared to other animal attacks (including other wild animals and domestic animals), such cases have increased in many parts of the world (Bombieri *et al.*, 2019). This is not only a threat to human lives but also indirectly complicates efforts to conserve large carnivores and restore several species worldwide.

Of the 291 bear attacks in Europe between 2000 and 2015 in which a human was injured or killed, the most occurred in Romania (131), Slovakia (54), Sweden (28), and Finland (17). There were two attacks in Estonia and 111 in Russia (Bombieri *et al.*, 2019). From 2002 to 2020, 34 wolf attacks on humans are known in Europe, 4 of them in Poland, 1 in Croatia, 1 in North Macedonia, 2 in Kosovo, 1 in Italy, 7 in the European part of Russia, 14 in Ukraine, 3 in Belarus and 1 in Moldova (Linnell *et al*., 2021).

Most of the attacks in Russia, Ukraine, Belarus, and Moldova were caused by rabid wolves.

The attacks on humans by two wolves in Poland have been analyzed in more detail. They were yearling wolves (a 13-month-old male and a 14-month-old female) that had lived near the households for several months before the attacks. Both wolves attacked people twice, causing minor injuries to a total of three women and two children. After the attacks, the wolves were shot. Both specimens had been fed by humans and increasingly expressed a loss of human shyness caused by irresponsible human behavior such as deliberate long-term feeding or illegal keeping (Nowak *et al*., 2021a).

In Estonia, it is possible to reduce these dangers by educating and informing people that if they behave incorrectly when meeting large predators, by making food available to large carnivores, or by illegally removing them from the wild and keeping them, the likelihood of attacks can also increase significantly. To this end, a number of behavioral guidelines have been drawn up so far to prevent attacks; for example, in the case of bears, the relevant guidelines can be found on the website of the Estonian Hunters' Society[15].

3.5 Hand-reared large carnivores

Historically, the hand-rearing of both wolves and bears has been widespread. Wolves who were accustomed to humans and hybrids of wolves and dogs were used, for example, in hunting. Nowadays, both hand-rearing large carnivores and artificial cross-breeding are generally prohibited. On the other hand, in connection with the development of animal protection, game rehabilitation has become more widespread, where animals are kept in special rehabilitation centers in order to treat injuries or raise motherless young animals and are later released into

[15] https://www.ejs.ee/10-soovitust-mida-teha-kui-metsas-karuga-kokku-juhtud/.

the wild. Most often, bear cubs abandoned by their mother as a result of human disturbance of the winter den are treated in this way.

Rehabilitation of bear cubs took place in Estonia between 1998 and 2010, when about 40 bear cubs were raised - most of them in the Nigula wildlife rehabilitation shelter - and released into the wild. In the case of bear rehabilitation, there is a great risk that bears released into the wild in Estonia will become accustomed to humans and become problematic, seeing humans primarily as feeders, not as a source of danger.

4 Conservation status, analysis of conservation effectiveness to date, and conservation and management practices

The legal status of the conservation, management, and use of large carnivores and damage management in Estonia is determined on the basis of the Hunting Act[16] and the Nature Conservation Act[17]. Guidelines are also set by several European Union legislation (including the Nature Directive) and international agreements to which Estonia has joined.

4.1 Estonian legislation and current practice

4.1.1 Legislation

According to the Hunting Act, wolves, lynxes, and brown bears are big game animals, hunting each of which requires a separate permit (they are not among the protected species in Estonia). The user of the hunting area is obliged to notify EB within 24 hours of the hunting of any large carnivore specimen or of any specimen found dead. According to the directives of the Environmental Board determining hunting limits for large carnivores, the hunted specimen must be reported immediately. The terms and conditions for hunting large carnivores are determined by the Hunting Regulations[18]. The following are the times and conditions for hunting large carnivores, the use of permitted hunting methods, and hunting with a hunting dog.

- The following types of **wolf** hunting are allowed: calling hunt, hunting from hides, stalking, driven hunt, and hunting using boundary flags and hunting dogs from November 1 until the end of the hunting year (i.e., until the end of February).
- The following types of **lynx** hunting are allowed, with the exception of female lynx with cubs: calling hunt, hunting from hides, stalking, driven hunt, and hunting with a hunting dog from December 1 until the end of the hunting year (i.e., until the end of February).
- The following types of **brown bear** hunting are allowed, except for a female bear with cubs: hunting from the hides or stalking from August 1 to October 31 in the area of damage caused by the bear for the purpose of preventing damage. In addition to the aforementioned condition, the Hunting Act stipulates that when hunting a brown bear with a rifle, the caliber of the rifle must be at least 6.5 mm, and the weight of the bullet used in the cartridge must be at least 9.0 g.

In the case of illegal hunting of large carnivores, the rates of damage to the environment are stipulated by the Government of the Republic Regulation "Basis and rates of damage for calculating the damage caused to the environment by the illegal killing of wild game or the destruction or damage to the habitat of wild game"[19] currently: wolf 1,000 euros, lynx 1,000 euros and bear 2,000 euros. In the event of the death of a pregnant specimen, the compensation rate is tripled.

According to the Nature Conservation Act, the bear's hibernation site and its surroundings within 300 m are permanent habitats. Within this area, activities related to hunting and forest management and use are prohibited until April 15, following the hibernating period.

[16] https://www.riigiteataja.ee/akt/117112021010
[17] https://www.riigiteataja.ee/akt/116062021003
[18] https://www.riigiteataja.ee/akt/120122019030
[19] https://www.riigiteataja.ee/akt/129052013010

In case of damage and for research purposes, EB has the right to allow hunting outside hunting season. Damages caused by large carnivores and expenses for damage prevention are (partially) compensated by the state in accordance with the Nature Conservation Act and the regulation of the Minister of the Environment: "Methodology for assessing the damage caused by an animal, the specified scope and procedure for compensation for damage, and the specified scope and procedure for compensating expenses incurred for damage prevention measures."

According to the International Union for Conservation of Nature (IUCN), the wolf, lynx, and brown bear are species in a favorable status (Least Concern), and according to the Estonian Red List, the wolf and lynx are "Vulnerable," and the brown bear is in a status of "Least Concern."

4.1.2 Organization of conservation and management

Once a year, KAUR prepares an assessment of the status of large carnivore populations and a proposal for the maximum permissible hunting quota and quota distribution (game monitoring report)[20]. In addition, the county hunting councils make their own hunting proposals. The hunting quotas are then determined by order of the EB.

As a rule, hunting permits are issued somewhat more than the permitted limit, but the obligation to register hunts and immediately inform about the hunted specimen generally ensures that overhunting is avoided. The wolf hunting quota has been issued since 2006 in two parts: the first, rather cautious part is determined in the fall before the start of the hunting season, and the second part is issued in the winter during the hunting season, taking into account the observation and hunting information gathered in the meantime. As a result, it is possible to minimize the risks that arise from the relatively low number of wolves and, at the same time, from the high reproductive potential.

In order to maintain the natural pack structure, since 2010, hunting has not been allowed, or wolf hunting bag limits have been significantly lower than in other regions in some larger areas of natural landscapes (including the Soomaa National Park and its surroundings, the Alam-Pedja nature reserve and its surroundings, the forest massif of North-West Estonia, etc.). It has also made it possible to increase the intensity of management in cultural landscapes, where the risk of damage is greater, with the same population size and range. From 2018 onwards, wolf management has been organized on the basis of management districts formed on the basis of the location of core habitats and concentrations of damages and consisting of several hunting districts. (20 districts in total; see also Kont & Remm, 2013; Remm *et al*., 2014). In the past, the limit was distributed by county, but this procedure was abandoned because the location of the counties does not coincide with the core areas of the wolf's habitat.

Bear and lynx hunting limits are distributed by county. Depending on the location of the damage, in addition to what was described above, bear and wolf hunting is partially allocated to specific damaged areas by hunting areas or groups of them.

4.1.3 Compensations

Based on the Nature Protection Act and EU regulations, EB compensates the primary producers of agricultural products for damage caused by brown bears, wolves, and lynx, as well as the costs incurred for the measures taken to prevent damage. On the basis of the corresponding procedure, EB reimburses 50% and up to 3,200 euros of expenses incurred for the prevention of predator damage. Damages caused by large carnivores are compensated in full minus the deductible rate of 64-128 euros. The plan is, with the amendment to the Nature Conservation

[20] https://www.keskkonnaagentuur.ee/et/kuttimine

Act, to change the rate of compensation for preventive measures and to increase in the limited amount of expenditure made per year.

4.2 International agreements and regulations, and practices in neighboring countries

4.2.1 European Union legislation and guidelines

The Habitats Directive of the European Union (92/43 EEC) promotes the conservation of the diversity of nature in the territory of the EU by means of measures that would maintain and, if necessary, restore the favorable nature conservation status of natural habitats and species important from the point of view of the EU. This directive is a key instrument in the conservation of biodiversity in Europe, which obliges 28 member states to maintain favorable conservation status for selected species and habitats. The status of a species is considered favorable if: (1) population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, (2) the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, (3) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis. Natura 2000 - the European Biodiversity Program, which is the largest internationally coordinated pan-European network of nature reserves - is also covered by the Habitats Directive.

The conservation status of species is determined in three annexes to the directive: Annex II – natural habitat types of community interest whose conservation requires the designation of special areas of conservation; annex IV – animal and plant species of community interest in need of strict protection and Annex V – animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures. Both the brown bear, the wolf, and the lynx are designated in Annexes II and IV of the directive. The directive's option to make exceptions for different countries has been used, and therefore Estonia's large carnivores have been excluded from Annex II, and the wolf and lynx have been transferred from Annex IV to Annex V. In Estonia, bear hunting is organized on the basis of Article 16, point 1 b of the directive (to prevent serious damage, in particular to crops, livestock, forests, fisheries and water and other types of property). The corresponding exceptions made for bear management under Article 16 are reported to the European Union every other year. In doing so, it is necessary to describe the volume of exemptions and the way of implementation, explain the reasons for exemptions, consider alternatives and ensure that the granting of exemptions does not have a negative impact on populations. Member states are obliged to report every six years on the status of the populations of the species listed in the directive, status changes, and threats and causes of changes.

The CITES Regulation of the European Union (Council Regulation No. 338/97) applies the protection of wild plant and animal species specified in the Washington Convention (CITES) by regulating trading with them. In the regulation, large Estonian carnivores are listed in Annex A - except in special cases, buying, offering to buy, acquiring for commercial purposes, showing them to the public for commercial purposes, using them for commercial income and selling, keeping for sale, offering for sale or transporting them for sale are prohibited. For the import and export of specimens of these species or their body parts or goods made from them, as well as for other transactions, a special permit must be requested from MoE.

The European Commission has also approved guidelines that contain recommendations and suggestions to achieve and maintain a favorable status of large carnivore populations and are important documents **for planning the conservation of large carnivore populations**: (1)

Guidelines for population-level management plans for large carnivores in Europe (Linnell *et al*., 2008) and (2) *Key actions for Large Carnivore populations in Europe* (Boitani *et al.*, 2015) Joint cooperation between countries is essential for the conservation of large carnivore populations because species do not know national borders and populations are spread over several countries. The above-mentioned documents are guidance material for large carnivore policy makers and species monitoring organizers at the national level regarding, among other things, hunting for large carnivores, sustainable forestry, wolf and dog hybridization, the release of captive-bred specimens into the wild, damage compensation systems and population monitoring.

4.2.2 International conventions

The Bern Convention, or the European Convention on the Protection of Flora and Fauna and their Habitats, was concluded in 1979, and Estonia has joined it since 1992. The aim of the Bern Convention is to preserve European wild flora and fauna and their natural habitats and to promote international cooperation for the conservation of wild nature, paying special attention to the protection of endangered species, including endangered migratory species. Those species for which conservation measures must be implemented as a matter of priority are listed in three annexes. The wolf and the brown bear are strictly protected species in Annex II of the Convention, and the lynx is a protected species in Annex III.

Action plans for the conservation of the wolf, lynx, and brown bear in Europe have been drawn up as implementation measures of the Bern Convention (Boitani, 2000; Breitenmoser *et al.*, 2000; Swenson *et al.*, 2000), and they also recommend the development of national action plans for the species. Under the Bern Convention, there is also an expert group on large carnivores, the purpose of which is to prepare various guidance materials.

The Washington Convention (CITES), i.e., the Convention on International Trade in Endangered Species of Wild Fauna and Flora was concluded in 1973, and Estonia has joined the convention since 1992. The Convention regulates the import and export of endangered species to countries. The 30,000 species to which the protection of the Convention extends are located in three annexes according to the degree of threat. The wolf, lynx, and brown bear are in Annex II - species that are not yet in danger of extinction but whose uncontrolled trade may threaten their conservation status. The CITES Convention is implemented in the European Union through Council Regulation No. 338/97 (see point 4.2.1).

The Convention on Biological Diversity was concluded in Rio de Janeiro in 1992, and its objective is the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources in order for not to reduce biodiversity in the long term so as to preserve its potential value for both current and future generations.

4.2.3 Legislation in neighboring countries

Wolf. In Latvia, the wolf is classified as a specially protected species whose use is limited. Thus, through the Hunting Act, the law allows the wolf to be hunted as game. According to the Hunting Act, wolf hunting can take place in Latvia from July 15 to March 31 (Ozolins *et al*., 2018). In Lithuania, the wolf has been a hunted game since 2005; it is hunted from October 15 to April 1, and the annual hunting quota is between 5 and 60 individuals, except in 2018/2019, when it was allowed to hunt up to 110 individuals (however, 102 animals were taken; in Balčthe iauskas *et al*., 2020). In Poland, the wolf is fully protected. In Russia, a hunting permit is required for wolf hunting, and hunting periods have been established when wolf hunting is encouraged in every possible way (Korablev *et al*., 2020). Publicly available official statistics from Russia are scarce. In Belarus, the wolf is among the species that can be hunted without restriction (Saveljev *et al*., 2020).

Lynx. In Latvia, the lynx, like the wolf, is classified as a specially protected species whose use is limited. Thus, the law allows lynx to be hunted as game through the Hunting Act. According to the Hunting Act, lynxes can be hunted in Latvia from December 1 to March 31 (Ozolins *et al*., 2017). In Lithuania, the lynx is a protected species, just like in Poland. Russia has a similar situation with the lynx as with the wolf (little publicly available official information). In Belarus, the lynx is among the non-hunted species (Saveljev *et al*., 2020).

Bear. In Latvia, the bear is a protected species. In Lithuania, the bear is considered an extinct species. Southern Poland has a very small part of the Carpathian population (the Baltic bear population does not spread in Poland). In Russia, bear hunting is organized similarly to wolf hunting, but there is little official information publicly available. In Belarus, the bear is among the non-hunted species (Saveljev *et al*., 2020).

4.2.4 Conservation, management, and damage management practices of other countries

Worldwide, most of the existing management instruments to encourage the coexistence of humans and large carnivores are designed to compensate for damage caused by large carnivores and/or to increase tolerance (Skogen, 2015). The direct dependence of damages on livestock grazing traditions and protective measures implemented to protect the herd has been studied a lot. The effective conservation of large carnivore populations in actively managed areas is not considered possible without the measures implemented for the protection of livestock. Compensation for the damages caused by large carnivores by the state is considered one of the important measures for the conservation of large carnivores, which improves the attitude of local residents towards large carnivores and nature conservation in general in those countries where large carnivores are fully or partially protected species. Compensation for losses is widespread in Europe, and as for among the countries close to us, the only countries it has not been implemented are Latvia and Russia. At the same time, compensating for damages and supporting damage prevention is the most expensive area of large carnivore conservation.

Table 2. Vulnerability and conservation status of wolf, lynx, and brown bear.

Act	**Wolf**	**Lynx**	**Brown bear**	**Explanation**
Red list assessment (IUCN, ver 3.1)	Least Concern	Least Concern	Least Concern	
Nature Directive (Estonian exception)	Annex V	Annex V	Annex IV	Annex IV – a species in need of strict protection, taking individuals from wild in exceptional circumstances, Annex V – a species of economic importance; it is the duty of the member state to ensure that the use of the species does not threaten its survival.

European Union CITES Regulation (338/97)	Annex A	Annex A	Annex A	Transactions with Annex A species are prohibited (except in exceptional cases)
Bern Convention	Annex II	Annex III	Annex II	Annex II - strictly protected, Annex III - protected
Washington Convention (CITES)	Annex II	Annex II	Annex II	Annex II - species that are not currently in danger of extinction but whose uncontrolled trade may endanger their conservation status.

5 Implementation of the action plan for the conservation and management of large carnivores for the years 2012–2021

5.1 Action plan

For the years 2012–2021, the central goal of the conservation and management of large carnivores was set to maintain the favorable status of the wolf, lynx, and brown bear populations (Männil & Kont, 2012). In doing so, it was considered important to take into account both ecological, economic, and social aspects. Within the framework of the action plan, monitoring and research activities have been carried out in the last ten years in the amount of approximately 539,000 euros, to which are added the wages of the KAUR game monitoring department.

5.2 Performance

Of the five main goals of the 2012-2021 action plan, two can be considered fulfilled, two partially fulfilled, and one goal was not achieved. Out of 39 individual activities, 22 were fully implemented, seven were partially implemented, and ten activities remained unfulfilled. It should be taken into account that this analysis was prepared at the beginning of 2021, when approx. 90% of the action plan period has passed. The following is an analysis of the main objectives of the previous large carnivore plan for the years 2012–2021; the analysis of individual objectives is in Annex 3 of the action plan.

1. <u>To maintain the number of wolf reproductive packs between15–25 annually, a total population size</u> of <u>approx.</u> <u>150–250 individuals (including young and old animals) existence before the start of the hunting season (in autumn).</u>

✓ **Completed**. In 2019, the number of wolf reproductions was estimated at 25; in 2020, the number of reproductions was 31. The number of wolves has been above the minimum of the target level in all years of the action plan period and above the maximum of the target level in two years (see chapter 2.1.1, figure 2A).

2. <u>To maintain 100-130 lynx females with cubs every year, total population size</u> <u>approx. 600-780 individuals (including young and old animals) existed before the start of the hunting season (in autumn).</u>

✗ **Not completed**. In 2020, there were at least 63 lynx reproductions in Estonia, and the total size of the population was estimated at 400–450 individuals in autumn. The number of lynxes was not at the target level in any year of the action plan period (see chapter 2.2.1, figure 4A). The reason for the low number is quite clearly the sharp decline and depression in the number of roe deer in the early 2010s and the resulting lack of food base, which in turn caused a noticeable decrease in the growth of the lynx population. Overhunting caused by over-optimistic growth prognosis in some years following the decline in roe deer numbers increased poaching, the effects of sarcoptic mange, and emigration to Latvia have been considered as its consequences. As a result, the number of the population in Estonia fell to a relatively low level and has not yet recovered to the target level.

3. To maintain the existence of at least 60 bear females with cubs of the year each year, the total size of the population is approx. 600 individuals (including young and old animals), by continuing hunting mainly to maintain the species' shyness of humans and to reduce the damage caused by the bear while encouraging the expansion of its distribution area towards the south.

✓ **Completed**. The number of bears in 2020 has been estimated at 900-950 individuals, and the number has been above the target level in all years of the action plan period (see chapter 2.3.1, figure 6A).

4. To reduce the damage caused by large predators by effective implementation of measures developed for the protection of property and by directing management to damage areas.

