No. 12

ESTONIAN

G A M E

ACTION PLAN FOR CONSERVATION AND MANAGEMENT OF LARGE CARNIVORES (wolf *Canis lupus*, lynx *Lynx lynx*, brown bear *Ursus arctos*) IN ESTONIA IN 2012–2021

Compiled by
Peep Männil and Raido Kont

Estonian Ministry of the Environment 2012

EESTI ULUKID on Eesti Terioloogia Seltsi aperioodiliselt ilmuv väljaanne, kus avaldatakse nii teaduslikke kui ka rakendusteaduslikke terioloogilisi artikleid, kanverentsimaterjale, liikide kaitse- ja ohjamise tegevuskavasid jt laiale lugejaskonnale mõeldud kirjatükke, mis käsitlevad Eesti imetajaliikidega seotud temaatikat.

ESTONIAN GAME is irregularly published bulletin of Estonian Theriological Society, whish contains scientific and other theriological articles, conference papers, action plans and other written material that meant for wider public.

Eesti Terioloogia Selts (ETS) asutati 1980. aastal. Alates 1991. aastast on selts iseseisev üksus Eesti Looduseuurijate Seltsi allüksusena. ETS'i peamisteks ülesanneteks on aidata kaasa terioloogide vahelise informatsiooni vahetusele ja tutvustada imetajatega seonduvat laiemale avalikkusele.

Eesti Terioloogia Selts publitseerib aperioodilisi väljaandeid "Eesti ulukid" ja "Folia Theriologica Estonica".

The Estonian Theriological Society (ETS) *was founded in 1980. Main goals of ETS are to facilitate information exchange between theriologists and popularize issues concerning mammals to wider public.*

Postiaadress/*Mailing address*: Struve 2, Tartu 51003, Estonia

Kaanefoto: Valeri Štšerbatõh

Käesoleva trükise väljaandmist toetab SA Keskkonnainvesteeringute Keskus

ISSN 1406-9075

CONTENTS

INTRODUCTION

In earlier times humans and large carnivores used the same habitats as equal competitors. With rise of human population and improvement of weapons humans gained superiority over large carnivores and started to push them out from their common habitats. By the beginning of the 20th century the process had taken quite a wide effect: populations of several species were hunted to extinction and others were pushed into larger remaining forest massifs. By the end 20th century advances in knowledge formed perception of top predators as a significant and crucial component of ecosystems (Schwartz et al., 2003).

By present time several scientific papers have revealed the significant effect of large carnivores' on functioning of ecosystems. Their importance have been proved in maintenance of biodiversity, limiting the spread of infectious diseases and alien species (Ritchie & Johnson 2009), but also in securing physical and chemical states of soil, water and air (Estes et al., 2011). Top predators have played and still have important evolutionary role in development and maintaining viable populations of their prey species. Advances in knowledge have brought about a U-turn in public opinion and today efforts are taken to preserve or restore favourable status of large carnivores which were once hunted by all means to deplete their populations.

Regardless of efforts to propagate usefulness and importance of large carnivores they are still perceived as competitors in use of common natural resource. Predation on both livestock and game ungulates reduces expected profits while foraging behaviour and physical fitness of those animals pose, at least theoretically, also a threat to human safety. Because of those reasons large carnivores are often regarded as unwanted neighbours or their numbers are preferred to keep low.

Being on top of the food web, predator numbers are naturally low compared to the lower levels of food chain and their home ranges are extensive. This makes conservation of large carnivores by established protected areas insufficient. Additional measures need to be taken also in areas which are subject to human economy (Linnell et al., 2001). In Europe, large carnivores are relatively rare and in need of strict protection while in Estonia they are still common and also listed as game species. Based on these above mentioned reasons, conservation and management of large carnivores in Estonia is a bigger challenge than it is for the majority of other local species.

In European Union wolf, lynx and brown bear are protected by the Habitat Directive with application of both habitat and individual protection. During the accession negotiations Estonia suggested removal of all three large carnivores from Annex II (habitat protection of enlisted species) and Annex IV (strict individual protection of enlisted species) and inclusion them to Annex V (where enlisted species can be harvested in controlled conditions). Estonia declared during the accession negotiations, that relevant management plans will be compiled to secure protection of large carnivores. In year 2000, management plans were compiled by the European Commission for European wolf, lynx and brown bear populations which proposed compilation of analogous plans in all EU countries where the species occur (Boitani, 2000; Breitenmoser et al., 2000; Swenson et al., 2000).