● **Partially completed.** The absolute value of the damage caused by registered large carnivores has increased (see chapter 3.4). One of the reasons for this is probably the increase in awareness and damage registration activity. With the increase in the number of bears, the popularity of beekeeping and the number of apiaries, and the probability of corresponding damage have increased simultaneously. At the same time, there are clear signals that the implemented preventive measures (predator preventive fences and herd guard dogs) are very effective. The division of wolf hunting quotas according to the zoning of management areas has been implemented. It is necessary to carry out an accurate analysis of prevention and control measures. In order to increase the effectiveness of preventive measures, it is necessary to define more precisely the duties and responsibilities of the property owner.

5. To increase people's awareness and form a favorable attitude towards large carnivores.

● **Partially completed, but partially rather not completed**. Several image-building and educational activities have been carried out, but social polarization seems to have increased - there are clear examples of both a positive and well-informed attitude towards large carnivores, as well as a clearly unjustified and irrationally negative attitude. One can also find examples of irrationally positive attitudes and ignoring the risks associated with large carnivores. It is very difficult to assess what public opinion would be if the actions had not been taken. In general terms, the social/public exchange of ideas on the topic of large carnivores during the preparation of the action plan can be considered healthy and promotes the development of the field.

6 Viability of populations, risk factors, and measures

6.1 The state of the populations

The populations of all three large carnivore species in Estonia must be considered part of the Baltic populations. Regardless of the status of the Baltic populations, the status and sustainability of local Estonian populations are certainly important. Since Estonia is a fairly small land area compared to the spatial extent of large carnivore populations, the cross-border coherence of Estonian populations with neighboring areas is very important. Political borders determine the monitoring and management of biodiversity, but the game moves between jurisdictions without recognizing national borders. For example, in Norway, as many as 49% of female bears identified based on feces and hair by microsatellite markers probably came from neighboring countries (Finland, Russia, and Sweden; Bischof *et al*., 2016). Thus, instead of artificial management boundaries for large carnivores, the increasing focus should be on monitoring, management, and conservation of the populations according to their structure and integrity (Linnell *et al.*, 2008, Hindrikson *et al.*, 2017). This is especially true for large carnivores, which have large home ranges, and all European populations extend across national borders.

LCIE estimates that the total number of individuals in the breeding age of the Baltic **wolf** population is stable at 1,700-2,240 animals[21]. In Estonia, the annual number of wolf reproductive packs in 2014–2019 was 19–25, and in 2020 31 (Veeroja *et al*., 2021). The total number of wolves after the hunting season (in spring) in Estonia in recent years has probably been between 100 and 200 animals of breeding age. In Latvia, the number of wolves after hunting was estimated at 426-531 animals in 2019 (Šuba *et al.*, 2021). In Lithuania, according to the data from 2018, 100 wolf packs are counted as the number of wolves (Balčiauskas *et al*., 2020), and the size of the Polish part of the Baltic population is estimated at 1040 animals of breeding age (Boitani 2018).

According to the criteria of the IUCN red list, the status of the Baltic wolf population is assessed in the category "Least Concern" (Boitani 2018), and the status of the Estonian population is **"Vulnerable."** At the same time, the extinction risk assessment of the Estonian population has been lowered by one level in relation to the expected good cohesion of the neighboring populations (respectively VU ^{0} or NT ^{00}) - if only the status of the Estonian population within Estonia's borders is taken into account, the assessment would be "e*ndangered.* " It is believed that the status of the population can quickly deteriorate in the event of too strong hunting pressure or the appearance of other factors (e.g., diseases).

According to LCIE and von Arx (2020), the Baltic **lynx** population is in a slight decline. The population size is considered to be 1,200-1,500 animals of breeding age. Although the state of the lynx population in Estonia has been poor in recent years, the number of the population in Latvia has increased, and at the beginning of the hunting season, experts estimate that there are 600-800 lynx in Latvia (Ozoliņš *et al.*, 2017a). In general, the situation of the lynx population in Latvia is estimated to be the best in the last hundred years (Bagrade *et al.*, 2016). Regarding the status of the entire Baltic population, it can be said that there is no strong genetic divergence between the core area of the lynx range (Russia) and the more important peripheral parts (including Finland, Belarus, and Estonia) (Rutledge *et al*., 2010).

According to the criteria of the IUCN red list, the status of the Baltic lynx population is assessed as "*Least Concern* " (von Arx, 2020**)**, and the status of the Estonian population is ***"Vulnerable."*** At the same time, the extinction risk assessment of the Estonian population has been lowered by one level due to the expected good cohesion with the neighboring populations (NT^{0}) - if only the status of the Estonian population within Estonia's borders is taken into account, the assessment would be "*endangered*." As the status of the population has been quite poor in recent years, there is a risk that, despite the lack of official hunting in recent seasons

[21] https://ww.lcie.org

(Veeroja *et al*., 2020), the status of the population may suddenly deteriorate further if unforeseen factors (diseases, poaching, etc.) occur.

The EU part of the Baltic **brown bear** population consists almost entirely of the Estonian population, whose migrations also reached northern Latvia in 2019 (Veeroja *et al*., 2020). The population is growing. According to the criteria of the IUCN red list, the status of the Baltic brown bear population, as well as the Estonian population, has been assessed in the category **"*Least Concern,*"** i.e., non-threatened **(**Huber, 2018;).

As far as we know, no quantitative population vitality analysis has been prepared for any large carnivore in Estonia. Considering the systematic monitoring of all three species for about 20 years in Estonia (see chapter 2.5.2 and annex 2) and a lot of basic scientific and applied research (see chapter 2.5.1), it can be assumed that a considerable amount of raw data for the relevant analysis has been accumulated by now.

6.2 Risk factors and measures

In the following sub-chapters, risk factors for large Estonian carnivore populations have been analyzed. The most important risk factors are diseases, the reduction of the food base, overhunting, illegal hunting, and unfavorable public opinion. The analysis is summarized in Table 3.

Table 3. Wolf, lynx, and brown bear risk factors and their impact assessment in Estonia and Europe (in brackets; European assessment according to sources Hindrikson *et al*., 2017; Boitani *et al.*, 2018; Huber, 2018; von Arx, 2020; see also cited sources in the following chapters 6.2. 1–6.2.15).

The importance of the risk factor is abbreviated and determined according to:
CR – critical importance, can lead to the destruction of the population within 20 years;
G – of great importance, can lead to a population decline of > 20% in 20 years;
ME – of medium importance, can lead to a population decline of < 20% in 20 years;
MI – of minor importance, has only local importance, and the risk of population decline within 20 years is < 20%;
"–" – the impact is missing or not relevant to assess.

	Hazard	Importance in Estonia (Europe)		
		Wolf	**Lynx**	**Brown bear**
1.	Low population density and loss of genetic diversity	MI–ME (ME)	MI–ME (ME)	ME (ME)
2.	Deterioration of the state of the population in neighboring countries	ME (–)	MI–ME (–)	MI (–)
3.	Hybridization and introgression	MI (MI)	–	–
4.	Diseases	G (ME)	ME–G (ME)	MI (ME)
5.	A decrease in the food base	MI–ME (MI)	G (ME)	MI (MI)
6.	Legal hunting	G (ME)	G (ME)	G (ME)
7.	Illegal hunting	G (G)	G (G)	G (ME)
8.	Line infrastructure - range barrier and death in traffic	ME (ME)	ME (ME)	ME (ME)
9.	Habitat loss, degradation and fragmentation	MI (ME)	ME (ME)	MI (ME)
10.	Selective hunting and disruption of population structure	ME–G (G)	MI (MI–ME)	ME (MI)
11.	Additional feeding and baiting	MI–ME (–)	–	ME (–)
12.	Disturbance	MI–ME (ME)	MI–ME (ME)	ME–G (ME)
13.	Exceptional removal from the nature	MI (MI)	MI (MI)	MI (MI)
14.	Unfavorable public opinion	G–CR (G)	ME (G)	G (G)
15.	Lack of cross-border cooperation	ME–G (G)	ME–G (G)	MI–ME (G)

6.2.1 Low population abundance and loss of genetic diversity

A similar population pattern that mostly correlates with genetic diversity has emerged for large carnivores throughout Europe. As a result of post-Ice Age pressure of human activities, western populations are more fragmented and affected by the effects of going through a population bottleneck. On the other hand, eastern populations are more coherent and stable (Kaczensky *et al.*, 2012; Pilot *et al.*, 2014; Hindrikson *et al.*, 2017; Lucena-Perez *et al.*, 2020). In some individual populations of large carnivores in Europe, both abundance and genetic diversity are good (Baltic and Scandinavian bear populations), but there are a number of them in which, for example, the reduction of genetic diversity is a very serious problem (Scandinavian wolf population, Central European lynx populations).

The loss of genetic diversity is a complex problem and mostly occurs through the lack of direct contact between different populations of the same species or intra-population fragmentation, which results in the restriction of gene flow, which can cause significant genetic drift and inbreeding. In general, Estonian populations of large carnivores are well connected with Latvian populations, but the connection with Russian populations is poorer (Plumer *et al*., 2016, Anijalg *et al*., 2018; Ratkiewicz *et al*., 2014).

The reduction or loss of connectivity between European **wolf** populations and also within populations is an important factor that requires strong measures, especially in areas where wolf hunting pressure has been strong for some time (Kaczensky *et al.*, 2012; Jansson *et al.*, 2014; Boitani, 2015; Plumer *et al.*, 2016; Chapron & Treves, 2017). Loss of genetic diversity is a problem in several European populations. The most well-known of them, and now very likely extinct, is the Sierra Morena wolf population in Spain (López-Bao *et al.*, 2018). Inbreeding is a very important and long-standing problem also in the Scandinavian wolf population (Ellegren, 1999; Vilà *et al.*, 2003; Hagenblad *et al.*, 2009). Although it is known that gene flow takes place between Estonia and Latvia (Hindrikson *et al*., 2013; Plumer *et al*., 2016), there is no information about the frequency and nature of gene flow in the entire Baltic population.

As for the **lynx** in Europe, the low abundance and relatively fragmented range in many populations is a problem (Rueness *et al.*, 2014; Lucena-Perez *et al.*, 2020). Between 1971 and 2018, 16 lynx reintroduction projects (a total of 170 animals) have taken place in Central Europe, which has turned out to be rather unsuccessful, as the lynx managed to stay put in only five of them (Mueller *et al.*, 2020). The low success rate is due to two main factors. In most cases, a very small number of animals from the same population (foundation individuals) have been introduced, leading to inbreeding and loss of genetic diversity. Inbreeding and low genetic variation have been found in all reintroduced populations that have been studied using genetic methods (Bull *et al.*, 2016). In addition, the isolation of European lynx populations is a big problem. On the other hand, Ratkiewicz et al. (2012, 2014) have found that the lynx populations that live in the Baltic countries (including Estonia), Finland, Belarus, and the European part of Russia (including the northern part of the Baltic population) form a fairly complete and interconnected genetic cluster compared to other European populations, i.e., genetically similar to each other and internally diverse.

In the case of the **bear**, currently, in Estonia, it is a population recovering from a bottleneck, the genetic diversity of which is lower than in other populations in Europe that have passed through the bottleneck (such as Slovakia and Sweden). The genetic diversity in Eastern Estonia is higher than in other regions, which is probably due to immigration from Russia (Anijalg *et al.*, 2020). However, it should be taken into account that the gene flow between Russian and

Estonian bears has been relatively small so far (Tammeleht *et al.*, 2010; Keis *et al.*, 2013; Anijalg *et al.*, 2018).

The low numbers of the population and the decrease in genetic diversity is a threat factor of low to medium importance for the wolf and lynx population in Estonia and a risk factor of medium importance for the brown bear.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and carrying out various basic and applied studies in order to have a good overview of their abundance and hunting in Estonia. If monitoring data and studies indicate a significant decline in numbers, hunting must be restricted to maintain numbers. Implementation of conservation and management area rules so that hunting is directed primarily to damaged areas.

6.2.2 Deterioration of the population in neighboring countries

The status of Baltic large carnivore populations may also deteriorate for reasons independent of Estonia's conservation and management action plan. The Latvian bear population and the Lithuanian lynx population (which are very small) probably play an insignificant role here, while the Latvian lynx and wolf populations, which are larger than the Estonian populations based on the latest data, play an important role (Ozoliņš *et al.*, 2017a,b). There is no permanent and sustainable bear population in Latvia, which is why the Estonian population is relatively isolated. In Latvia, action plans for wolf and lynx populations have recently been developed for the years 2018-2028 (Ozoliņš *et al.*, 2017a, b). It is very important to have more meaningful cooperation in the field of monitoring than at present in order to achieve a good and comprehensive overview of the population and to improve and standardize monitoring methodology and cooperation. It must be remembered that the IUCN risk assessment of the status of the Estonian wolf and lynx population has been lowered due to strong populations in the neighboring areas (see chapter 4.1).

A significant deterioration of the status of the populations in neighboring countries is currently a risk factor of medium importance for the wolf, of low to medium importance for the lynx, and of low importance for the brown bear. In connection with the realization of various other risk factors, it is potentially a risk factor of increasing importance for all species.

Measure: Enhancing and increasing international information exchange and cooperation and supporting and developing the activities of various cooperation networks in order to have a better overview of what is happening in neighboring countries and to prevent risk factors from materializing in Estonia. For the same reasons, it is also important to carry out international studies (including a study of the genetic coherence of populations with neighboring areas).

6.2.3 Hybridization and introgression

Hybridization is a biological process in which two distinct, but closely related taxa interbreed and can strongly influence the genetic makeup, long-term survival, and development of a species (Gompert & Buerkle, 2016). While natural hybridization is seen as rather positive (e.g., genetic rescue, Brennan *et al.*, 2014; speciation, Lavrenchenko & Bulatova, 2016), anthropogenic hybridization is a potential threat to the preservation of populations and even species (Donfrancesco *et al.*, 2019). Anthropogenic hybridization is well documented in canids (Gottelli *et al.*, 1994; Elledge *et al.*, 2008; Khosravi *et al.*, 2013; Freedman *et* al., 2014; vonHoldt *et al.*, 2016), including frequently between wolves and domestic dogs (Randi, 2008; Leonard *et al.*, 2014). In Europe, wolf-dog hybridization cases have now been identified in all wolf populations (Salvatori *et al.*, 2020). In North America, several canine species have emerged as a result of hybridization; for example, the red wolf (*Canis rufus*) and the eastern wolf (*Canis lycaon*) are both crosses of wolf and coyote (vonHoldt *et al.*, 2018).

Although the historical range of the wolf is recovering in Europe, rather little systematic research has been performed on hybridization (Donfrancesco *et al.*, 2019). European nature conservation regulations (i.e., the EU Nature Directive and the Bern Convention) impose several legal obligations on European governments regarding wolf conservation. The exact obligations vary from country to country (Fleurke & Trouwborst, 2014; Appendix C). In Europe, there is currently no specific and clear definition of a wolf-dog hybrid. A guideline for the prevention of hybridization and hybrids has been drawn up, but it is not sufficient to solve specific situations (Donfrancesco *et al.*, 2019; Salvatori *et al.*, 2020). It is worth noting that, as of 2017, hybridization and introgression ranked second among genetic threats to European wolf populations (Hindrikson *et al.*, 2017). The perception of hybridization as a very important threat comes from the difference in methods for determining a hybrid (genetic, if very certain, or based on appearance), as well as from the different operating models of different countries when managing hybrids.

In the Baltic wolf population, hybridization has been confirmed for several decades (Anderson *et al.*, 2002; Hindrikson *et al.*, 2012; Stronen *et al.*, 2013). Hybridization can be a threat to the preservation of the favorable status of the wolf due to a decrease in its adaptability, and it can also increase its aggressive behavior and the amount of damage (Randi, 2011). The possibility of crossbreeding between wolves and dogs is greater under anthropogenic pressure, especially in the periphery of the population and in areas with high anthropogenic mortality - situations where the status of the wolf population has significantly deteriorated due to overhunting or some other reason (Godinho *et al.*, 2011; Hindrikson *et al.*, 2012). It is also facilitated by the disruption of the social structure of the wolf population (Valdmann *et al*., 2004a).

Since the existence of wolf and dog hybrids is probably not directly dangerous for the preservation of the status of the Estonian wolf population, hybridization (and especially introgression) is a minor threat factor in Estonia. Under certain conditions, such as very low numbers of wolves, the social structure of packs broken to a large extent, etc., hybridization can become a medium threat factor for the wolf. Lynx and brown bears do not hybridize with other species.

Measure: When hybrids of wolves and dogs are identified (on the basis of external characteristics), they must be removed from the wild (hunted) as soon as possible. When carrying out wolf-related DNA studies, in case of doubt, the presence of hybrids must also be analyzed.

6.2.4 Diseases

A large-scale spread of diseases and their significant impact on the number of populations of large carnivores occurs in canids as most of the diseases that affect them are family-specific and are, therefore, freely transmitted from one canid species to another. In Estonia, one of the biggest threats to the wolf and, to a lesser extent, to the lynx is sarcoptic mange, the main carriers of which are foxes and raccoon dogs. A noticeable expansion of the spread of sarcoptic mange in both wolf and lynx populations has been observed since 2009 (game monitoring reports 2009–2020, KAUR[22]). The impact of sarcoptic mange on wolf and lynx populations has not been studied separately, and sarcoptic mange has not threatened the status of carnivore populations in the long term, but during the years of sarcoptic mange spread, the number and growth rate of the population may decrease significantly. In addition, canine distemper has

[22] https://www.keskkonnaagentuur.ee/et/kuttimine

been detected in small carnivores (fox, raccoon dog) in nature in Estonia in the last two years, which can also threaten wolves in certain cases. At the same time, no infected or dead specimens have been found in Estonia. See also chapter 2.4.3.

Sarcoptic mange is a high-risk factor for the wolf and a medium to high-risk factor for the lynx, which can be very important as a mortality factor in the short term. The impact of other possible diseases in Europe cannot be predicted at this time. No high-impact disease outbreaks have been found in the bear recently, but given the high population density, an unexpected high-impact disease could be quite devastating. Thus, diseases are a minor risk factor for the bear.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and carrying out various basic and applied research in order to have a good overview of the spread of diseases. The spread of sarcoptic mange can also be limited by improving control over the disposal of fallen livestock as large carnivores come into contact with the spreaders of the disease (foxes, raccoon dogs) in the sites of animal waste taken to the forest.

6.2.5 A decrease in the food base

As a specialist predator, the lynx, whose main prey species in Estonia is the roe deer, is most affected by the reduction of the food base. Probably one of the important reasons for the sharp decline in the lynx population in 2011-2013 is the drastic decline in the number of roe deer and the subsequent depression in those years. In order to affect the wolf population, the number of multiple ungulates would need to decrease significantly at the same time, which could theoretically happen if the moose population declines, the wild boar population recovers very slowly from African swine fever, or swine fever starts to spread again, and the roe deer population declines again. The brown bear has the widest food spectrum of the large carnivores and feeds mostly on plants. Thus, a significant reduction in the food base is very unlikely. However, it may be that in the case of very heavy deforestation, eutrophication, fertilization, and the establishment of extensive monoculture stands, the availability of food resources, ants, and wild berries, which are important for the bear, will decrease (Strengbom, J. & Nordin, A. 2008; Lundmark et al. 2014; Domevščik, 2018). See also chapters 2.1.5, 2.2.5 2.3.6 and 2.4.1.

Reduction of the food base is a low to medium risk factor for the wolf, a high-risk factor for the lynx, and a low-risk factor for the bear.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and carrying out various basic and applied research in order to find out more precisely the effects of the reduction of the food base. An analysis comparing and weighing various possible causes, a risk assessment and forecast of strong fluctuations in abundance, and an action plan to minimize such threats (including reduction of the food base) are also prepared (See also chapters 8.2.1, 8.2.4, 8.2.8 and 8.2.9.).

6.2.6 Legal hunting

Overhunting (including legal hunting) was the most important reason for the decline and extinction of large carnivores in various European countries in the 18th and 19th centuries (Chapron *et al.*, 2014). In Estonia, the abundance of all three species has been at a very low level in different periods during the 20th century but also at the beginning of the 2000s. It must be remembered that in the form of the campaign to exterminate large carnivores a century ago, it was legal hunting in the legal space of that time. In the case of the lynx, one of the reasons for the sharp decline in numbers was probably the continuation of lynx hunting in 2012-2015 following the decline of roe deer at the beginning of the last decade in 2010-2011 (Veeroja *et al.*, 2020, Schmidth *et al.*, 2021). In its own way, the development of extensive and complex game monitoring and hunting management systems all over Europe and other countries also speaks of the strength of the dangers that can accompany hunting.

Although the direct effects of hunting on large carnivore populations are increasingly clear, a complex understanding of the genetic consequences of hunting on populations, such as the management of populations near the borders, is lacking (Reljic *et al.*, 2018). Hunting, like any anthropogenic factor, affects the genetic diversity of large carnivore populations (Allendorf *et al.*, 2008), especially for the wolf as a social species (Ausband *et al.*, 2015). For example, in the case of the wolf, the consequences of hunting are reduced genetic variation and gene flow, changed population structure, disruption of social structure, increased hybridization with dogs, and a decrease in the lifespan of pups (Valdmann *et al.*, 2004a; Jędrzejewski *et al.*, 2005; Creel & Rotella, 2010; Rutledge *et al.*, 2010; Hindrikson *et al.*, 2013; Ausband *et al.*, 2015). At the same time, intensive wolf hunting in Latvia in the last twenty years has not led to noticeable changes in the gender and age structure of the population (Šuba *et al.* 2021). Legal overhunting can become an important risk factor for bears as well.

Hunting, including organized hunting, has a very large impact on the abundance of all three large carnivore species and is, therefore, a major threat factor. The danger is especially important in the case of wolves and lynx, whose populations are relatively small, and the possible accompanying dangers are thus greater than those of the bear. At the same time, the risk is greater for species with low reproductive potential (bear). In addition, the presence of strong conflicts with humans (wolf, bear) increases the risk of setting excessively large hunting quotas.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and carrying out various basic and applied studies in order to have a good overview of their abundance and hunting in Estonia. Formation and implementation of a large carnivore cooperation council in order to ensure balanced conservation and management of large carnivores (including well-organized hunting) through the involvement of various parties.

6.2.7 Illegal hunting

Managing large carnivore populations in today's anthropogenic and urbanizing landscapes is considered one of the greatest conservation challenges in the world (Woodroffe, 2000). Illegal hunting is a key issue (Carter *et al.*, 2017) and one of the most important factors that affect large carnivores to a very significant extent (Andrén *et al.*, 2006; Ryser-Degiorgis, 2011; Boitani, 2015; Suutarinen & Kojola, 2017) and slows the spread of large carnivores in Europe (Liberg *et al.*, 2012). It has been shown that for different species, illegal hunting can account for a very large proportion of mortality in certain areas: In Sweden, it has been estimated that as much as 51% of the wolf population is illegally hunted (Liberg *et al.*, 2012) and, for example, 15-20% of the annual increase in the lynx population in Central Europe (in the Bohemian forest ecosystem) (Heurich *et al.*, 2018). In Poland, the annual mortality of the wolf population due to poaching is estimated at 33% (Nowak *et al.* 2021b), and in Białowieża Forest in Eastern Poland, illegal hunting has accounted for 50% of wolf and 53% of lynx mortality (Mysłajek & Nowak, 2014). See also chapters 2.1.6 and 2.2.6. A Swedish study (Liberg *et al*., 2020) found that the proportion of illegally hunted wolves was positively correlated to population size and negatively correlated to the number of legally hunted individuals and concluded that legal hunting could reduce the poaching of large carnivores.

In Estonia, only a few cases of illegal hunting have been proven. According to EB's supervision department (L. Plumer) and several sources who wished to remain anonymous, illegal hunting of large carnivores, especially wolves, can still take place in Estonia on a scale that significantly affects the population (hints from conversations that took place during the preparation of the action plan). Since 2015, 16 misdemeanor proceedings have been initiated in Estonia in connection with the illegal hunting of large carnivores on the basis of § 50 (hunting without a hunting permit) of the Hunting Act (EB). Often, other norms have also been violated with one act (for example, hunting during a prohibited time or violation of the hunting quota established by the EB). In four cases, the procedure is in progress during the preparation of the action plan; in four cases, a decision of the general procedure has been prepared; in four cases, the procedure has been terminated by the statute of limitations; and in one case the termination was based on voluntary compensation for damage, and in three cases there were no signs of a misdemeanor (illegal exceeding of hunting quota occurred due to deficiencies in hunting regulations). Four proceedings are related to lynxes, four to bears, and eight to wolves (EB, former Environmental Inspectorate).

In the case of **wolves**, the risk of illegal hunting may arise from the mistaken belief that there are significantly more wolves than monitoring data indicate or that it is seen as a means to reduce livestock damage. In the first case, the existence of a transparent and reliable monitoring system, effective communication of monitoring methodology and results, and more active communication between the collectors of monitoring data (hunters) and analysts (KAUR) can help. In the second case, it could be helpful to apply the principles of management and conservation area, which direct the cores of populations of large carnivores to areas away from areas with more intensive livestock farming. In this case, effective preventive measures are certainly important.

In the case of **the lynx**, due to low numbers, illegal hunting may threaten the current population that is in a relatively disadvantaged status through direct and indirect effects. The effect of illegal hunting on the abundance of lynx is not known in Estonia today, and it would certainly require closer investigation.

In the case of **the bear,** the risk of illegal hunting can be increased by the high number of the population. It is also important to consider the bear's lowest reproductive potential among the three large carnivore species.

For all three species, illegal hunting can also be driven by commercial interests (trophy, animal parts). A bear may also be mistakenly hunted during a wild boar hunt or to prevent a suspected attack during a hunt.

For all three species, illegal hunting is a major threat factor.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and ensuring the existence and further development of a transparent and reliable monitoring system. Effective communication of monitoring methodology and results and more active communication between monitoring data collectors (hunters) and analysts (KAUR). Implementation of conservation and management area principles, which direct the cores of large carnivore populations to areas away from areas with more intensive livestock production. In this case, effective preventive measures are certainly important. Changing legislation to increase penalty rates for poaching to make poaching unprofitable.

6.2.8 Line infrastructure - barrier to spread and death in traffic

In the case of large carnivores, the development of infrastructures is related to two important aspects. First, they can reduce or prevent the movement of large carnivores within their home ranges, being a direct obstacle to daily movement. Another and much bigger problem is when infrastructure objects become functional barriers that slow down the movement of individuals between populations and parts of the population. The ability of individuals to move freely is one of the most important bases for the overall functioning of the animal population. For example, highways can prevent the dispersal of juveniles. As a consequence, the genetic diversity of the population and, over a longer period of time, the fitness of the species decreases.

In Estonia, there are still no barriers that completely prevent the range of large carnivores created in connection with highways or other objects under development. At the same time, this problem is clearly rising to the agenda with the development plans of three national line objects - the Rail Baltic railway (this threat is also assessed to be similar in Latvia; Ozoliņš *et al.*, 2018) and the Tallinn-Tartu and Tallinn-Pärnu-Ikla four-lane highways.

In addition to transportation, the construction of large enclosures in suitable habitats for large carnivores, for example, related to cattle breeding or game farms, can also prove to be problematic. Also, the border fence is to be built on the eastern border of the EU. However, it is expected that the border fence will not be built on the shores of Lake Peipus and Narva River, and enough fence breaks will be left on the southeastern border, and these border sections will remain open to large carnivores. Therefore, the cross-border movement of carnivores needs constant monitoring, and for this purpose, cooperation is carried out with the Police and Border Guard Board, and, if possible, cooperation with neighboring countries is also developed.

In addition to the effect of line infrastructures preventing the range, transport infrastructures also pose a risk of the death of individuals in collisions with vehicles. However, relatively few large carnivores killed in traffic have been registered in Estonia (see chapter 2.1.6, 2.2.6, 2.3.7). The construction of game crossings and the prevention of game ending up in traffic during the development of highways and railways are also clearly recognized and prioritized in Estonia. Several relevant guidelines and studies[23] have also been prepared, which mostly point out as recommendations that for the purpose of the functioning of big game passes (ecoducts, green bridges, tunnels, etc.) in the estuary areas, clear-cutting of forests, mining of mineral resources and construction activities must be avoided.

Since the traffic frequency on the roads, as well as the fencing of highways and railways, is on the rise in Estonia, artificial dispersal barriers and/or related deaths due to the large home range and the migration range of dispersing young animals, which is the largest of the three species, are in perspective a risk factor of medium importance for the wolf, and also of medium importance for the lynx and bear for similar reasons risk factor. In the past, it has been a minor risk factor.

Measure: Carrying out various basic and applied studies in order to have a good overview of the scope of the problem in Estonia. Cooperation and professional exchange of information and international exchange of information between conservation and control organizers and authorities (including the Police and Border Guard Board and the Transport Administration) and local governments so that the passage of large carnivores is ensured during the construction of barriers and their deaths in traffic accidents are reduced.

6.2.9 Habitat loss, impoverishment, and fragmentation

The so-called Nature Directive of the European Union[24] and the Natura 2000 network of protected areas has played a major role in protecting large carnivores. However, as the Natura 2000 network was established before the period of expansion of large carnivore populations across Europe, the existing network may not be sufficient to protect the quality of large carnivores and their habitats today. For example, in Poland, it has been found that within the Natura 2000 network (one of the network's criteria is that 20-60% of the species' habitats should be in protected areas), the Baltic and Carpathian wolf populations are better protected

[23] https://www.mnt.ee/et/tee/elusloodus/kasiraamat-loomad-ja-liiklus-eestis
[24] https://eur-lex.europa.eu/legal-content/ET/TXT/PDF/?uri=CELEX:01992L0043-20070101&from=EN

(respectively 28% and 47% of the population's range is located in the Natura 2000 network areas), than the expanding population of Central European plain (12%), and therefore the Natura 2000 areas in Western Poland should be increased by at least 8% (Diserens *et al.*, 2017). Habitat reduction, impoverishment, and fragmentation are considered one of the most important reasons for the poor status of the lynx in Lithuania, Poland, Belarus, and Ukraine (Schmidt *et al.*, 2021).

For large carnivores, as large and highly mobile animals, it is important that the habitats in our nature remain coherent; in other words, it is very important that the green network areas created in Estonia are preserved and function as habitats and migration corridors in the future. In 2018, the Environment Agency also prepared a corresponding guide in order to maintain the green network and take into account it's functioning[25].

The quality of the habitats of large carnivores depends to a great extent on the existence and coherence of forest habitats. In Estonia, the existence of relatively good habitats for large carnivores is indicated by the location of the populations of the three species in mainland Estonia (Veeroja *et al*., 2020) and also by the north-south forest area in the transition zone of Estonia, which, for example, male bears use as a movement corridor (Anijalg *et al.*, 2020). It is important to get rid of the outdated thinking that large carnivores are part of "wild nature" and only inhabit protected areas and to understand that large carnivores are a natural part of almost all landscapes, including areas with strong human impact (López-Bao *et al.*, 2017). Degradation and fragmentation of habitats can be significantly caused by long fences, along roads, at the state border, as well as in the case of pastures, but also by densely populated areas and densely located numerous logging sites (see also chapter 6.2.8).

At the present time, habitat loss, impoverishment, and fragmentation are rather of minor importance for the wolf and bear and of medium importance for the lynx. Since in the future, the proportion of landscapes without immediate human disturbance will tend to decrease, and objects that fragment habitats will be continuously added, in the longer term, this may become an important risk factor.

Measure: Preservation of green network areas and compliance with guidelines prepared by the Environment Agency. Using the zoning of large carnivore conservation and management areas as one of the basic materials in other spatial plans, including green networks, infrastructure, real estate, land use, etc. (see also chapter 8.7.4). Organization of training for the compilers of the green network, general plans and thematic plans with a large spatial extent, and EIA.

6.2.10 Selective hunting and disruption of population structure

The long-term survival and ecological functioning of socially complex species may depend on more than just the abundance value of their populations (Brainerd *et al.*, 2008; Chapron *et al.*, 2014). For example, the stability of wolf social units (packs) can be as important as their population size, but often only the latter is considered. In a long-term study (26 years) in which 387 radio-collared individuals were observed, it was found that the death of the breeding individual (alpha animal) of the pack led to the disintegration of the pack in 77% of cases (Borg *et al.*, 2015). Therefore, hunting the leaders of the pack is an activity that needs to be thought through better than before and is especially suitable in areas that are not suitable for the habitat of a wolf pack.

Although human activities can also affect solitary species through social connections, generally, communal species are more sensitive. In the case of lions, it has been shown that social groups, rather than individuals, are the basic building blocks around which predator-prey

[25] https://keskkonnaagentuur.ee/sites/default/files/rohev6rgustiku-planeerimisjuhend_20-04-18.pdf

interactions should be modeled, and the formation of social groups can provide the underlying stability of many ecosystems (Fryxell *et al.*, 2007). In communal mammals such as wolves, even small population declines can disrupt social stability (Fryxell *et al.*, 2007) and reduce the functional role of the population more than would be expected from their abundance alone (Wallach *et al.*, 2009). One of the most important human factors affecting the social structure of the wolf pack is hunting. One type of hunting, selective hunting, changes the natural structure of the population. This can lead to changes in age composition, pack size, lifespan, prey-catching ability, pack home range size and stability, social behavior, and genetic diversity (Wallach *et al.*, 2009). Taken together, such effects can lead to adverse ecological and evolutionary consequences (Fenberg & Roy, 2008).

Selective hunting of large carnivores probably occurs in all species because larger-bodied specimens are preferred in trophy hunting, and therefore, for example, in the case of bears, large males are hunted more often (Reljic *et al*., 2018). In Norway, however, it has been found that age and sex (male) increase the hunting risk of the lynx (Nilsen *et al.*, 2012). Since it is not allowed to hunt female lynx with cubs in Estonia, the hunting pressure is probably greater on males. In the case of the wolf, selective hunting can occur in hunting larger packs, which leads to a higher probability of a successful hunt. However, this is an important disruptor of the social structure, which can (1) increase pup mortality (Brainerd *et al.*, 2008) and (2) produce more individual young animals that have not learned to successfully hunt wild ungulates alongside their parents, which also increases the risk of their becoming as nuisance specimens.

Selective hunting is a medium to high-risk factor for the wolf due to cohabitation and a very strong social structure, a rather low-risk factor for the lynx, and a medium risk factor for the brown bear due to increased hunting interest (trophy) in old males.

Measure: Continuous monitoring (surveillance) of the status of large carnivores and carrying out various basic and applied studies in order to have a good overview of their abundance and hunting in Estonia. Formation and implementation of a large carnivore cooperation group in order to ensure balanced conservation and management of large carnivores (including well-organized hunting) through the involvement of various parties. Raising awareness and educating people about the harmful effects of selective hunting.

6.2.11 Supplementary feeding and baiting

Supplementary feeding of bears and wolves, luring them with food (e.g., for hunting or nature tourism), and luring them away from human settlements is a controversial measure. Anthropogenic food can change the location of the animal's home range, movement habits, feeding behavior, and preferences, and bear hibernation (Jerina *et al.*, 2012; Zlatanova *et al*., 2014; Krofel *et al*., 2017b; Penteriani *et al.*, 2017, 2018). In many European countries, supplementary feeding of bears is a recommended measure (Kavčič *et al*., 2015), in contrast to North America (Garshelis *et al.*, 2017). In addition, the supplementary feed can also directly affect bear nutrition by increasing body weight and energy requirements, as observed in brown bears feeding on garbage dumps (Garshelis *et al.*, 2017).

For the brown bear, supplementary feeding sites can be one of the most important food sources (Kavčič *et al.*, 2015), and most bears use supplementary feeding sites if possible (Krofel & Jerina, 2016). This can have a negative impact on the health of the animal and on the cubs learning their food habits if females with cubs visit the artificial feeding places (Penteriani *et al.*, 2017). In addition, such feeding sites can artificially increase the local population density, which in turn increases the contact of bears with each other and with other species (e.g., lynx; Krofel & Jerina, 2016), etc. Thus, the use of feeding sites may induce lower fitness under certain conditions, as artificial food becomes equally attractive or more attractive than other resources (Penteriani *et al.*, 2018). As it turned out, in Slovenia, the supplementary feed was the most important food category for bears and accounted for 34% of the bears' annual food energy intake. Of this, 22% was corn, and 12% was animal carcasses (Kavčič *et al.*, 2015). Also, in areas with denser human populations, an important part of the wolf's food base can be anthropogenic food objects (including waste; Zlatanova *et al*., 2014).

In Estonia, supplementary feeding of the game is prohibited in protected areas[26]. In addition, there are additional restrictions on supplementary feeding due to the spread of African swine fever (ASF) - supplementary feeding of wild boar is prohibited everywhere in Estonia[27]. Since, for wild boars, feed of both plant and animal origin is suitable, the supplementary feeding of large carnivores is also essentially prohibited. The only difference is game waste, which can be used for supplementary feeding and/or left in wild after hunting. Supplementary feeding of the game is also prohibited in connection with the location of game damage and areas where hunting is prohibited[28]. Attracting game in other ways (sound, smell, etc.) is not legally defined and regulated.

Supplemental feeding is a low to medium risk factor for the wolf and, a medium risk factor for the brown bear, no risk for the lynx. If the attracting of large carnivores by other means becomes more widespread than it is now, it may become a separate threat factor for all three species.

Measure: Carrying out various basic and applied studies in order to have a good overview of the scope of the problem in Estonia. Raising people's awareness and training and preparing instructional materials about the dangers of supplemental feeding and baiting. Improving the control of the handling of agricultural animal remains.

6.2.12 Disturbance

The main sources of disturbance to large carnivores are anthropogenic, including those that can be divided into lethal (hunting, persecution), non-lethal (logging, landscape activities, hunting), and urbanization and infrastructure (settlement expansion, road construction, traffic, agriculture; Gaynor *et al*., 2018) based on risk to game. Large carnivores avoid the proximity of humans, and for example, if a female bear with cubs under one year of age is woken up from the winter den usually does not return there - the cubs die. Therefore, animals can also die directly as a result of non-lethal disturbances (logging, hiking, public events in the countryside, hunting). In the study of bear hibernation sites conducted in Estonia (Tammeleht *et al.*, 2020), more than half of the hibernation sites were known to have been abandoned due to human disturbance, and this is very likely to have a negative effect on the bear's breeding success. The same study also found that protected areas, where the probability of disturbance is lower, have few habitats suitable for hibernation. If you find a bear den, you must report it immediately by calling the state helpline on 1247 or sending a letter with a description of the den location or coordinates to the Environmental Board's general email at info@keskkonnaamet.ee. On the basis of § 4 (5) point 4 and § 51 [1] of the Nature Conservation Act (NCA), a bear's hibernation site automatically becomes a permanent habitat, where hunting and forest management work are prohibited within a radius of 300 meters from the hibernation site until April 15 of the same year in order to avoid disturbing the bears. Landowners are sent a protection obligation notice informing them of the restrictions (based on § 4 subsection 1 of NCA).