Current conservation and management plan is based on Estonian Nature Conservation Act § 49 sections 2 and 3, respectively:

§ 49. Action plan for conservation and management of species

(1) An action plan will be prepared for:

1) organization of the protection of a species in the protected category I;
2) ensuring the favourable conservation status of a species, if the results of the species inventory indicate that the current measures fail to do so, or if prescribed by an international obligation;
3) management of a species if the results of the species inventory indicate a significant negative impact to the environment caused by the increase in the population of the species, or a danger to the health or property of persons.

(2) An action plan shall include:

1) biological data, population dynamics data and information about species range;
2) conditions for guaranteeing the favourable conservation status of an endangered species;
3) risk factors to the species;
4) the objective for conservation or management;
5) the priority of measures for achieving a favourable conservation status or management of the species, and a schedule for application thereof;
6) the budget for organization of conservation or management.

(3) The action plan will be established by the Minister of the Environment.

(4) The action plan will be published on the website of the Ministry of the Environment.

Current plan is a follow-up to previous compilation, regulating conservation and management of large carnivores during years 2002–2011 (Lõhmus 2001) which was the first relevant document for Estonia. Since commencement of the first plan several changes have taken place, particularly a significant improvement of knowledge about status of large carnivores. These advances are based on numerous research projects conducted in Europe and results of population monitoring designed and carried out in Estonia.

The aim of this plan is to secure favourable population status of wolf, lynx and brown bear on the levels of Estonian and Baltic populations in both short (10 yr.) and long (30 yr.) time perspectives and with consideration of ecological, economical and social aspects. To achieve this, both risk factors and management need determinants are presented together with possible mitigation methods and their applications.

The conservation and management plan is compiled by Peep Männil and Raido Kont (Estonian Environment Agency) with assistance from Dr. Tiit Maran (Estonian Theriological Society, Tallinn University), Dr. Jaanus Remm and Dr. Riinu Rannap (University of Tartu), also Tõnu Traks, Hanno Zingel, Andres Talijärv, Üllar Rammul, Egon Niittee and Tarmo Aasmaa (Ministry of Environment), Agu Leivits and Uno Treier (Estonian Environmental Board), Andres Lillemäe (Estonian Hunters Society), Tiit Randla (expert) and Inga Jõgisalu, Marko Kübarsepp, Rauno Veeroja and Lauri Klein (Estonian Environment Agency).

EXECUTIVE SUMMARY

The current large carnivore conservation and management plan is a follow-up to a previous version for years 2001–2011. The document has been compiled in accordance with Estonian Nature Conservation Act.

During the period of preceding plan the population sizes and ranges of all three large carnivore species have increased due to the taken measures. Still, wolf and lynx numbers have slightly decreased since 2009, but it has been a planned change related to significant increase in wolf damages and in case of lynx the major decline in its main natural prey (roe deer) population. Present status of all large carnivore populations in Estonia is considered to be good.

The plan defines risk factors to favourable conservation status together with determinants of required management measures. The main risk factor for wolf is unfavourable public opinion which results in pressure to increase hunting quotas and/or elevated poaching. Lynx suffers from deficit of natural prey species which may lead to a decline in population numbers together with anthropogenic pressure to increase the quotas and/or increased poaching activities. The main risk factor for brown bear is selective hunting which may lead to increased natural mortality. The most important determinant for management of wolf is mitigation of damage, for lynx securing the prey availability and for brown bear maintenance of shyness towards humans together with decreasing the extent of damages.

Long (30 y.) and short (10 y.) term aims are set in the plan. The long term aims are to maintain wolf, lynx and brown bear populations in a favourable conservation status while also considering the ecological, economical and social aspects. This is achieved by maximizing species distribution range in suitable habitats, keeping population size optimal and demographic structure as well as behaviour and food base as natural as possible to maintain the viability, ecological functionality and evolutionary potential of the species. At the same time predator damages to agriculture and other property are minimized. The aim is also to keep large carnivores in the list of game species together with increased awareness and people's positive attitude towards these animals. Estonian large carnivore populations are considered to be a part of Baltic populations, so conservation and management actions are planned in accordance to have a wider positive impact also on level of Baltic population.