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[26] Nature Conservation Act §14 subsection 1 point 10, RT I, 30.12.2020, 7

[27] EB directive, 16 October 2020 No. 1-1/20/186. Organizing wild boar hunting to prevent African swine fever in the wild boar population on the territory of the Republic of Estonia and determining the hunting quota and structure for the 2020/2021 hunting year

[28] Hunting Act § 46, SG I, 10.07.2020, 91

Like the bear, the wolf and the lynx are very sensitive to disturbance during the breeding period. However, since the wolf and lynx are active throughout the year and are strictly associated with the den site during a shorter period, the probability of disturbance is also somewhat lower. In the case of a wolf, an additional source of disturbance (especially during the period of young litters) is disturbance related to nature tourism - simulated howling, searching for den sites, etc.

The disturbance is a low to medium risk factor for wolves and lynxes, and generally a medium risk factor for bears. In the case of frequent disturbance of the bear's hibernation sites, it can even become a significant risk factor.

Measure: Improvement of the information exchange about bear winter dens. Raising people's awareness and training and preparing instructional materials about the dangers of disturbing hibernating bears and wolves, and lynx. Introducing the problems of orphaned bear cubs and proposing good solutions.

6.2.13 Exceptional removal from the wild

Exceptional removal from wild mainly concerns two large carnivore species - wolf and bear. Removal of predators from the wild can be done in the so-called non-lethal way (relocation, but also sterilization), but also with the help of different lethal control methods. One example is the selective and often out-of-season hunting of those individuals that pose a greater threat to livestock (nuisance specimens). Although the removal of large carnivores from the wild is a controversial measure, it is still widely used in situations where no satisfactory preventive measure or other alternative can be found to prevent damage to livestock (Eklund *et al.*, 2017). However, removal from the wild can affect the social structure of a predator's population, which in turn can lead to increased immigration leading to continued damage to livestock (Wielgus & Peebles, 2014).

In the case of the wolf, the removal of hybrid specimens from the wild is considered important, although this is a controversial issue both legally and ethically (both in public and in the scientific community; Donfrancesco *et al.*, 2019). Although the Bern Convention has set guidelines for dealing with hybrid specimens (Bern Convention Recommendation No. 173, 2014 and this in order to reduce the impact of hybridization on wolf populations), in reality, the implementation of these guidelines takes place differently and often ineffectively in different countries. Only five Member States have an implementation policy in line with the recommendation of the Bern Convention, which encourages the removal of hybrid specimens from nature (Salvatori *et al.*, 2020). In all countries with a Baltic wolf population, lethal removal from nature is indicated as a measure in national conservation and management action plans for hybrids. See also chapter 6.2.3.

In addition to management and control purposes, the removal of individuals from the wild may be necessary for nature conservation purposes. For example, between 2012 and 2015, Estonian lynxes were caught and introduced to Poland in order to strengthen the population there[29].

Since exceptional removal from nature usually only concerns individual specimens, it is a low-risk factor for all three large carnivore species.

Measure: Raising people's awareness and training and preparing instructional materials regarding the removal of large carnivores (bears, lynxes, and wolves) from nature. Carrying out a legal analysis of raising large carnivores under human care.

[29] https://elfond.ee/tehtud/liigikaitse/eesti-ilveste-taasasustamine-poola

6.2.14 Unfavorable public opinion

The success of the protection of large carnivores depends on several factors, including public opinion (Chapron *et al.*, 2014). It has been found that a higher level of education, younger age, male gender, and living in an urban area increases tolerance toward large predators (Naughton-Treves *et al*., 2003, Pohja-Mykra & Kurki, 2014). In the case of unfavorable public opinion, the probability of illegal hunting increases, as well as political pressure to significantly increase hunting quotas, which is why forming a positive attitude among people is one of the key issues for the protection of large carnivores. For example, unfavorable public opinion is listed as a common threat to almost all wolf populations in Europe (Hindrikson *et al.*, 2017).

The presence of game damage is one of the most important reasons that increase negative attitudes locally, such a trend is also visible in Estonia (Plumer *et al.*, 2016), and although it has been found that national support for measures introduced to prevent damage by large carnivores improves people's attitude towards large carnivores (Dalmasso *et al.*, 2012), then in many cases this is not the case (Bautista *et al.*, 2017). In the past, Estonian legislation has favored compensating damages rather than preventing them, which in itself does not contribute to reducing damages and thereby also improving public opinion. See also chapter 3.4.

If public opinion disapproving of large carnivores is widespread, decision-making related to them can become highly politicized. As a result, important decisions can be non-objective (i.e., not based on science), and this, in turn, can lead to tragic consequences for populations. Decisions without scientific basis can have particularly serious consequences for populations with low numbers (such as wolf and lynx), slow reproduction (bear), and low ability to spread (depends, among other things, on the environment).

In Estonia, unfavorable public opinion is a risk factor of high to critical importance for the wolf, of high importance for the bear, and of medium importance for the lynx.

<u>Measure:</u> Implementation of the procedure for limited-conservation areas and control areas. Continuous implementation and improvement of the damage prevention system. Raising and training people's knowledge and competence and preparing instructional and educational materials in connection with the popularization of large carnivores (bears, lynxes, and wolves) and the prevention of conflicts and damage. Review and amendment of the legislation on large carnivore damage.

6.2.15 Lack of cross-border cooperation

In Europe, most large carnivore populations are transboundary, covering up to eight countries (e.g., the Carpathian lynx population), while the legal responsibility for the management and protection of large carnivores rests at the national and national regional administrative levels. Despite efforts to coordinate pan-European large carnivore management at the population level (Trouwborst, 2015), improving transboundary cooperation remains a key activity for large carnivore conservation (Boitani *et al*., 2015). There is also no common policy in Europe regarding the management of large carnivore damage – damage compensation systems differ between countries and even within the same country (e.g., Spain), and this is an important problem in the case of predator populations shared between different countries (Reljic *et al*., 2016). Compensation programs are part of claims handling policies and, therefore, also vary greatly from country to country, leading to differences in compensation amounts across Europe (Bautista *et al*., 2017).

The Estonian populations of all three species belong to the Baltic populations distributed over several countries. Without a coherent and viable population in neighboring areas, the viability of Estonian populations would be much lower. At this point, it should be remembered that the

IUCN threat assessment of the status of the Estonian wolf and lynx population has been lowered due to strong populations in the neighboring areas (see chapter 6.1). Compared to the brown bear, the most critical connection with the neighboring areas in the case of the lynx is due to its relatively low abundance (including well below the target value) and poor growth indicators in recent years and due to its high dependence on one prey species, the roe deer which lives here on the northern border of its range and whose well-being, in turn, largely depends on the climate here. On the other hand, the need for cross-border cooperation is also important in the case of the wolf, whose population in Estonia will probably remain the lowest of the large carnivores in both the short and long term and whose home range is the largest of the three species. Therefore, it is important that populations in neighboring countries are monitored and managed in cooperation on the same basis. Direct cooperation with Latvia and Russia, which share a land border with Estonia, is certainly important. The number of bears has shown strong growth and a high level in a situation where the vast majority of the Baltic population is located in Estonia. Thus, for the bear, the threats associated with a lack of cross-border cooperation are expected to be the least of the three species.

Lack of international cooperation is a medium to high-risk factor for wolves and lynxes and a low to medium-risk factor for bears.

Measure: Enhancing and intensifying international information exchange and cooperation in order to have a better overview of what is happening in neighboring countries and to prevent the realization of the above-mentioned risk factors in Estonia (including participation in various international information days, conferences, round tables, training, and working groups). Harmonization of monitoring systems and conservation and management practices for large carnivore populations. Continued execution of international cross-border studies (including telemetry of large carnivores and study of genetic coherence of populations with neighboring areas).

7 Conservation and management objectives for the years 2022–2031

7.1 Principal directions of conservation and management activities

This action plan for the conservation and management of wolves, lynxes, and brown bears provides guidelines and an action plan for the years 2022-2031 in order for Estonian society to function and develop peacefully with natural, viable, and ecologically functioning large carnivore populations.

This action plan has six principal directions to achieve the goals: favorable status of populations (A), species conservation and management plan (B), effective damage management (C), transparency of conservation and management principles and practices (D), science-based monitoring of species and related problems and exploration (E), extensive knowledge of large carnivores and competence (F). The contents and main aspects of these six directions are presented below; the specific conservation goals with metrics are described in chapter 7.2, and the specific activities are in chapter 8.

A Sustainability of large carnivore populations according to the European Union biodiversity conservation rules – the natural populations of all three large carnivore species are coherent both within Estonia and with neighboring areas, and Estonian populations are continuously viable in the long term (the probability of extinction in the next 100 years is < 5%); Estonian populations are treated as an integral and important part of the complete Baltic population; there is a functional international information exchange and cooperation in the conservation and management of populations (certainly with Latvia and Russia and at the EU level, but also more broadly); preferential hunting of nuisance specimens in damaged areas; illegal hunting is minimized.

B A clear and functional zoning and implementation system for large carnivore protection and management areas – sufficiently large areas (i.e., with the extent of several home ranges) are designated that contain high-quality habitats for each species and where populations can naturally function as a full part of the area's biodiversity; large carnivore protection areas are in all parts of Estonia and formed for all three large carnivore species (combined as much as possible); the determination of management areas is based on the real location of damage and settlements, and the vast majority (≥ 75%) of hunting is concentrated in these areas; the zoning of large carnivore protection and management areas is used as a basis for other spatial plans, including green networks, infrastructure, real estate, land use, etc.

C Effective damage prevention and compensation system – at the state level, various effective prevention activities (electric fences, livestock guarding dogs, etc.; see also chapter 7.2.2) are preferred compared to damage compensation; the cost of damage prevention is much higher (≥ 2 times) compared to damage compensation; according to the zoning of large carnivore protection and management areas, exceptions are made in the system of prevention and compensation, if necessary, so that the effectiveness of both measures is maximized; in the case of repeated damage, compensation for damage is conditional on the implementation of preventive measures, but there may be exceptions in areas where large carnivores are kept.

D Science-based nature, clarity, and recognition of management and conservation decisions – an open and widely used hunting-related information channel (presumably a software platform) will be developed for different parties; a cooperation council uniting various parties, including hunters, animal breeders, conservationists, scientists, communities, conservation and management organizers, etc., which deals with information exchange, negotiations, conflict resolution, goal setting, advising on national decisions, etc., and which meets regularly (presumably several times a year); different interest groups (including hunters, volunteer, and professional nature observers, researchers) participate in the collection of basic data for management decisions.

E Scientific monitoring and research of the abundance of species and the status of populations - on the basis of the existing system, a modernized and as accurate, clear, and operational monitoring methodology as possible is developed and implemented (methods based on trail cameras and/or DNA analyzes and/or machine learning, etc. to clarify and supplement the observational information); basic studies of population abundance, vitality and structure are carried out for all three species; the error of population abundance estimation is at most ±10% (a higher error rate is allowed if the abundance is significantly higher than the specified target level, see chapter 7.2.1); the extensive study of large carnivores will continue, including ecology, genetics, sociology, culture and other basic and applied research.

F Public awareness and the professional competence of the parties, including the ecology of large carnivores, the threats, and solutions associated with them - as a common understanding in society, large carnivores are not seen as an enemy but as an important part of Estonian nature and the ecosystem, with which it is natural to live together in the same landscapes today; parties in direct contact with large carnivores (hunters, rangers, animal breeders, etc.) are trained, competent and recognized in their field; authorities and spatial planners (local governments, general and detailed spatial plans, green network, environmental impact assessment, etc.) are trained and aware of large carnivores, their peculiarities, and related topics.

7.2 Conservation and management objectives and performance evaluation

The plan for the conservation and management of large carnivores sets three basic conservation goals: the favorable status of the populations, the prevention of damage, and science-based and objective knowledge and regional competence, the measurable goals (metrics) of the first two of which are presented in the following subsections. In terms of knowledge and competence, it is difficult to set specific goals (metrics) for assessing progress, and the fulfillment of this goal can be evaluated rather subjectively. The effectiveness of the plan must be evaluated annually in terms of population abundance and damage frequency metrics, and a more comprehensive analysis must be performed every five years, i.e., in the middle and at the end of the action plan period in 2026 and 2031. In addition to the fulfillment of the conservation objectives, the implementation of all the planned principal directions, the realization of the activities (see chapter 8), and the effectiveness must also be analyzed. If a deviation from the set goals is identified during the assessment or the goals are found to be impossible, additional measures or a justified and proper change of the goals must be planned and implemented.

7.2.1 Favorable status of populations

The Estonian populations of all three large carnivores are considered coherent and viable if the population's probability of extinction according to population viability analysis is < 5% within 100 years following the moment of assessment (see also IUCN Red List criterion E – quantitative analysis of extinction probability; IUCN, 2019[30]).

It is important that populations of large carnivores are coherent and viable continuously (Linnell *et al*., 2008). It is desirable that the status of the populations corresponds to the IUCN

[30] https://www.iucnredlist.org/resources/redlistguidelines

category "Least Concern" or LC (IUCN 2000; 2019) at the level of the Baltic population, and due to the small area of Estonia, close and well-coordinated cross-border cooperation is essential for this. In summary, in terms of nature conservation, the goal is a situation where all large carnivore species are widespread and numerous in Estonia and the Baltic population.

The most important target metrics of the Estonian population are (1) the number of reproductive units before the hunting season, i.e., females with offsprings born in the previous winter or spring, and (2) the number of adults (breeding age) individuals in the spring, after the hunting season, i.e., the size of the base population (without juveniles).

By species, the threshold values are as follows:

Wolf – number of wolf packs with pups under one year old before the hunting season: **20-30;**

Lynx – number of females with kittens under one year old before the hunting season: **≥ 80**;

Brown bear – number of females with cubs under one year old before the hunting season: **≥ 70.**

In the case of the lynx, the spring number of individuals of reproductive age, or the so-called base population, is **≥ 350 individuals,** and in the case of the brown bear, **≥ 650 individuals.** In the case of wolves, a base population size of **≥ 140 individuals** must be achieved during the implementation period of the plan, preferably within five years. The calculation of the minimum level of the base population is based on a 3-year average.

For the mentioned threshold values of the number of adults, (1) the calculated size of the Baltic population of each species has been taken into account (see chapters 2.1.1, 2.2.1, and 2.3.1)[31] ; (2) IUCN and LCIE recommendations that the size of the entire Baltic population should be at least 1000 individuals of breeding age; (3) The proportion of forest habitats in Estonia in the distribution area of the Baltic populations - approximately 20–25% for wolf and lynx and approximately 60–70% for bear; (4) lower than the average population density of ungulates (wolf and lynx prey species) in the range of Baltic populations in Estonia (approx. 10–15% of biomass[32]); and (5) KAUR game monitoring specialists' assessments of the population's age and social structure and Estonian societal tolerance.

For implementation decisions, other metrics are used in parallel with these indicators, e.g., autumn abundance, which includes adults and young animals, spatial, gender, and the age structure of the population, increment indicators, etc.

When the number of large carnivores (number of reproductive units) falls below the threshold value, only problem and nuisance specimens are allowed to be hunted with a special permit (in other words, regular hunting is not allowed). The assessment for hunting is given by the Environmental Board in its discretionary decision, taking into account the number of damage

[31] https://www.lcie.org
[32] Results of game monitoring in the Baltic population area; Estonia: KAUR; Latvia: Jānis Ozoliņš, personal communication; Lithuania: Linas Balčiauskas personal communication; Poland: https://www.bdl.lasy.gov.pl/portal/tworzenie-zestawienia-rlo-en

cases in the area in the current year and the extent of the damage or the possible danger to humans due to the unnatural behavior of the specimen.

Hunting for wolves and lynx above the threshold value of the number of large carnivores (number of reproductive units) is allowed if it is ensured that the status of the population is sufficiently good and that it is excluded that the number will fall below the threshold value in the next three years. Whereas permission to hunt lynx is not considered until the number of females with cubs is at least 100. A bear may be hunted in an area of bear damage for damage prevention purposes. When starting hunting for large carnivores, social tolerance is also taken into account because as the number of carnivores increases, so does the risk of conflict with people, especially in the form of increased damage in the case of bears and wolves.

Proposals regarding the necessity and quota of hunting are made every hunting year by a cooperation group that unites different parties and is convened based on the plan.

The number of adults after the hunting season accounts for approximately 50-60% of the total population after the breeding season in the case of the wolf, approximately 55-60% in the lynx, and approximately 75-80% in the brown bear. The ratio between the number of reproductive units and the total number in autumn after the breeding season is calculated to be approximately 1:10 for the wolf, approximately 1:6 for the lynx, and approximately 1:10 for the brown bear (see also Annex 2, current monitoring methodology). In the case of the wolf, it has been calculated that the proportion of individuals not belonging to the packs in autumn is expected to be around 15–20%.

Populations are connected if there is a successful migration, i.e., reaching the genetic population of the target area with neighboring areas (Latvia and Russia). Over the year, there must be a successful migration of at least one individual for each species (based on data from telemetry, trail cameras, and track counts). Within the borders of Estonia, there must not be any anthropogenically isolated area for large carnivores (by transport corridors, settlements, etc.) with an area of ≥ 250 km², including both currently inhabited and uninhabited but potentially suitable areas of the species.

- In addition to the above, the effectiveness of the large carnivore reserve system must be analyzed. These are sufficiently large areas located in different parts of Estonia, which contain high-quality habitats for each species, where populations can function in a natural way and where ≤ 25% of the hunting quota is carried out.

7.2.2 Damage prevention

Prevention activities of damage caused by large predators can be considered successful if the frequency of damage to the total number of Estonian livestock (sheep, goats, beef cattle, etc.) and bee colonies are at the same level or lower than at present. In addition to farm animals, it is also important to monitor and reduce attacks on dogs and other domestic animals. The threshold numbers for evaluating the performance of activities are as follows.

Sheep and goats - the number of animals damaged by large carnivores within a year are **≤ 1%** of the total number of sheep and goats registered in Estonia in the same year (according to ARIB calculations). If more precise data is not available, approx. 85,000 animals as the calculated total number of sheep and goats should be used, and in this case, the total number of damaged sheep and goats during the year should be ≤ 850.

Beef cattle - the number of animals damaged by large carnivores within a year is **≤ 0.03%** of the total number of beef cattle registered in Estonia in the same year (according to ARIB calculations). If more precise data is not available, approx. 80,000 animals as the calculated total number of beef cattle should be used, and in this case, the total number of beef cattle damaged during the year should be ≤ 24.

Bees - the number of bee colonies damaged by large predators within a year is **≤ 0.6%** of the total number of Estonian bee colonies in the same year (according to ARIB and Statistical Office's calculations). If more precise data is not available, ca. 50,000 hives as the estimated total number of bee colonies should be used (Pulver *et al.*, 2018), and in this case, the total number of bee colonies damaged during the year should be ≤ 300.

- In addition to the above, the effectiveness, efficiency, and fairness of the damage assessment, prevention measures, management, compensation, and subsidies caused by large carnivores must be analyzed. In doing so, ensure that ≥ 75% of wolf and bear hunting takes place in damaged areas (lynxes are not expected to cause a lot of damage) and that prevention costs are at least twice as high as costs for damage compensation.

7.2.3 Knowledge and competence

Objective quantitative, as well as qualitative assessment of public awareness and district competence is a very difficult goal. Therefore, exact numerical target values are not proposed in the following cases. Certainly, when implementing the plan, the importance of fact-based awareness and professional competence to achieve the goals must be emphasized. When evaluating the mentioned qualitative target metrics, it is advisable to use the evaluations of different parties, including animal breeders, hunters, conservationists, and scientists. If possible, it is advisable to use different existing metrics for evaluation; quantitative metrics can also be developed according to the question and the situation. As qualitative, quantitative, and evaluative target metrics, it is important to analyze the following.

- Wide trustworthiness, modernity, and scientific bases of large carnivores and their directly related monitoring methodology, as well as the clarity of hunting decisions for different parties.
- A reliable, scientific, and internationally recognized estimate of the abundance and population status of all three large carnivore populations. At the same time, the 95% confidence interval of the abundance estimate can be at most ±10% of the value obtained as an estimate.
- Animal breeders' awareness of predator control preventive measures and willingness to implement preventive measures. Also, the state's willingness to support preventive measures. For example, the number and proportion of animal breeders in Estonia who have implemented preventive measures and the number and proportion of livestock and bee colonies protected by preventive measures and which are threatened by predator attacks can be used as a measure.
- Determining the frequency of illegal hunting and effective measures to reduce illegal hunting.
- Frequent and constructive communication between parties involved in large carnivores, including information, communication and discussion, negotiation of societal issues and goal setting, and conflict resolution.
- The existence and favoring of science-based, objective, and democratic topic coverage and debate in public communication and media. For example, the frequency and trend of scientifically objective approaches and hostile language in the public media about large carnivores can be used as a metric.

- The professional competence of parties directly in contact with large carnivores (hunters, animal breeders, etc.), decision-makers (government institutions and local governments), and space planners and impact assessors (local governments, EIA experts, etc.) on the topic of large carnivores. For example, the number of trainings organized for different target groups and the number of participants in training can be used as a metric, but the content and competence of the assessments, decisions, and plans actually made in relation to large carnivores should also be analyzed.

7.3 Organization and responsibility

Activities related to large carnivores are usually divided between different institutions and organizations. Although some issues are dealt with by several agencies, leadership roles and responsibilities are generally clearly divided.

Ministry of the Environment (MoE) – preparation of legislative changes; official communication and reporting with the European Union.

Environmental Board (EB) – managing the implementation of the conservation and management plan; species conservation and management planning; large-scale spatial planning of species protection, control, and prevention activities; coordination and implementation of preventive measures and damage management; hunting organization; environmental supervision (former Environmental Inspectorate); planning and organizing various inventories and surveys; promoting awareness and competence.

The Environment Agency (KAUR) – wildlife monitoring; preparation of hunting proposals; organization of applied research; promoting awareness and competence.

In addition to the aforementioned state institutions, various public, private and third-sector organizations (including animal breeders, hunters, conservationists, scientists, entrepreneurs, etc.) and experts in the field will be involved in the implementation of the plan.

In order to implement the plan, it is planned to form a cooperation body bringing together national institutions and interest groups (see point 8.1.1), the purpose of which is to ensure smooth cooperation and, among other things, to provide input regarding the conservation and management of large carnivores, as well as the organization of hunting based on the expectations of various interest groups.

Hunters are certainly important cooperation partners in the cooperation network - users of hunting districts have an obligation to collect monitoring data arising from the Hunting Act, and the Estonian Hunting Society (EHS), which unites the vast majority of Estonian hunting organizations, also plays a growing role as the developer of the hunting information system JAHIS. It is appropriate to carry out preventive measures and damage handling in cooperation with organizations bringing together animal breeders, among them the Estonian Sheep and Goat Breeders' Association, the Estonian Beef Breeders' Association, the Estonian Association of Professional Beekeepers, the Estonian Beekeepers' Association. When performing basic research, it is advisable to involve competent research and development institutions. In promoting the involvement of volunteers (including in monitoring), citizen science, and public awareness, close cooperation must be carried out with non-governmental organizations operating for the same purposes and also with nature tourism companies.

8 Plan of conservation and management activities for the years 2022–2031

The activities planned for the years 2022–2031 for the conservation and management of large carnivores are described in the following subsections (chapters 8.1–8.7). The activity schedule and budget are presented in Table 3 (Chapter 8.8). The priority of activities is divided into three according to the following classification.

Priority I – indispensable activity without which achieving the goal in the planned period of time is impossible; it is an activity aimed at the preservation of values and the elimination of active risk factors and activity necessary for evaluating the effectiveness of the conservation management;

Priority II – necessary action aimed at restoring values and eliminating potential risk factors;

Priority III – recommended activity, i.e., activity that indirectly contributes to the preservation and restoration of values and the elimination of risk factors.

8.1 Cooperation and professional exchange of information

8.1.1 Formation and implementation of the cooperation council of large carnivores

Priority: **I**
Risk factors: **1–15** (Table 3, Chapter 6.2)

Constructive information exchange and cooperation between different interest groups and parties related to large carnivores is of critical importance for the success of the action plan and is directly necessary for several activities. The lack of information exchange and cooperation and unjustified negative regional and public opinion due to ignorance can have the most serious consequences for both large carnivore populations (see chapter 6.2) and lead to preventable damages. As an important instrument for further cooperation, a cooperation body that unites different parties and advises on decisions related to large carnivores will be assembled and implemented. In the cooperation council, the best available information is shared, including discussions on the organization of monitoring, conflicts that have arisen are resolved, and input is also given to the organization of hunting (see also chapter 8.7.5). Among other things, the cooperation council will present and discuss the implementation of this action plan. For the sake of a smooth exchange of information, the council should meet regularly, presumably several times a year, and it is necessary to set a clear, goal-supporting, and flexible work procedure. The cooperation council should include representatives of various parties, including hunters, animal breeders, conservationists, scientists, communities, conservation and management organizers, state institutions, etc. It is necessary to implement the cooperation council as soon as possible, preferably from the beginning of the action plan period, and continue indefinitely. The Cooperation Council will be created by the Ministry of the Environment.

8.1.2 International information exchange and cooperation

Priority: **II**
Risk factors: **2, 8, 14, 15–3** (Table 6.2, Chapter 6.2)

From the point of view of the favorable status and sustainability of all Estonian populations of large carnivores, genetic coherence with neighboring areas is essential. Therefore, for the successful conservation and management of these species, cross-border cooperation between countries is necessary. It would be desirable to harmonize the monitoring systems and conservation, and management practices of large carnivore populations in Estonia, Latvia, Lithuania, and Poland. A close exchange of information and cooperation with Russia, Belarus, and the countries of Fennoscandia will certainly contribute to the goal. It is necessary to continue cooperation in international working groups, including LCIE, IUCN, Federation of Nature and National Parks of Europe (EUROPARC), Eurolynx, and others. International cooperation is necessary continuously during the entire period of the action plan and after that. Cross-border cooperation is primarily organized by the Ministry of the Environment and the Environment Agency.

8.1.3 Supporting and developing the activities of various cooperation networks

Priority: **III**
Risk factors: **9, 11, 12, 14, 15** (table 3, chapter 6.2)

From the point of view of the favorable status and sustainability of all Estonian populations of large carnivores, it is essential to support the activities of various cooperation networks. A good example in Estonia today is the National Animal Roundtable, whose activities have given several positive results for the popularization of large carnivores, the last measurable result being the issuance of a new two-euro coin with a design of a wolf. The organizers are interested parties, that is, various associations of the third sector.

8.2 Basic and applied research

8.2.1 Specifying the abundance and analysis of the viability of the populations

Priority: **II**
Risk factors: **1, 2, 5, 6, 8, 9, 15** (table 3, chapter 6.2)

The abundances of all three large carnivore species in Estonia have been estimated so far without confidence intervals. Thus, the accuracy of abundance estimates is not known. The reason for this is probably the complexity of studying them due to the ecology of these species (low population density, large home ranges, pack way of life in wolves, hibernation in bears, etc.), the unknown poaching rate, and the weaknesses of the methods used so far (including relatively high estimation). Since all three Estonian populations could not remain sustainably viable without coherent populations in neighboring countries, both international cooperation (see chapter 8.1.2) and a very good and accurate understanding of the status of Estonian populations are important.

Accurate abundance estimation (confidence interval of maximum ±10% of abundance) and **modeling and analysis of population viability, availability, quality and location of habitats, and environmental carrying capacity, i.e., social tolerance and threat scenarios, are** required. DNA-based methods have great potential in the selection of the methodology for the estimation of abundance, but in addition, it is advisable to combine other methods and data (results of previous monitoring, observations of individuals, telemetry, etc.). Combining different methods makes it possible to increase the accuracy of the assessment and validate the result. Unfortunately, most of the above-mentioned methods are quite expensive, which is why the possibilities of their use are limited, and the most cost-effective combination must be chosen.

When analyzing the viability of the population, it is recommended to proceed from the IUCN Red List criterion E (quantitative analysis of the probability of extinction) and the solutions recommended for it (IUCN, 2019[33]). As far as we know, no quantitative analysis of population vitality has been prepared for large Estonian carnivores. Considering the systematic monitoring of all three species for about 20 years in Estonia (see chapter 2.5.2 and annex 2) and a lot of basic scientific and applied research (see chapter 2.5.1), it can be assumed that the basic data for the corresponding analysis is largely available.

As an estimate of abundance, it is also important to clarify the number of individuals in the breeding age after the hunting season - the so-called base population size. This is especially important in the case of the lynx, as it is unknown why the population of the lynx has not reached previous levels despite the recovery of the food base. The descending order of species priority is, therefore: lynx, wolf, and bear, but all three species are highly prioritized. At the beginning of the study, it is advisable to perform an analysis and selection of the usability of possible methods to prepare detailed documentation of the applied methodology. It is also advisable to apply the principle of international evaluation (peer-review) in the study. As a result of accurate population estimates and population viability analysis, if necessary, population target numbers (see chapter 8.3.1) can be adjusted so that the long-term viability of populations is ensured. The cost of the study is at least (minimum) 74,000 euros. The cost of the activity includes the cost of the laboratory, the wages of the experts, including travel expenses and taxes, 200 euros per day (a total of 300 working days per year), the cost of data analysis and report preparation (100 days, 140 euros per day).

The study must be carried out during the first 3-4 years of the action plan. The organizers of the study are the Environmental Board and the Environment Agency.

8.2.2 Feasibility analysis and planning of protection and management areas

Priority: **II**
Risk factors: **1, 5, 6, 7, 9, 14** (Table 3, Chapter 6.2)

Very high levels of human disturbance have been identified as a problem in case of all of Estonia's large carnivore populations, one of the most important being the disruption of the population and the natural pack structure by hunting. For example, the hunting of alpha-individuals and subsequent disintegration of the pack in the case of the wolf, but selective hunting has also occurred in the case of the lynx and bear. At the same time, large carnivores cause considerable damage to livestock farmers. Spatial zoning and planning of the conservation and management system have been seen as a solution for coexistence with natural populations of large carnivores in the same landscapes. The distribution of management intensity based on the location of damage and habitats has already been applied to the wolf since 2018 (see chapter 4.1.2; Kont & Remm 2013).

During the study, the location of the habitats of each large carnivore species and the location and dynamics of damage caused by large carnivores will be mapped. The possibility of directing the majority of large carnivore hunting quota (≥ 75%) to areas of repeated damage and denser human settlement while leaving larger habitat cores for the development of the natural population structure and, in the case of the wolf, also for the survival of the natural pack structure in the packs there, will be analyzed. The possibility of directing hunting to specific nuisance individuals, preferably immediately after damage, also needs to be clarified. The optimal degree of temporal and spatial dynamics of protection and control areas will be determined. The current system of management areas is used as the starting point for analysis

[33] https://www.iucnredlist.org/resources/redlistguidelines

and planning. According to the results of the analysis, a pan-Estonian plan of protection and management areas will be drawn up, and the wolf, lynx, and brown bear conservation and management procedures will be specified accordingly. The efficiency of the planning of protection and management areas is expected to be significantly higher if it becomes the basis for other spatial plans, including green networks, infrastructure, real estate, land use, etc. (see also chapter 8.7.4). As one basis for the analysis, the results of the previous study on the distribution of wolf management intensity (Kont & Remm, 2013) and the feasibility study of large carnivore management areas (Remm *et al*., 2014) will be used.

The activity will be started in the second year of the action plan at the latest, but it is advisable to start the preparations at the beginning of the action plan. It probably makes sense to prepare the plan interactively, in stages, and in parallel with the implementation of the principles of protection and management areas. Completion of the plan and final implementation may take place in the second half of the plan period. If necessary, the activity will be divided into several stages - e.g., creation of a theoretical basis, mapping of the situation in Estonia and analysis of feasibility and risks, preparation of a plan and procedure for protection and management areas, and implementation of the plan (Chapter 8.6.1). Beforehand, it is necessary to gain a good understanding of the status of the populations as an input for the analysis (see chapters 8.2.1, 8.2.4, 8.2.7, 8.2.8). The study will be carried out in the following two years, and the cost of the study is at least (minimum) 5,000 euros per year. The cost of the activity includes the cost of data analysis and report preparation (36 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.2.3 Validation of the existing monitoring system

Priority: **II**
Risk factors: **1, 5, 6, 7, 9, 10, 14, 15** (Table 3, Chapter 6.2)

During the preparation of the action plan, feedback from various parties revealed that although, in general, they are quite satisfied with the monitoring system of large carnivores in Estonia so far (see chapter 2.5.2 and appendix 2), the monitoring system as a whole or its parts are not sufficiently clear and understandable. Also, estimates of the reliability of measurements and conclusions made during monitoring (e.g., standard error of numerical values, such as population abundance estimation) have been lacking so far. Public and regional communication of the principles and methodology of the system has been lacking.

With this activity, a detailed guide and explanation of the monitoring methodology will be updated or prepared, including instructions for the primary data collectors, the methodology for finding the population size estimate, the methodology for determining the hunting quota, alternative monitoring methods, etc. Assessments of the reliability of the results will be added to the monitoring methodology, and an international evaluation based on the peer-review principle will be carried out. The methodology will then be introduced regionally and publicly, including an introductory seminar, e.g., at the large carnivore cooperation council (see chapter 8.1.1, 8.7.2), articles in specialized magazines (e.g., Eesti Loodus, Eesti Jahimees; see chapter 8.7.7) and materials available online (e.g., on the KAUR website and in Loodusveeb). During the validation of the monitoring system, the possibility of further development of the system, including the modernization of the methodology (see chapter 8.4.3), involvement of volunteers (see chapter 8.4.5), etc., are taken into account. At the beginning of the plan, the activity is carried out from the state budget funds by the Environment Agency and the Environmental Board.

8.2.4 Analysis of telemetry data of the use of space by the wolf and continued data collection

Priority: **II**
Risk factors: **1, 4, 5, 6, 7, 8, 9, 10, 14, 15** (Table 3, Chapter 6.2)

Between 2012 and 2020, telemetric monitoring of 20 wolves was carried out[34]. Up to this day, the collected data is largely unanalyzed. With the measure, based on the data collected so far, a scientific analysis of the Estonian wolf population's home range, habitat, and space use, as well as the food base and feeding behavior will be carried out, an analysis of the gaps in the work so far will be performed, and wolf marking, and telemetric monitoring will be continued. It is desirable to collect new data more intensively than before in Western and South-Western Estonia, but also in other regions, including along the Russian border. The activity is necessary, among other things, to clarify the status of the population (chapter 8.2.1) and to plan and implement protection and management areas (chapter 8.2.2, 8.6.1). The analysis of the data collected so far will be carried out at the beginning of the action plan period, and during this process, a detailed plan for further investigation will be determined. The activity takes place annually, and its cost is at least approx. 20,000 euros per year. The cost of the activity includes the cost of purchasing equipment, field work, fuel, and data analysis (140 days, 140 euros per day). The activity is performed by the Environment Agency, and the funding is provided from the state budget.

8.2.5 Survey of the illegal removal of large carnivores from the wild

Priority: **II**
Risk factors: **6, 7, 10, 11, 12, 13, 14** (Table 3, Chapter 6.2)

There is little solid evidence on the frequency and forms of illegal hunting. According to the supervision department of EB (former Environmental Inspection; L. Plumer) and various sources who wish to remain anonymous, the level of illegal hunting may be significant in Estonian populations, and its impact on the viability of populations may be significant (see also chapter 6.2.7). The purpose of the study is to clarify whether and to what extent poaching occurs in the Estonian population. After that, to set guidelines for further action. Possible methods are, for example, a sociological study and survey in different circles (including hunters, nature watchers, etc.), public opinion polling and analysis, analysis of telemetrically monitored wolves and lynxes, and interviewing environmental monitoring staff. In addition to illegal hunting, the illegal removal of large carnivores from wild will be investigated (including raising orphaned bear cubs under human care etc.). The time of carrying out the survey is preferably at the beginning of the action plan period. The cost of the study is 2,000 euros per year. The cost of the activity includes the cost of data analysis and report preparation (14 days, 140 euros per day); the study lasts for two years and is organized by the Environmental Board.

8.2.6 Analysis of the effectiveness of compensation and prevention measures

Priority: **II**
Risk factors: **7, 12, 14** (Table 3, Chapter 6.2)

The effectiveness and fairness of the damage prevention and compensation system are critical to reducing conflict and negative public opinion about large carnivores. The performance and effectiveness of the current damage prevention and compensation system and practice will be analyzed. Damages that have actually occurred so far, control activities, preventive activities, and reimbursement of expenses will be connected. Deficiencies and shortcomings of the current damage compensation system will be clarified. Recommendations will be drawn up to

[34] https://www.keskkonnaagentuur.ee/et/suurkiskjad

increase the efficiency of the system. The analysis will be repeated every 3-4 years. The activity is the basis for further damage prevention and damage management practice (chapter 8.3.3, 8.5) and an important input for the planned system of large carnivore protection and management areas (see chapter 8.2.2, 8.6.1). The activity will take place in 2022 and 2025, and the cost is 2,000 euros per year. The cost of the activity includes the cost of data analysis and report preparation (14 days, 140 euros per day); the study will be organized by the Environmental Board.

8.2.7 A study of the genetic cohesion of populations with neighboring areas

Priority: **II**
Risk factors: **1, 2, 15** (Table 3, Chapter 6.2)

The real degree of genetic cohesion of Estonian large carnivore populations, i.e., the frequency of migration reaching the genetic population of the neighboring area, will be clarified. The analysis will definitely be carried out in the direction of Estonia-Russia, preferably also in the direction of Estonia-Latvia. The descending order of species priority is the wolf, lynx, and bear. As a first step, a review and gap analysis of existing data, literature, and previous research results will be prepared, and then knowledge gaps will be filled with new empirical data. Cooperation with large carnivore researchers from neighboring countries is necessary (see chapter 8.1.2). The activity provides input for the assessment of the status of the populations (see chapter 8.2.1). The activity takes place between 2023 and 2025, and the cost is 5,000 euros per year. The cost of the activity includes the cost of data analysis and report preparation (36 days, 140 euros per day); the study will be organized by the Environment Agency and the Environmental Board.

8.2.8 Risk assessment and analysis of the population of large carnivores

Priority: **II**
Risk factors: **1, 2, 4, 5, 6, 7, 9, 10, 14, 15** (Table 3, Chapter 6.2)

In the years 2011–2013, there was a very strong decline in the number of lynxes. One of the reasons for the decline is considered to be a significant reduction in the number of roe deer (food base); overhunting, illegal hunting, the spread of sarcoptic mange, etc., could also have had a strong side effect (Schmidt *et al*., 2021). An analysis comparing and weighing various possible causes, a risk assessment and prognosis of strong fluctuations in abundance, and an action plan to minimize such threats will be prepared. A comparative analysis of risks and activities will also be prepared for the wolf and the brown bear. Since Estonia is a very small land area for populations of large carnivores, risk analysis and an action plan are necessary to ensure the sustainable viability of the populations. Among other things, an analysis of the effectiveness of the settlement of lynxes from Estonia to Poland and an assessment of the effectiveness of the introduction as a possible species conservation measure can provide valuable information. The activity will be carried out at the beginning of the action plan period. Input will be given to the analysis of the status and perspectives of the populations (see chapter 8.2.1) and to the validation and development of the monitoring system (see chapters 8.2.3, 8.4.3). The activity will take place in 2022, and the cost is 5,600 euros. The cost of the activity includes the cost of data analysis and report preparation (40 days, 140 euros per day); the study is organized by the Environmental Board.