The aims for the period 2012–2021 are:

- Maintaining the wolf population at the level of 15–25 annual breeding packs (relevant to population size of 50–250 individuals) and lynx population at the level of 100–130 annual reproductions (relevant to population size of 600–780 individuals) before the beginning of hunting season (autumn). The aims for the annual population sizes are defined within this range according to current monitoring results and hunting is applied to keep the population within this range;
- Maintaining brown bear population with 60 annual reproductions (relevant to population size of 600 individuals), whereas hunting helps to maintain fear towards humans and minimize the damages. Expansion of bear range southwards is favoured;
- Reducing the extent of damages caused by large carnivores by effective means developed to protect property and targeting management practices to regions where major damages occur;
- Rising people awareness and promoting more favourable attitudes towards large carnivores.

In the current plan target population size is expressed as number of reproductions which leads to calculated population sizes in autumn. Number of reproductions is a directly monitored parameter which reflects both the population size and trend and is better applicable to conservation and management measures than the earlier used spring population size.

The plan presents seven measures which are targeted to achieve the aforementioned goals: change of legislation, carrying out and developing regular monitoring, applied research, damage recording and processing, population regulation, awareness rising, public opinion improvement and international cooperation. There are 39 different actions planned to the first 5 year period, the actions are scheduled and prioritized into three categories. There are 4 highest priority actions (class I, inevitable actions for plan fulfilment): maintenance of monitoring at least in a current level, preservation of the current general management principles, continuing compensating the costs for damages and damage prevention and renewing the action plan. There are 29 actions of the second priority category (activities necessary to improve achievement of the set aims) and 6 actions of the third category (recommended activities which support the aims indirectly). The most resource consuming activities are applied research among which the studies of wolf and lynx movements and habitat use are the biggest. Extensive activities are also improvement of monitoring system, development of damage handling procedures and promoting positive public opinion. Substantial part of activities, including the highest priority activities are carried out by state institutions and are covered by their budgets. For the period of 2017–2021 the list of activities and budgets are updated in 2016 with revision of the paragraphs related to specific activities. Thorough update of the plan is foreseen in 2021.

1. REVIEW OF LARGE CARNIVORE BIOLOGY

1.1. Wolf

General characteristics

Wolf (*Canis lupus*) belongs to the family *Canidae* (dogs) in the order *Carnivora*. Eurasian wolves are divided according to their phenotypes to 8 (recently 6) subspecies (Boitani, 2000). Estonia is inhabited by a subspecies common to European forested areas *C. lupus lupus* L., described first by Karl Linne in Sweden in 1758. Main coloration of Estonian wolves is yellowish-grey, upper parts of back and tail are darker while cheeks, chin and abdomen are light grey. Front side of forefeet usually have a darker “foot stripe” below ankle while some of Estonian wolves are lacking this feature. Colour variation of North American wolves is much wider than in European wolves with range from white to black (Kaal, 1983). Our adult female wolves’ average body length is 114 cm, back height 70 cm and they weigh 33 kilograms, male wolves have the respective measurements 124 cm, 76 cm and 45 kg. Thus there is sexual dimorphism in adult animals while it is not clearly expressed in juveniles up to age of one year.

Habitat selection

Wolf is very highly adaptive species and is present in all habitats of the Northern hemisphere (Mech & Boitani, 2003a). They inhabit various habitats of European forest zone avoiding larger human settlements and roads (Jedrzejewski et al., 2004; Kaartinen et al., 2010; Kaartinen et al., 2005). During periods of low numbers wolf has stayed in Estonia only in larger forest areas while during high population numbers they also use habitats with proportionally high part of cultural landscapes. Wolf habitat selection is significantly defined by density and location of prey species.