8.2.9 Base study of the bear population

Priority: **III**
Risk factors: **1, 2, 4, 5, 6, 9, 10, 14, 15** (table 3, chapter 6.2)

The bear has recently been the least studied of the large carnivore populations in Estonia. Comprehensive telemetry studies of habitat use, home range, and feeding behavior have recently been carried out on wolves and lynx, which have provided valuable basic information for both science and applications. In the case of the bear, several basic parameters, which are necessary to specify the results of the monitoring of the population status and estimate the abundance and develop a modernized bear monitoring methodology (see chapters 8.2.1, 8.4.3), are missing or outdated.

The aim is to obtain a modern and accurate estimate of the following parameters of the population: litter size, lifespan, fertile age, home range size, habitat use, food base, and diet in different seasons. These indicators are necessary to ensure the reliability of conservation and management decisions. The methodology prescribes the use of trail cameras, random observations of specimens, telemetry, uterine samples, intestinal contents and feces samples, DNA tests (from tissues and/or feces), and GIS analysis. The study will be started in the third year of the action plan at the latest (preparations can be made earlier), and it is probably necessary to simultaneously collect and analyze data during almost the entire period of the action plan. The cost of the study is 74,000 euros per year. The cost of the activity includes the wages of experts, including travel expenses and taxes, 200 euros per day (a total of 300 working days per year), and the cost of data analysis and report preparation (100 days, 140 euros per day). The activity will be organized by interested parties and research institutions.

8.3 Development of legal field

8.3.1 Evaluation of the performance of the action plan for large carnivores and update of the plan

Priority: **I**
Risk factors: **1–15** (Table 3, Chapter 6.2)

The effectiveness of the plan in terms of the main population parameters and the frequency of damage (see chapters 8.2.1 and 8.2.2) must be evaluated annually, and a more comprehensive analysis will be performed every five years, i.e., in the middle and at the end of the action plan period, in 2026 and 2031. If a deviation from the set goals is identified during the assessment or the goals are found to be impossible, additional measures or a justified and proper change of the goals must be planned and implemented. The action plan budget will be prepared in 5-year periods in advance for both periods (Chapter 10). The implementation of the action plan will be introduced and discussed in the cooperation council of large carnivores (chapter 8.1.1). The activity will take place in 2026, and the cost is 5,000 euros. The cost of the activity includes the cost of data analysis and report preparation (36 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.3.2 Increasing penalty rates for illegal hunting

Priority: **I**
Risk factors: **1, 6, 7, 10, 13, 14** (table 3, chapter 6.2)

Increasing the penalty rates for illegal hunting of big game has already been planned for 2012-2021 (Männil & Kont, 2012) but has not been implemented so far. However, these penalty rates have been disproportionately low for a long time, taking into account the state of the populations, EU practice, and guidelines, as well as the penalty rates applicable to other groups of species (e.g., fish). Also, the higher penalty rates than before would enable the monitoring and processing of illegal hunting to be enhanced, if necessary. When determining the penalty rates, we are guided by previous experience and take into account the views of different parties (see chapter 8.1.1). According to the initial plan, the penalty rates will be raised to a level that would allow criminal investigations to be initiated in cases of suspected illegal killing of individuals of all three species. Since the criminalization of illegal hunting can lead to conflicting reactions (see also chapter 6.2.14), clear and well-executed notification and, if necessary, the involvement of different parties is important (see chapter 8.1.1, 8.7.4). The activity will be carried out in the years 2024-2025 from state budget funds, and the organizer is the Ministry of the Environment.

8.3.3 Reviewing and correction of the legislation on large carnivore damage

Priority: **I**
Risk factors: **1, 6, 7, 10, 12, 14** (table 3, chapter 6.2)

In order to reduce damages caused by large carnivores to domestic animals, amendments will be made to the Nature Conservation Act and regulations regarding preventive measures and compensation for damages. The aim is to create a situation where animal breeders would be more motivated than before to deal with damage prevention. Remedies that are considered effective in preventing damage from large carnivores and the procedure for supporting preventive measures will be described (see also chapter 8.2.6). Compensation for damages is associated with their recurrence so that, in general, state support is reduced in case of repeated damages if the sufferer has not implemented preventive measures. The possibility of implementing 100% compensation of prevention costs in large carnivore protection areas will be analyzed (see chapter 8.2.2, 8.6.1). In addition, cooperation projects dealing with testing the effectiveness of non-lethal predator repellents in different regions of Estonia will be encouraged, and assistance services will be improved for herders in whose herds predation has taken place in order to slow down the development of predator enmity. The planned activities would be oriented to the immediate moment of occurrence of wolf damage, the sequence of events following which is one of the main sources of igniting anger toward wolves. At the same time, supporting activities will more specifically connect projects regarding wolves and the goals of the Estonian state.

Corresponding legislative changes (increasing the rate of compensation for prevention costs, making environmental damage proportional) were prepared during the period of the previous action plan for large carnivores, in the years 2012-2021; it is necessary to review the change plan if necessary, modernize it and then implement it. The changes concern the methodology for assessing the damage caused by large predators, the designation of damage-prone areas, and the implementation of preventive measures. The activity must be carried out at the beginning of the action plan period and is necessary for the successful development of damage prevention and damage handling practice (see chapter 8.5.3) but is also the basis for the system of protection and management areas (see chapter 8.2.2, 8.6.1). The organizers of the activity are the Ministry of the Environment and the Environmental Board, and the activity is expected to be carried out from the state budget in 2023.

8.3.4 Determining the identity of a large carnivore found dead and killed in a traffic accident

Priority: **I**
Risk factors: **7, 10, 12, 13** (Table 3, Chapter 6.2)

It should be legislated that when a large carnivore is found dead, its body parts belong to the state. According to the currently valid legislation, living large carnivore specimens are property without an owner, and a dead large carnivore specimen or its body parts belong to the finder from the moment of discovery, but large game killed in a traffic accident or killed as a result of a traffic accident belong to the user of the hunting area[35]. The confiscation of an illegally killed large carnivore is decided by the person handling the case. Unfortunately, such a solution makes it possible to hide illegal hunting and other illegal removals of large carnivores from nature. The large dead carnivores found should be examined by an EB expert, which in turn allows for a better collection of basic information about mortality and its causes (see also chapters 8.2.1, 8.2.5). It is necessary to analyze the existing legislation and introduce the corresponding changes. The activity will be carried out at the beginning of the action plan period, and it will be financed from the state budget and organized by the Ministry of the Environment and the Environmental Board.

8.3.5 Improving the control over the handling of agricultural animal remains

Priority: **II**
Risk factors: **4, 5, 7, 10, 11** (Table 3, Chapter 6.2)

According to the currently valid legislation, it is forbidden to feed the remains of farm animals to the game (including large carnivores), but there is no real possibility of sanctioning violations. This may be one of the reasons why, despite the existence of the ban, several interviews held during the preparation of the action plan have revealed that the problem is quite extensive. Analysis of solution options and corresponding legislative changes will be prepared and implemented in the first half of the action plan period. The activity will be organized by the Ministry of Rural Affairs, and the funding will come from the state budget.

8.3.6 Legal analysis of hand-reared large carnivores

Priority: **III**
Risk factors: **3, 7, 12, 13, 14** (Table 3, Chapter 6.2)

Until now, the legal status of young animals of large carnivores illegally raised under human's care has been incompletely defined in the legislation. Such individuals almost always die or become nuisance individuals that are then executed. Therefore, it is necessary to clarify whether such an activity should be equated with illegal hunting, which is also an illegal removal of an individual from the wild. An analysis of the existing Estonian legislation and the legislation and practice of other EU countries will be carried out. Before the analysis is completed, it is advisable to carry out a study on the illegal removal of large carnivores from the wild (see chapter 8.2.5). As a result of the analysis, the problem will be described in detail, and possible solutions will be offered, after which we will proceed to the implementation of the corresponding legislative changes. The activity will take place in 2024, and the cost is 4,000 euros. The cost of the activity includes the cost of data analysis and report preparation (29 days, 140 euros per day). The activity is organized by the Ministry of the Environment.

[35] Hunting Act §34 subsections 4 and 5

8.3.7 Creating legal status for herding dogs beyond pet status

Priority: **III**
Risk factors: **6, 7, 12, 14** (Table 3, Chapter 6.2)

According to the interpretation of the Animal Protection Act, livestock guarding dogs (LGD-s) are equated with pets. Therefore, the conditions for keeping LGD-s are being examined-regarding whether they meet the conditions of keeping a pet (is there, for example, a shelter). At the same time, a LGD in a shelter is easy prey for wolves, and in case of wolf attacks, the LGD would not be of any help in repelling the attackers. When interpreting the Animal Protection Act, an exception should be made for working dogs and guard dogs in the definition of a pet, and if necessary, they should be treated as a separate category. The activity will take place in 2023; the Ministry of Rural Affairs and the Ministry of the Environment will be the organizers; the funding will come from the state budget.

8.4 Continuation of monitoring and development of the monitoring system

8.4.1 Maintaining the existing monitoring system

Priority: **I**
Risk factors: **1, 4, 5, 6, 7, 8, 9, 10, 14, 15** (Table 3, Chapter 6.2)

Monitoring activities will continue in their current form (see Annex 2) until the modernized system, or parts of the system are completed and put into use. In the event that the methodology or any of its important parts is changed (see chapters 8.2.3, 8.4.3, 8.4.5), a period of at least three years will generally be necessary, during which parallel data collection will be carried out with both methodologies (in its current form and the new one) in order to validate and calibrate the new methodology with previous data. The activity takes place every year, the organizer is the Environment Agency, and the funding comes from the state budget.

8.4.2 Development of hunting information system

Priority: **II**
Risk factors: **1, 4, 5, 6, 7, 9, 10, 14** (Table 3, Chapter 6.2)

The channel for collecting and mediating hunting-related information to mediate operational information and notifications of different target groups as well as the public will be further developed. The vast majority of game monitoring data is received from hunters. In order for monitoring to provide an opportunity to make high-quality conservation and management decisions, the data collected must be accurate and reliable. For this purpose, on the initiative of EHS, in cooperation with the Ministry of the Environment (MoE), EB, and KAUR, the information system JAHIS has been developed, which enables real-time hunting information collection, data flow handling, and notification. The data collected with the help of JAHIS is, to a large extent, the basis for fulfilling the tasks of the state in the organization of hunting for large carnivores.

In the case of the information system solution being developed, it is very important that it ensures the transparency of hunting organization and game monitoring, and that the user base of the information system is as wide as possible. For example, not all Estonian hunting organizations are users of JAHIS. It is necessary to ensure the following software functions: collection and transmission of monitoring data, application and transmission of hunting permits, real-time monitoring of hunts (where hunting is currently held) and receiving information on hunted animals. It would probably be possible to increase the clarity and trustworthiness of hunting and hunting organizations to the wider public with the help of JAHIS or a similar information system - e.g., real-time hunting information and reporting of hunting venues and hunting statistics.

When hunting large carnivores, the state must also collect data on the persons who have hunted the large carnivore and/or in whose possession hunting products will be because, in the case of later transactions, they require a CITES document, and if it is possible to check the data more thoroughly during its issuance, then this is one way to reduce the interest in illegal hunting or also in the legalization of illegally hunted specimens. Corresponding data must be reflected in JAHIS.

The development of the hunting information system is carried out in cooperation between hunters (EHS) and state institutions (MoE, KAUR, EB). It is reasonable to plan development activities, at least on a small scale, continuously during the entire action plan period according to the problems that are raised on an ongoing basis. Larger software developments should be carried out as separate projects. The main organizers of the work are the Ministry of the Environment and the Estonian Hunting Society; the cost of the work (software development) is at least 50,000 euros per year, which has been partially financed from the state budget so far. A tenth of the cost (at least 5,000 euros per year) would be the development of the part concerning the monitoring of large carnivores.

8.4.3 Modernization and refinement of the monitoring methodology

Priority: **II**
Risk factors: **1, 4, 5, 6, 7, 8, 9, 10, 14, 15** (Table 3, Chapter 6.2)

Although, in general, the existing monitoring system for large carnivores (see chapter 2.5.2 and annex 2) has proven itself, during the preparation of the action plan regarding the used methodology and practice, critical feedback has come from various parties regarding the lack of clarity and accuracy of the existing monitoring methodology and practice. Among other things, there have been no estimates of the reliability of the monitoring results (e.g., confidence intervals for numerical estimates, such as population abundance, etc.). Since large carnivores have a relatively low abundance (currently wolf and lynx in particular) and are, therefore, relatively vulnerable to various abundance-related threats (see chapter 6.2), it is necessary to increase the accuracy of abundance estimates and related metrics. The aim is to achieve a precision of estimates where the 95% confidence interval is at most ±10% of the estimated value (e.g., abundance).

An important part of wolf and lynx monitoring so far is based on track observations from the snow, but due to the warming of the climate, the possibility of this methodology is becoming less and less predictable. For example, in 2020, KAUR received observation data from only 99 out of 396 game square census transects (25%; Veeroja *et al*., 2020) due to little snow. On the other hand, several good methods have been developed in connection with the development of science and technology, which do not depend on snow conditions and allow for obtaining more accurate data than before.

After the validation of the existing monitoring system (see chapter 8.2.3) and the first results of the population abundance and viability analysis (see chapter 8.2.1), an analysis of the needs and possibilities for the development of the monitoring system will be performed, and then a complete and modernized monitoring methodology will be prepared and implemented. To obtain the best results, the new monitoring methodology would probably have to be a combination of different methods. The possibilities and applicability of trail cameras, DNA-based methods, machine learning and image recognition, citizen science, and the inclusion of volunteer observational data, etc., are considered. If possible, the information flow will be integrated from different sources, such as JAHIS (see also chapter 8.4.2), nature observations (Nature Observations Database, PlutoF/biodiversity, etc.), border guard observations of border crossings of large carnivores, various trail cameras (KAUR, hunters, beekeepers, nature observers, etc.), etc. KAUR has already started testing and implementing trail cameras and machine learning methods. In the case of new methods, a period of at least three years is generally necessary, during which parallel data collection is carried out with both methodologies (current and new) in order to validate and calibrate the new methodology with previous data (see also chapter 8.4.1).

Monitoring methodology development activities are carried out in several cycles, during which it is important to get to know and test new methodological solutions, perform a feasibility and cost-effectiveness analysis, calibrate with the currently used methodology, and combine different methods into a complete, clear, and accurate monitoring methodology. Activities have essentially already been started and must be continued. It is likely that it will be possible to reach the implementation of a fully modernized comprehensive methodology only in the second half of the action plan period. The organizers of the activity are the Environment Agency and the Environmental Board, and the funding is provided from the state budget.

8.4.4 Media awareness monitoring and training

Priority: **II**
Risk factors: **7, 12, 13, 14** (Table 3, Chapter 6.2)

Large carnivores are a topic that has been the subject of many societal, public and inter-organizational disputes. The public media plays a big role in the coverage of topics and in directing debates. Unfortunately, it is easy to find examples in recent years where the treatment of large carnivores in the press has not been objective and unbiased. Since large carnivores are a topic that can easily cause social divisions (see also chapters 6.2.14, 8.4.6), media awareness plays a very important role in mitigating this risk.

During the period of the action plan, regular monitoring of media awareness and topic handling (e.g., survey and observation) is carried out every 2-3 years, and training for journalists and others is carried out according to the results of the monitoring studies. In advance, it is necessary to prepare a monitoring methodology. The goal is to ensure an objective and science-based treatment of large carnivores and awareness of the current situation among the creators of Estonian public media. Different types of media: TV, radio, newspapers, magazines, etc.; and various media sections: nature, science, rural life, hobbies, politics, society, daily news, etc., are included.

In addition, other interest groups that are directly related to or come into contact with large carnivores (including hunters, livestock owners, and beekeepers, see also chapters 8.7.2-8.7.4) also need regular training on large carnivores.

The activity will take place in 2022, 2024, and 2026 and the cost of the activity is 5,000 euros per year. The cost of the activity includes the salary of the trainers, together with travel expenses and taxes, 200 euros per day (a total of 25 working days per year), which is organized by the Environmental Board.

8.4.5 Involvement of volunteers in monitoring data collection

Priority: **II**
Risk factors: **1, 4, 5, 6, 7, 9, 14, 15** (Table 3, Chapter 6.2)

Interest in large carnivores is growing in Estonian society. The involvement of volunteers and citizen science in the monitoring of large carnivores would provide several advantages: it would be a good opportunity to popularize and learn about large carnivores; there will be an opportunity to create a parallel and independent data line with the monitoring data collected by hunters so far; a wider circle of participants allows more effective identification of system deficiencies and finding better solutions, etc. In addition to local volunteers, there is probably potential for involving nature tourists (including foreign tourists) in voluntary monitoring, but cooperation with tourism organizers is necessary for the organization thereof.

Similar experiences of other countries will be mapped, the feasibility of involving volunteers will be analyzed, and, accordingly, the capacity will be created to implement citizen science in the monitoring of large carnivores. It is likely that the information transmission channel for volunteers (e.g., Nature Observations Database, PlutoF/eBiodiversity) would be different from that of hunters (JAHIS). Therefore, the ability to reconcile different information flows is necessary. The activity will be started after the validation of the existing monitoring system (chapter 8.2.3) in parallel with the modernization of the monitoring system (chapter 8.4.3) or as a sub-activity of it. The activity will take place between 2024 and 2026, and the cost is 5,000 euros per year. The cost of the activity includes the cost of data analysis and report preparation (36 days, 140 euros per day), and the activity is organized by the Environment Agency.

8.4.6 Base survey and monitoring of public awareness and public opinion

Priority: **II**
Risk factors: **6, 7, 12, 13, 14, 15** (Table 3, Chapter 6.2)

Large carnivores are a topic that has been the subject of sharp societal and regional disputes and even conflicts. The societal gap of opinion (fear-love) currently seems to be the biggest for the wolf, smaller for the bear, and the smallest for the lynx. In a democratic society (like Estonia), public opinion has a very strong power in influencing public sector decisions. On the one hand, this is a good and desirable situation (one of the main features of a healthy democracy), but in a situation where popular public opinion does not match scientific "truth" or objective reality, there is a risk of ill-considered and even wrong decisions. Large carnivores have a relatively low abundance in Estonia (at the moment, especially wolf and lynx), and therefore these species are particularly sensitive to threats related to abundance (see also chapter 6.2). The consequences can be, for example, an increase in illegal hunting, strong political pressure to increase the hunting quotas to unreasonably and dangerously high levels, etc. Therefore, in the interests of both species conservation and social balance, it is very important to regularly monitor society's awareness and common opinions and attitudes in addition to the number of species and the state of the population.

A more comprehensive basic study and analysis will be carried out at the beginning of the action plan period, which will provide an overview of the situation and recommendations for further monitoring. In addition, relevant questions will be included in the MoE environmental awareness survey commissioned every two years[36].

The activity will take place in 2023, and the cost is 5,600 euros per year. The cost of the activity includes the cost of data analysis and report preparation (36 days, 140 euros per day), and the activity is organized by the Environment Agency.

8.4.7 Development of bear monitoring methodology

Priority: **III**
Risk factors: **1, 5, 6, 7, 8, 9, 10, 14, 15** (table 3, chapter 6.2)

[36] https://www.envir.ee/et/keskkonnahariduse-uuringud

Brown bear monitoring so far is mainly based on random observations and, therefore, methodically difficult to verify (see also Annex 2). A special feature of the bear compared to the wolf and the lynx is hibernation, which is why it is not possible to systematically collect bear track observations from the snow. However, the bear is more often in the field of view of the trail cameras near the feeding sites. Thus, the basic data of the current monitoring of the brown bear are significantly different from that of the wolf and the lynx.

At the moment, bear monitoring is based on random observations made by hunters (including observations of family groups). The most promising addition to the bear monitoring methodology would probably be based on trail cameras. In the event that bears monitoring remains based on random observations, then accurate basic information on the use of space by Estonian bears in different seasons (including the size of the home range) is necessary. In addition, information on the characteristics of the distributions of fertile age and life span, and litter size is necessary for assessing the state of the population. If these parameters are precisely known, the abundance could be estimated much more accurately than before based on random observations. The prerequisite for the development of a detailed monitoring methodology for the bear is a basic survey of the population (Chapter 8.2.9). Therefore, it is realistic to start specifying the bear monitoring methodology more thoroughly in the second half of the first half of the action plan, after the validation of the existing monitoring system (chapter 8.2.3) and in parallel with the modernization of the monitoring system (chapter 8.4.3) or as a sub-activity of it.

The activity will take place in 2024-2025, and the cost is at least (minimum) 5,600 euros per year. The cost of the activity includes the cost of data analysis and report preparation (40 days, 140 euros per day). The activity is carried out by interested parties, e.g., research institutions.

8.5 Damage prevention and management

8.5.1 Ensuring the existing damage prevention and compensation system

Priority: **I**
Risk factors: **6, 7, 10, 12, 14** (table 3, chapter 6.2)

Damage prevention and compensation activities will continue in their current form until the modernized system or parts of the system are completed and put into use (see chapter 8.5.3, 8.5.5). Pursuant to § 61 of the Nature Conservation Act, damage caused by large carnivores is compensated for up to 3,200 euros per person per year. Measures taken to prevent damage caused by large predators are reimbursed to the extent of 50%, up to 3,200 euros per year for one person. Regular monitoring/analysis of the effectiveness of the prevention and compensation system (see chapter 8.2.6) and, if required, making changes to the system is necessary. The activity is carried out annually. Each year, approximately 300,000 euros are planned for the compensation and prevention of damages caused by big carnivores. The organizers of the activity are the Environmental Board and the Ministry of the Environment, and the activity is financed from the state budget.

8.5.2 Update of guidance materials related to damages

Priority: **II**
Risk factors: **6, 7, 14** (table 3, chapter 6.2)

The instructional materials prepared by EB (T. Talvi) are reviewed and updated for the assessment of damages caused by large carnivores and for the establishment of preventive measures[37]. Before supplementing the instructional materials, it is recommended to carry out a study of the effectiveness of preventive measures (see chapter 8.2.6) and to make corresponding changes in the legislation (see chapter 8.3.3). The activity will be carried out in 2025, and the cost is 5,600 euros. The cost of the activity includes the cost of preparing instructional materials (40 days, 140 euros per day), and the organizer is the Environmental Board.

8.5.3 Increasing the operativeness and effectiveness of damage assessment and compensation

Priority: **II**
Risk factors: **6, 7, 14** (table 3, chapter 6.2)

In current practice, after damage to a domestic animal caused by a large carnivor, an EB specialist inspects the scene and makes an assessment of the species of the damager (e.g., wolf or dog) and the extent of the damage. The assessment is the basis for the compensation decision. Unfortunately, it can take up to three days for the damage assessor to arrive, sometimes more - for example, if the damage occurs on Friday, the damage assessment specialist will not arrive until Monday or Tuesday. Unfortunately, after such a long time, physical evidence at the scene is often lost or damaged (e.g., as a result of scavenging by other species, including ravens, crows, foxes, etc.). As a result, the reliability of the determination of the cause of damage, even by a specialist, is low.

On the basis of the action plan, readiness for EB for faster damage assessment - within one day, will be prepared. In addition, a protocol will be created, and training will be carried out, on the basis of which the animal breeder can record the scene and physical evidence (photos,

[37] https://www.keskkonnaamet.ee/et/eesmargid-tegevused/loomakahjud

samples, access barriers, etc.) and register the event before the arrival of the specialist. It is also important to ensure the high competence of damage assessors and thus, the reliability of the determination of damages. Misidentifications can cause unjustified negative public opinion towards large carnivores and unwanted ecological consequences for populations (see also chapter 6.2).

In the case of subsidies for preventive measures (e.g., anti-predator fences, livestock guarding dogs), the problem is that payments are made with a long delay (in March of the following year). Unfortunately, many small producers have little liquid resources (i.e., free money), and the long delay in the payment of benefits thus creates economic inequality. A procedure will be developed that will significantly increase the speed of payment of benefits for preventive measures. Among other things, the possibility of compensating the measures as an advance payment, e.g., on the basis of a construction project, is being considered.

Unfortunately, to the knowledge of the Estonian Sheep Breeders' Union, there have also been cases when benefits are used wastefully or not for the intended purposes. Such cases lead to inequality, resentment, and a loss of the image of the system in the eyes of other breeders and the public. On the basis of the action plan, control over the establishment and use of preventive measures will be increased. For example, the procedure is specified so that compensation for the prevention of predator damage is paid only for strictly targeted and effective preventive measures.

The preparation of the activity starts at the beginning of the action plan and is implemented, at least in a preliminary form, no later than in the third year of the action plan. The activity will be coordinated with the analysis of the effectiveness of preventive measures (Chapter 8.2.6). The organizers of the activity are the Environmental Board and the Ministry of the Environment, and the activity will be carried out from state budget funds.

8.5.4 Collection and analysis of DNA samples from damaged livestock

Priority: **II**
Risk factors: **6, 7, 14** (table 3, chapter 6.2)

In Estonia, a methodology has been developed to collect DNA samples from livestock damaged by predators and to determine the species of damage (wolf or dog; Plumer *et al.*, 2018). An important strength of the system is that the reference population is the dataset of Estonian wolves, which increases the accuracy of the methodology. Thus, the methodology enables accurate and reliable identification of the animal causing the damage. Unfortunately, this possibility has been used very little so far; most determinations of the damaging species are based on the specialist's visual observation and assessment. As a result, determinations of the animal causing the damage are relatively unreliable. There are known cases where the damage caused by other species (dog, jackal) is deliberately misidentified, stating that the wolf caused the damage - the motive is to obtain compensation for wolf damage. This, in turn, can lead to unjustified negative public opinion about the wolf and unwanted ecological consequences for the population (see also chapter 6.2).

In the course of the action plan, significantly more frequent DNA-based determination of the animal that caused the damage will be implemented. It will be carried out consistently throughout the entire action plan period; if necessary, preparations will be made in the first year to increase readiness, including instructions, training, sampling tools, agreements with laboratories performing the methodology, etc. The activity (collection of samples) takes place annually, the samples are analyzed in 2022, 2024, and 2026, and the cost of the activity is 5,600 euros per year. In the remaining years, the activity will be financed from the state budget. The cost of the activity includes laboratory costs, data analysis, and report preparation costs (40 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.5.5 Feasibility analysis and development of a carnivore damage insurance system

Priority: **III**
Risk factors: **6, 7, 14, 15** (Table 3, Chapter 6.2)

One of the disadvantages of carnivore damage compensation is the slowness of damage assessment and payouts, but also the fact that the state only compensates damages caused by large carnivores (wolf, lynx, brown bear) (due to their protection status in the EU), but not damages caused by other predators (including dogs, jackals, etc.)). This, in turn, can lead to a bias in damage definitions (or a desire for it) towards large carnivores, an unreasonably negative public opinion regarding large carnivores, and as a consequence, unwanted ecological consequences for populations (see also chapter 6.2). The creation and implementation of an insurance system for predator damage which would cover damage caused by other animals in addition to large carnivores, has been proposed as a possible solution. It is known that such a system exists, for example, in Latvia, where insurance covers damages caused by dogs and the state covers damages caused by large carnivores.

The activity is carried out in two stages in cooperation between animal breeders and local insurance companies: (1) analysis of the experience of other countries, solution options, and feasibility in Estonia; (2) implementation of the solution in Estonia that proved to be the most suitable as a result of the analysis. It is probably worth combining the activity with the analysis of the effectiveness of preventive measures (Chapter 8.2.6). It is possible that due to the zoning of large carnivore protection and management areas (Chapter 8.2.2, 8.6.1) or other circumstances, the participation of the state is necessary in some parts or in some cases. The activity will take place in 2023, and the cost is 4,200 euros. The cost of the activity includes the cost of data analysis and report preparation (30 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.6 Organization of conservation and management

8.6.1 Implementation of the procedure for protection areas and management areas

Priority: **II**
Risk factors: **1, 2, 3, 5, 6, 7, 9, 10, 14, 15** (table 3, chapter 6.2)

According to the feasibility analysis and planning of large carnivore protection and management areas (chapter 8.2.2), a pan-Estonian spatial procedure of hunting organization and conservation measures will be tested and implemented. Sufficiently large areas (i.e., with the extent of several home ranges) will be designated in all regions of Estonia, which contain high-quality habitats for each species and where the populations can naturally function as a full-fledged part of the region's biodiversity (so-called protection areas). The aim is to ensure the formation of a natural population and pack (wolf) structure.

Depending on the location of repeated damage and human settlements, management areas will be determined, and ≥ 75% of the hunting quota will be directed there. The purpose of hunting is primarily to prevent damage, and it is preferred to hunt nuisance individuals, if possible, immediately after repeated damage. In the case of bears, hunting is allowed only to prevent damage. It is probably necessary to match the system of damage prevention and compensation with the system of protection and management areas - including, for example, 100%

compensation for predator damage prevention measures in large carnivore protection areas. The zoning of large carnivore protection and management areas is used as a basis in other spatial plans, including green networks, infrastructure, real estate, land use, etc. (see also chapter 8.7.4).

The implementation of the system will be started in the third year of the action plan at the latest, interactively, in stages, and in parallel with the feasibility analysis and planning of the storage and control areas. Implementation of the system in its final form will probably take place in the last years of the action plan. Constant feedback and cooperation with different interest groups and parties (see also chapter 8.1.1), a clear and science-based decision-making system, and regional and public information (chapters 8.7.4, 8.7.5, 8.7.7) are necessary. The organizer of the activity is the Environmental Board; financing is provided from the state budget.

8.6.2 Improving information about bear winter dens

Priority: **II**
Risk factors: **1, 12, 13, 14** (Table 3, Chapter 6.2)

The existing and prospective information channels for informing EB and KAUR about the bear's winter den will be reviewed and improved - including the state helpline number 1247, JAHIS, Nature Observations Database, PlutoF/eBiodiversity, etc. If necessary, training will be organized for managers and dispatchers of information channels to receive and transmit information about a bear's winter den. An information campaign is organized for possible target groups: hunters, foresters, nature observers, hikers, etc. (see also chapter 8.7.4, 8.7.6). The information received about winter dens is necessary for the protection of hibernation sites (permanent habitat) as well as for the basic research of the bear population (chapter 8.2.9) and population monitoring (chapter 8.4.1, 8.4.3, 8.4.5). The action plan will be implemented at the beginning of the period, and the ability to receive and transmit messages will be maintained continuously and indefinitely. The organizer of the activity will be the Environmental Board, and the funding will be provided from the state budget.

8.7 Increasing knowledge and competence

8.7.1 Translation and presentation of the action plan

Priority: **II**
Risk factors: 1–15 (Table 3, Chapter 6.2)

This action plan will be translated into a foreign language (without the budget chapter) and published online in English and Russian. The previous two action plans for large carnivores have been published in the Estonian Teriological Society publication Eesti Ulukid (Lõhmus, 2002; Männil & Kont, 2012). The plan translated into a foreign language can also be used by officials, researchers, and interested parties of foreign institutions (including neighboring countries) dealing with large carnivores. It is advisable to introduce the action plan and its parts, as well as related ideas and the progress and debate of the implementation of the action plan in other professional and popular media channels (e.g., Eesti Jahimees, Eesti Loodus, ERR, etc.; see also section 8.7.4, 8.7.5, 8.7.7). Publication of the base studies provided for in the Action Plan (e.g., sections 8.2.1, 8.2.2, 8.2.4, 8.2.5, 8.2.6, 8.2.7, 8.2.9) as internationally peer-reviewed scientific articles will increase their credibility and weight as a long-term basis for applications. The activity will take place in 2022, and the cost is 8,400 euros. The cost of the activity includes the cost of foreign language translations (0.1 euros per word, the volume of the program is approx. 42,000 words, translation into two different foreign languages). The organizer of the activity is the Environmental Board.

8.7.2 Monitoring methodology training

Priority: **II**
Risk factors: **1, 6, 7, 9, 10, 14** (Table 3, Chapter 6.2)

"Hands-on" training will be organized for the collectors of basic monitoring data: hunters, volunteers, etc. The monitoring instructional materials prepared by KAUR will be reviewed and, if necessary, updated. Monitoring training must be combined with improving and developing the accuracy of monitoring methodology (chapters 8.4.3, 8.4.5, 8.4.7). Since hunters are obliged to collect initial monitoring data according to the current law (see chapter 2.5.2), it is justified that their training should be defined as vocational education, so the possibilities for conducting training are much wider. The training is held every 2-3 years; the years of taking the place of the training are 2023 and 2025, and the cost is 5,600 euros per year. The cost of the activity includes the cost of training (40 days, 140 euros per day). The organizer of the activity is the Environment Agency.

8.7.3 Training in damage prevention and damage management

Priority: **II**
Risk factors: **6, 7, 10, 14** (Table 3, Chapter 6.2)

Science-based "hands-on" training, exchange of experiences, and training for prevention of predator damage and action in case of damage will be organized. The target groups are animal breeders, damage management specialists, and hunters. During the training, a network of damage- support persons and the readiness of potential sufferers to quickly reach a claim-handling specialist will be created. The activity will be coordinated with the analysis of the effectiveness of preventive measures (chapter 8.2.6) and the modernization of the instructional materials for damage prevention and treatment (chapter 8.5.2). The training is held every 2-3 years (years of training: 2022, 2024, 2026, cost 5,600 euros per year). The cost of the activity includes the cost of training (40 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.7.4 An introduction to the principles and applications of game and population biology

Priority: **III**
Risk factors: **7, 8, 9, 14** (Table 3, Chapter 6.2)

A series of seminars and training will be organized to introduce various target groups to the basic knowledge and applications of game and population biology, as well as the plan, activities, and procedures prescribed by the large carnivore action plan. The aim is to increase awareness and understanding, spread the use of science-based ecological principles in various fields and popularize the topic of large carnivores. Training and information days for hunters have been organized several times in the past, but awareness is still too low. It seems that it is not an unwillingness to understand, and therefore the regular repetition of the training is justified. Also, the scientific understanding of large carnivores and the Estonian population is constantly developing (see also chapter 8.2, 8.4) - therefore, a direct information channel is necessary to reach the communities that come into contact with large carnivores. Since hunters are far from the only circle that comes into contact with large predators, training for other target groups is also justified. The training is divided into two broad parts according to the level of professional training and tasks of the target groups:

(1) specialists - including monitoring specialists, volunteer monitors, hunters (see also chapter 8.7.2), animal breeders, damage assessors, support persons in cases of damage, professional and voluntary founders of preventive measures (see also chapter 8.7.3), local governments (including managers, planners, environmental specialists, etc.), EIA experts, space planners, teachers (including in kindergartens and hobby groups), nature guides, animal protectionists, journalists (see chapter 8.4.5) and others;

(2) the public and the progeny - including kindergarten children, pupils, students, nature lovers, enthusiasts, and the general public.

Among the target groups, hunters are the largest group in direct contact with large carnivores, and hunters are also required to collect initial monitoring data (see chapter 2.5.2). Therefore, training for hunters must be defined as vocational education, so the possibilities for conducting training are much wider, including state funding and definition as a conservation priority. It must be clarified whether cooperation with the Ministry of Education and Research is necessary for this. Strategically, it is important, including for the introduction of pan-Estonian protection and management areas (chapters 8.2.2, 8.6.1), to organize training for the compilers of the green network, general plans and thematic plans with a large spatial scale, and EIA.

As mentioned above (chapter 3.3), an important target group is also the nature guides, who need to be trained more in order to avoid possible threats and problems, and for this, the relevant instructional materials must be prepared.

The training of the aforementioned second target group is combined with social awareness and public opinion monitoring (Chapter 8.4.6). Various pieces of training are spread over the entire period of the action plan, but within the limits of the target groups, training events can take place every 2-3 years. The years of the event are 2022, 2024, and 2026, which cost 5,600 euros per year. The cost of the activity includes the cost of training and preparation of materials (40 days, 140 euros per day). The organizers of the activity are those interested in the topic.

8.7.5 Seminars on natural culture and social vision

Priority: **Priority III**
Risk factors: **14, 15** (Table 3, Chapter 6.2)

An annual series of natural culture and social vision seminars will be organized. The goal is to conceptualize, debate, and create socio-cultural solutions on how to live peacefully in the same landscapes today with natural, viable, and ecologically functioning large carnivore populations. The series of seminars is an information exchange and discussion platform parallel to the large carnivore cooperation council (chapter 8.1.1), but with a wider group of participants, with a different focus and angle of approach in many ways and bringing together several other parties. The activity is, among other things, necessary to make sense of public opinion and cultural phenomena and to raise awareness of possible social threats (see also chapter 6.2.14), as well as to form a long-term perspective and goal. Certainly, also to increase social cohesion. The years of the event are 2022, 2024, and 2026, which cost 5,600 euros per year. The cost of the activity includes the cost of training (40 days, 140 euros per day). The organizers of the activity are those interested in the topic.

8.7.6 Introducing the problems of orphaned bear cubs and proposing good solutions

Priority: **III**
Risk factors: **12, 13, 14** (Table 3, Chapter 6.2)

Through various media channels (homepages and websites of institutions, Loodusveeb, social media, ERR, newspapers, magazines, etc.), the public will be informed about what to do if a bear's winter den or bear cubs are found (see also chapter 8.6.2). The information will constantly be kept available on the websites, and the activity will be repeated as a small-scale campaign every three years; the time of occurrence is 2023 and 2026, costing 4,200 euros per year. The cost of the activity includes the cost of preparing the materials (30 days, 140 euros per day). The organizer of the activity is the Environmental Board.

8.7.7 Presentation of large carnivores in public media and information days

Priority: **III**
Risk factors: **7, 11, 12, 13, 14** (Table 3, Chapter 6.2)

If possible, relevant and objective information on the subject of large carnivores will be broadcast in various information and media channels (websites, Loodusveeb, social media, ERR, newspapers and magazines, displays, expositions, exhibitions, etc.) and information events (seminars, information days, etc.; see also chapter 8.4.4, 8.4. 6, 8.7.1, 8.7.4, 8.7.6). The goal is to create a positive and knowledge-based media background and a favorable environment for increasing social awareness of large carnivores, their related problems, and solutions and for the popularization of large carnivores. As a result, threats caused by unstable public opinion will decrease (see chapter 6.2.14), and social cohesion will increase. It will be carried out on a small scale, consecutively and indefinitely; the years of the event are: 2022, 2024, and 2026, and cost 4,200 euros per year. The cost of the activity includes the cost of preparing the materials (30 days, 140 euros per day). The organizers of the activity are those interested in the topic.