Social structure and territoriality

Wolves are territorial animals that form packs. Wolf pack consists of a reproductive pair and their pups of the year but in older packs there can also be offspring from previous years. Population contains also territorial pairs who have not yet started breeding and single individuals who are usually subadults dispersing from their parents’ territories (Mech & Boitani, 2003a). Home ranges of wolves vary widely within their range depending on distribution and density of prey species. In Europe wolf home range size is from 80–240 square kilometres in

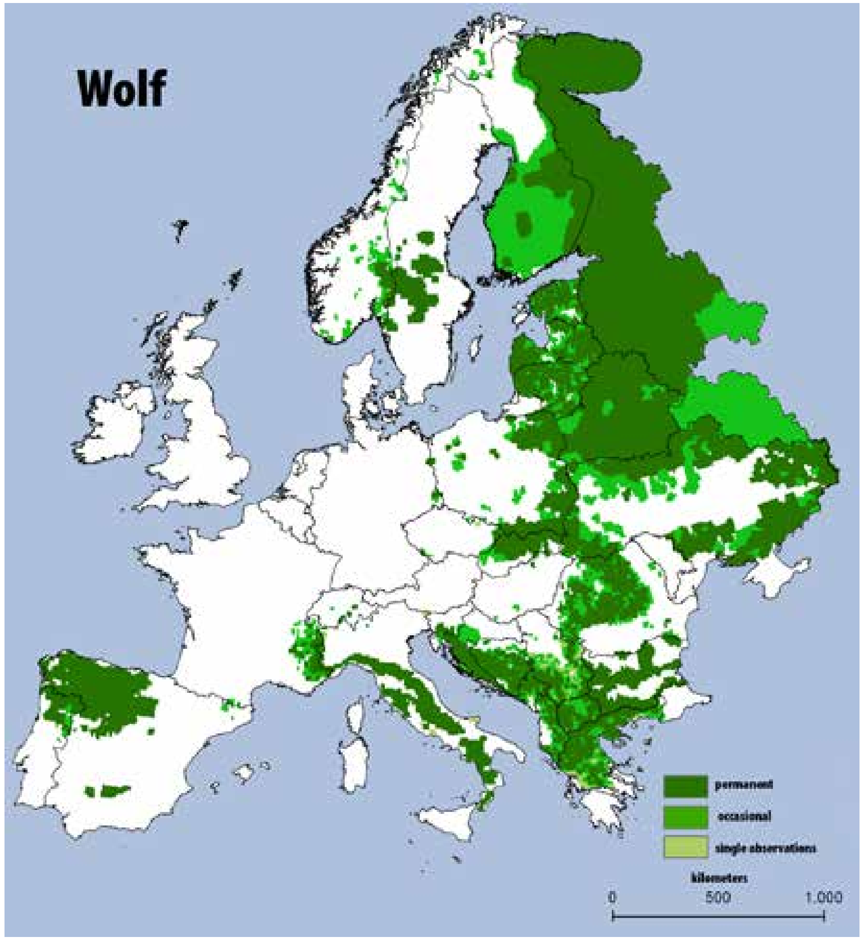

Figure 1. Distribution of wolf in Europe (source: www.lcie.org).

South and Central Europe to up to 500 square kilometres in Northern Scandinavia (Okarma et al., 1998). Estonian relevant studies are limited, but they indicate wolf home range to be 250–500 square kilometres (Kübarsepp & Kont , 2008). Wolves protect their territories against intruding co-specifics. Usually it does not allow territories of different packs to overlap or the overlap is very limited. Wolf packs can separate into smaller groups of different size to mark their territory or forage and this can often lead to erroneous interpretation of pack size and numbers (Mech & Boitani, 2003a)