9 Evaluation of the performance of conservation and management

The plan for the conservation and management of large carnivores has set three basic conservation goals: (1) favorable status of populations, (2) damage prevention, and (3) science-based and objective knowledge and societal competence. For the first two, the following measurable goals (metrics) have been set. No quantitative measures are set for knowledge and competence.

1. The most important target metrics of the Estonian population are (1) the number of reproductive units before the hunting season, i.e., females with offsprings born in the previous winter or spring, and (2) the number of adults (breeding age) individuals in the spring, after the hunting season, i.e., the size of the base population (without juveniles). By species, the threshold values are as follows:

Wolf – number of wolf packs with pups under one year old before the hunting season: 20–30;

Lynx – number of females with kittens under one year old before the hunting season: ≥ 80;

Brown bear – number of females with cubs under one year old before the hunting season: **≥ 70.**

In the case of the lynx, the spring number of individuals of breeding age, or the so-called base population, is ⩾ 350 individuals, and in the case of the brown bear, ⩾ 650 individuals. In the case of wolves, a base population size of ⩾ 140 individuals must be achieved during the implementation period of the plan, preferably within five years. The calculation of the base population's minimum level is based on the 3-year average.

The number of adults after the hunting season accounts for approximately 50-60% of the total population after the breeding season in the case of the wolf, approximately 55-60% in the lynx, and approximately 75-80% in the brown bear. The ratio between the number of litters and the total number after the autumn breeding season is calculated to be approximately 1:10 for the wolf, approximately 1:6 for the lynx, and approximately 1:10 for the brown bear (see also Annex 2, current monitoring methodology). In the case of the wolf, it has been calculated that the proportion of individuals not belonging to the packs in autumn is expected to be around 15–20%.

2. Prevention activities of damage caused by large carnivores can be considered successful if the frequency of damage to the total number of Estonian livestock (sheep, goats, beef cattle, etc.) and bee colonies are at the same level or lower than at present. In addition to farm animals, it is also important to monitor and reduce attacks on dogs and other domestic animals. The threshold numbers for evaluating the performance of activities are as follows.

Sheep and goats - the number of animals damaged by large carnivores over a year are **≤ 1%** of the total number of sheep and goats registered in Estonia in the same year (according to ARIB calculations). If more precise data is not available, approx. 85 000 animals as the calculated total number of sheep and goats should be used, and in this case, the total number of damaged sheep and goats within a year should be ⩽ 850.

Beef cattle - the number of animals damaged by large carnivores within a year is **≤ 0.03%** of the total number of beef cattle registered in Estonia in the same year (according to ARIB calculations). If more precise data is not available, the approx. 80 000 animals as the calculated total number of beef cattle should be used, and in this case, the total number of beef cattle damaged within a year should be ⩽ 24.

Bees - the number of bee colonies damaged by large carnivores within a year is **≤ 0.6%** of the total number of Estonian bee colonies in the same year (according to ARIB and Statistical Office's calculations). If more precise data is not available, ca. 50 000 hives as the estimated total number of bee colonies should be used (Pulver *et al*., 2018), and in this case, the total number of bee colonies damaged within a year should be ⩽ 300.

3. Objective quantitative, as well as qualitative assessment of public awareness and district competence is a very difficult goal. To assess this, it is advisable to use the assessments of different parties, including animal breeders, hunters, conservationists, and scientists. If possible, it is advisable to use different existing metrics for evaluation, and quantitative metrics can also be developed according to the question and the situation.

The conservation and management of large carnivores can be considered effective if, in addition to the aforementioned metrics, the natural populations of all three large carnivore species are connected both within Estonia and with neighboring areas, and the Estonian populations are continuously viable in the long term (the probability of extinction in the next 100 years is < 5%). The activities that support the achievement of the goals are: international information exchange and cooperation in the conservation and management of communities (certainly with Latvia and Russia and at the EU level, but also more broadly); preferential hunting of nuisance specimens in damaged areas; illegal hunting is minimized; sufficiently large areas (i.e. with the extent of several home ranges) have been designated that contain high-quality habitats for each species and where the populations can function naturally as a full part of the area's biodiversity; the determination of management areas is based on the real location of damage and settlements, and the vast majority (≥ 75%) of hunting is concentrated in these areas; the zoning of large carnivore protection and management areas is used as a basis in other spatial plans, including the green network, infrastructure, real estate, land use, etc.; at the state level, various effective preventive activities (electric fences, livestock guarding dogs, etc.; see also chapter 6.3.2) are preferred, compared to compensation for damages; the cost of damage prevention is much higher (≥ 2 times) compared to damage compensation; in case of repeated damages, the prerequisite for damage compensation is the implementation of preventive measures, but there may be exceptions in areas where large carnivores are kept; a cooperation council uniting various parties, including hunters, animal breeders, conservationists, scientists, communities, conservation and management organizers, etc., which deals with information exchange, negotiations, conflict resolution, goal setting, advising on national decisions, etc., and which meets regularly (presumably several times a year); different interest groups participate in the collection of basic data for management decisions (including hunters, volunteers and professional nature observers, researchers); on the basis of the existing system, a modernized and as accurate, clear and operational monitoring methodology as possible has been developed and implemented (methods based on trail cameras and/or DNA analyzes and/or machine learning, etc., specifying and supplementing the observation information); basic studies of population abundance, vitality and structure have been carried out for all three species; the error of population abundance estimation is at most ±10% (a higher error rate is allowed if the abundance is significantly higher than the set target level, see chapter 6.3.1);

as a common understanding in society, large carnivores are not seen as an enemy, but as an integral part of the Estonian nature and ecosystem, with whom it is natural to live together in the same landscapes today, parties in direct contact with large carnivores (hunters, rangers, animal breeders, etc.) are trained, competent and recognized in their field; authorities and spatial planners (local governments, general and detailed plans, green network, environmental impact assessment, etc.) are trained and aware of large carnivores, their peculiarities, and related topics.

The organization of the conservation and management of large carnivores can be considered effective if the priority I and II activities provided for in the plan (see chapter 8) have been implemented.

This action plan for the conservation and management of large carnivores contains the best available scientific information about the state of large carnivore populations in Estonia. During the next ten (five) years, the organization of the conservation and management of large carnivores will be based on this plan. At this point, it is assumed that by following the action plan and applying the results of monitoring and research in organizing the conservation and management of the populations, the favorable conservation status of the populations will be achieved. The best assessment of the effectiveness of the implementation of the plan is, therefore, the status of the population. At the same time, it is also necessary to evaluate the effectiveness of the various activities of the action plan and their impact on maintaining the favorable conservation status of the populations. The performance of the plan is evaluated at different levels at different steps:

1. A game monitoring report is prepared every year, assessing the status of the populations and the changes that have occurred in them and describing their presumed causes. In the reports prepared by the Environment Agency, the status of the populations is assessed in chapter 2.5.2 of this plan on the basis of the outlined monitored parameters. The report is required annually in connection with the need to manage these species and enable their use in hunting. The parameters monitored by game monitoring are also sufficient to fulfill the requirements arising from the EU Nature Directive.

2. According to the European Union (EU) Nature Directive (92/43 EEC), every six years, the member states submit reports to the European Commission (EC) on the state of the populations of the species included in the annexes of the directive, which also include the wolf, lynx, and bear. Reports must include species range (based on 10×10 km ETRS 89 grid in ETRS LAEA 52 10 projection), size of populations and habitats, and trends. In addition to these indicators, the reports must also state risk factors and future forecasts. Reports must be based on monitoring data, not expert opinions. The EC prepares summary reports on the status of species for the EU based on the reports of the member states. During the implementation period of this plan, the obligations to submit the corresponding report are in 2025 and 2031.

3. A summary assessment of the plan's activities will be given at the end of the plan's implementation period as part of the preparation of a new plan in 2031. An interim assessment of the performance of the activities will be given during the update of the action plan in 2026.

4. At the end of the fixed-term activities, an assessment of its effectiveness is given in the final report of the corresponding activity by the person conducting the activity.

10 Time schedule and budget

The following table 4 presents the schedule and budget for the first five years (2022-2026) of activities foreseen by the plan for the conservation and management of large carnivores. The activities, schedule, and budget for the second half of the entire ten-year period (2027–2031) will be prepared in 2026 during the update, interim report, and analysis of the action plan (see chapter 8.3.1).

Table 4. In the first half of the action plan, the schedule and estimated cost of large carnivore conservation and management activities are planned for the years 2022-2026. Prices (in hundreds of euros) include all costs and taxes except VAT. Designation: x – the activity is planned on the basis of state budget funds, and the need for resources becomes clear during the planning of a specific activity. The table continues on the following pages.

	Activity	Possible organizer	Priority	2022	2023	2024	2025	2026	Total
1	**Cooperation and professional exchange of information**								
1.1	Formation and implementation of the cooperation council of large carnivores	MoE	I	x	x	x	x	x	
1.2	International information exchange and cooperation	MoE, KAUR	II	x	x	x	x	x	
1.3	Supporting and developing the activities of various cooperation networks	those interested	III	x	x	x	x	x	
2	**Basic and applied research**								
2.1	Specifying the abundance and analysis of the viability of the populations	EB, KAUR	II	•	•	740	•	•	740
2.2	Feasibility analysis and planning of protection and management areas	EB	II	•	50	50	•	•	100
2.3	Validation of the existing monitoring system	EB, KAUR	II	x	•	•	•	•	
2.4	Analysis of telemetry data of the use of space by a wolf and continued data collection	KAUR	II	200	200	200	200	200	1000
2.5	Survey of the illegal removal of large carnivores from the wild	EB	II	20	20	•	•	•	40
2.6	Analysis of the effectiveness of compensation and prevention measures	EB	II	20	•	•	20	•	40
2.7	A study of the genetic cohesion of populations with neighboring areas	EB, KAUR	II	•	50	50	50	•	150
2.8	Risk assessment and analysis of the population of large carnivores	EB	II	56	•	•	•	•	56
2.9	Base study of the bear population	those interested	III	•	•	740	740	740	2220
3	**Development of legal field**								

3.1	Evaluation of the performance of the action plan for large carnivores and update of the plan	EB	I	•	•	•	•	50	50
3.2	Increasing penalty rates for illegal hunting	MoE	I	•	•	x	x	•	
3.3	Reviewing and correction of the legislation on large carnivore damage	MoE, EB	I	•	x	•	•	•	
3.4	Determining the identity of a large carnivore found dead and killed in a traffic accident	MoE, EB	I	x	x	•	•	•	
3.5	Improving the control over the handling of agricultural animal remains	MRA	II	x	x	•	•	•	
3.6	Legal analysis of a large carnivore raised under human care	MoE	III	•	40	•	•	•	40
3.7	Creating legal status for herding dogs beyond pet status	MRA, MoE	III	x	•	•	•	•	
4	**Continuation of monitoring and development of the monitoring system**								
4.1	Maintaining the existing monitoring system	KAUR	I	x	x	x	x	x	
4.2	Development of hunting information system	EHS, MoE	II	50	50	50	50	50	250
4.3	Modernization and refinement of the monitoring methodology	KAUR, EB	II	x	x	x	x	x	
4.4	Media awareness monitoring and training	EB	II	50	•	50	•	50	150
4.5	Involvement of volunteers in monitoring data collection	KAUR	II	•	•	50	50	50	150
4.6	Base survey and monitoring of public awareness and public opinion	KAUR	II	•	56	•	•	•	56

4.7	Development of bear monitoring methodology	those interested	III	•	•	56	56	•	112
5	**Damage prevention and management**								
5.1	Ensuring the existing damage prevention and compensation system	EB, MoE	I	3000	3000	3000	3000	3000	15000
5.2	Update of guidance materials related to damages	EB	II	•	•	•	56	•	56
5.3	Increasing the opperativness and effectiveness of damage assessment and compensation	EB, MoE	II	•	x	x	•	•	
5.4	Collection and analysis of DNA samples from damaged livestock	EB	II	56	x	56	x	56	168
5.5	Feasibility analysis and development of a carnivore's damage insurance system	EB	III	•	42	•	•	•	42
6	**Organization of conservation and management**								
6.1	Implementation of the procedure for protection areas and management areas	EB	II	•	•	x	x	x	
6.2	Improving information about bear winter dens	EB	II	x	•	•	•	•	
7	**Increasing knowledge and competence**								
7.1	Translation and presentation of the action plan	EB	II	84	•	•	•	•	84
7.2	Monitoring methodology training	KAUR	II	•	56	•	56	•	112
7.3	Training in damage prevention and damage management	EB	II	56	•	56	•	56	168
7.4	An introduction to the principles and applications of game and population biology	those interested	III	56	•	56	•	56	168
7.5	Seminars on natural culture and social vision	those interested	III	56	•	56	•	56	168

7.6	An introduction to the problem of orphaned bear cubs and good solutions	EB	III	•	42	•	•	42	84
7.7	Presentation of large carnivores in public media and information days	those interested	III	42	•	42	•	42	126
Total				3746	3606	5252	4278	4448	21330

Tabel 5. Budget breakdown by priority (in hundreds of euros).

Priority	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
I	3000	3000	3000	3000	3050	**15050**
II	592	482	1302	482	462	**3320**
III	154	124	950	796	936	**2960**
Total	**3746**	**3606**	**5252**	**4278**	**4448**	**21330**

11 Definitions and abbreviations

Population - a set of individuals of the same species living together in the same area.

Favorable conservation status of the population - the status of a population or species is considered favorable if: (1) its abundance and its changes are such as to indicate the ability of the population to sustain itself over a longer period of time; (2) the population's natural range has not declined and is unlikely to decline in the future; (3) the species-specific habitat is sufficiently widespread to ensure the persistence of the population;

DNA - Deoxyribonucleic acid; hereditary material of living organisms, on the basis of which it is possible to identify or assess the origin and kinship of individuals, the state and perspectives of populations, etc.

eBiodiversity – a biodiversity information website managed by the University of Tartu, which works on the PlutoF platform; https://elurikkus.ee.

EHS – Estonian Hunters' Society, a non-governmental organization, is uniting regional hunting organizations; https://www.ejs.ee.

EU – European Union, an economic and political association, including nature conservation policy, bringing together 27 mainly European countries; https://europa.eu.

EASGB– Estonian Association of Sheep and Goat Breeders; a non-profit association is uniting about 180 Estonian sheep and goat breeders; the members own about 20% of Estonian sheep, including many sheep kept for nature conservation purposes (maintenance of semi-natural communities); https://lammas.ee.

Habitat loss - reduction of habitat area; mostly occurs with habitat depletion and/or fragmentation; see also "habitat."

Habitat fragmentation – the division of a continuous habitat area into several smaller parts, the number of habitat patches increases; occurs mostly together with habitat degradation and loss, but can also occur almost independently (e.g., as a result of building a fence through the habitat); see also "habitat."

Habitat degradation - a decrease in the suitability (quality) of the habitat; this may not involve loss of habitat area or fragmentation, but these three processes often occur together; see also "habitat."

Habitat - an area within which the conditions, resources, and other factors necessary for the long-term survival and reproduction of a species exist; is a species-specific term; note that some parts of the habitat may be temporarily or permanently uninhabited by the species (although the conditions are present) and individuals may stay outside the habitat for short periods.

EUROPARC - Protected areas of the European Union; https://www.europarc.org.

Genetic diversity - is the number of different variants (e.g., alleles) of hereditary material (DNA) that can be measured: (1) in the genome of the same individual, (2) across individuals within a population, and (3) across different populations within the range of a population or a whole species.

IUCN - International Union for Conservation of Nature, an association of government agencies and civil associations, and experts whose goal is the protection of the natural environment and biodiversity; compiles and manages the IUCN Red List of Threatened Species; www.iucn.org.

JAHIS- Hunting information system, software for managing hunting documentation and collecting and transmitting game monitoring data developed by EHS; https://jahis.ejs.ee.

KAUR - Environment Agency; a state institution that collects, analyzes, and mediates environmental data; https://www.keskkonnaagentuur.ee.

EB – Environmental Board; the state institution that implements the state's policy of environmental use, nature conservation, and radiation safety; https://www.keskkonnaagentuur.ee.

MoE – Ministry of the Environment, a government agency that organizes environmental and nature conservation and the use of natural resources; https://www.envir.ee.

EIA - environmental impact assessment is the description and assessment of the expected impact of the planned activity, the analysis of mitigation measures for negative impacts, and the selection of the most appropriate solution option.

Repetitive damage – repeated attacks of a large predator of a similar nature (i.e., the same individual) in the same area, within a relatively short period of time on domestic animals or damage caused by them to other property; by calculation, situations, where similar cases of damage occur at least 3 times within a month within a distance of about 10 km, are considered repeated damage.

LG - local government.

LCIE - Large Carnivore Initiative for Europe; a group of specialists aiming at the coexistence of humans and viable and wild large carnivore populations in Europe; https://www.lcie.org.

Loodusveeb – the website of KAUR and other MoE administrative authorities, which brings together information and news related to the biodiversity of Estonia; https://loodusveeb.ee.

NOD – Nature Observations Database managed by KAUR and related website and smartphone application; https://lva.keskkonnainfo.ee.

Nuisance individual - a large carnivore specimen that has caused repeated damage; by calculation, situations where similar cases of damage occur at least 3 times within a month within a distance of about 10 km, are considered repeated damage.

Peer review - a quality management system for research and development work, during which an independent expert (or several) with similar competence to the author of the work reviews the work, gives an assessment, and points out the shortcomings and strengths of the work; the goal is to ensure the reliability of the finished work.

PlutoF – nature observation software platform, database, and related website and application managed by the University of Tartu; see also "eBiodiversity"; https://plutof.ut.ee.

Population - a collection of individuals of one species living together in the same area and interbreed freely, which is spatially separated from other populations, but individuals may move from one population to another.

Population viability analysis - a set of different methods that provide a species-specific risk assessment due to the characteristics of the population or population and natural and anthropogenic environmental conditions; usually, the result is an estimate of the probability of extinction or decline in abundance of a population for a specified time period (e.g., 10, 20 or 100 years after the estimate).

ARIB - Agricultural Registers and Information Agency; a state institution that collects, analyzes, and mediates data and information related to agriculture and rural life; https://www.pria.ee.

Trail camera – image and/or video recording device with motion sensor trigger; in recent years, there has been widespread use of non-human presence detection and tracking of game.

Big game - including large carnivores, are game within the meaning of the Hunting Act, for which a separate hunting permit is issued for hunting each individual; according to the Hunting Act, big game are moose, red deer, roe deer, wild boar, brown bear, wolf, lynx and gray seal.

TalTech – Tallinn University of Technology; https://taltech.ee.

UT – University of Tartu; https://www.ut.ee.

Game - a mammal or bird, sometimes also reptiles and amphibians living freely in nature; hunting game, i.e., a game that is or has traditionally been hunted, is often distinguished.

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13 Annexes

Annex 1. An abundance estimate based on the results of a genetic study of the wolf.

File: reWiLD_2021_Suurkiskjate_KOK_Lisa_1_Hundi_arvukuse_hinnang.pdf

Annex 2. Description of the current monitoring methodology of large carnivores, wolves, lynxes, and brown bears.

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Annex 3. Implementation of activities planned for 2012–2021.

File: reWiLD_2021_Suurkiskjate_KOK_Lisa_3_ 2012–2021_tegevste_teostamine.pdf