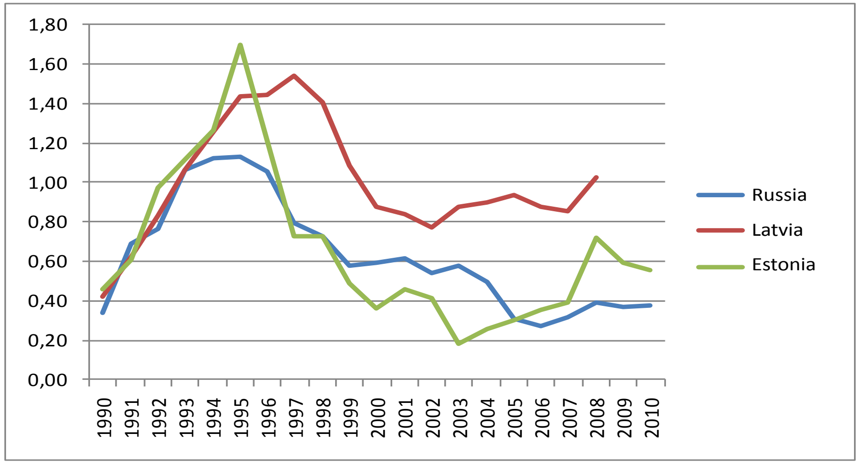

Figure 2. Wolf population density (individuals per 100 km²) in Estonia, Latvia and Russia (Leningrad, Pskov, Novgorod, Tver and Smolensk Oblasts) during years 1990-2010. As the methodology for assessing population abundance is different in every area and the precision of results remain unknown, trends can be compared rather than absolute numbers.

Breeding and dispersal of young wolves

Wolves are monogamous animals which mean that one male fertilizes one female, pairs are stable and both adults take care of the young. The rutting season is in late January and February and young are born in May (Kaal 1983). Female wolves become sexually mature in their second year of life (Bibikov, 1985) and give birth to their first litter usually in the age of two or three years (Kojola 2005). Age of females giving birth to their first litter varies with different environmental conditions, mainly with food availability. In favourable conditions or under strong hunting pressure wolves start to breed earlier, increasing so significantly the population growth potential (Danilov, 2005; Fuller et al., 2003). In Finland the average litter size (in beginning of winter) of first time breeders is 3.1 and of repeated breeders 5.1 (Kojola, 2005).

Dispersal of young wolves (emigration from the birth site to explore new habitats) has been telemetrically studied in Finland. The observed wolves left their parents' territory at the age of 10–24 (most often 11–12) months, mostly in April–May when approximately 80% of the young left. Staying longer in the birth territory is often related to death of one alpha-individual who is replaced in the pack by a young wolf. Average distance of dispersal (after establishment of new home territory) is 99 kilometres with range from 35 to 445 kilometres (n=20, Kojola et al., 2006).

Demography

Demographic population structure of wolves in Estonia can at the moment be described only through hunting statistics. During years 2004–2010 average proportion of individuals, less than one year old was 56% (37–67%). In Russia proportion of pups in hunting bag has been 51% (Bibikov 1985), in Latvia 43% (Ozolins et al., 2008) and in Finland 42% (Kojola 2005). In different parts of North America the respective value has been 29–67%, depending largely on prey availability (Fuller et al., 2000). Yearlings formed in an average 18.6% of the hunting bag in 2006–2009 while, according to sources referred to above, relevant proportion has been 15% for Russia, 13% in Latvia and 28% in Finland. In 2006–2010 proportion of females was 46% among juveniles and 35% among the older animals. This difference can be explained with higher natural mortality of females or higher immigration rate of males from neighbouring countries. This can be true for immigration of males from Latvia as wolf sex ratio in hunting bag there is close to parity or even biased towards females (Ozolins et al., 2008). At the same time dispersion studies of Finnish wolves show no significant difference among sexes (Kojola et al., 2006). So hunting bag does not necessarily reflect real proportion of young in the population but can lead to overestimation – young animals tend to be less cautious and are easier to hunt.

Diet

Wolf is a generalist predator with broad spectre of prey items and it takes opportunistically the most available food in a given place and time. Wolf diet can contain both large prey animals like moose, deer or wild boar as well as small rodents, invertebrates, carrion and vegetal food (Boitani 2000). In Europe wild ungulates are the main prey item while beavers, hares, fox, raccoon dog, domestic animals and livestock have secondary importance. Red deer is the preferred species of prey compared to roe deer. Moose or wild boar prevails only in regions without deer or where deer population densities are low (Okarma, 1995). Red deer has been the main and preferred prey item in the Polish Carpathian region (Nowak et al., 2005), roe deer in the Central and Western Poland (Nowak, 2011) moose in the Finnish taiga (Kojola et al., 2004) and wild boar in Byelorussia (Sidorovich et al., 2003). In Estonia, in different periods the main prey item has been roe deer, wild boar and moose, but preference is determined by availability and density of those prey species in time and space (Valdmann et al., 1998, Kübarsepp & Valdmann 2003, Valdmann et al., 2005, Kübarsepp & Kont, 2008). In Latvia ungulates are closely followed by beaver, which was present in 8.6% of

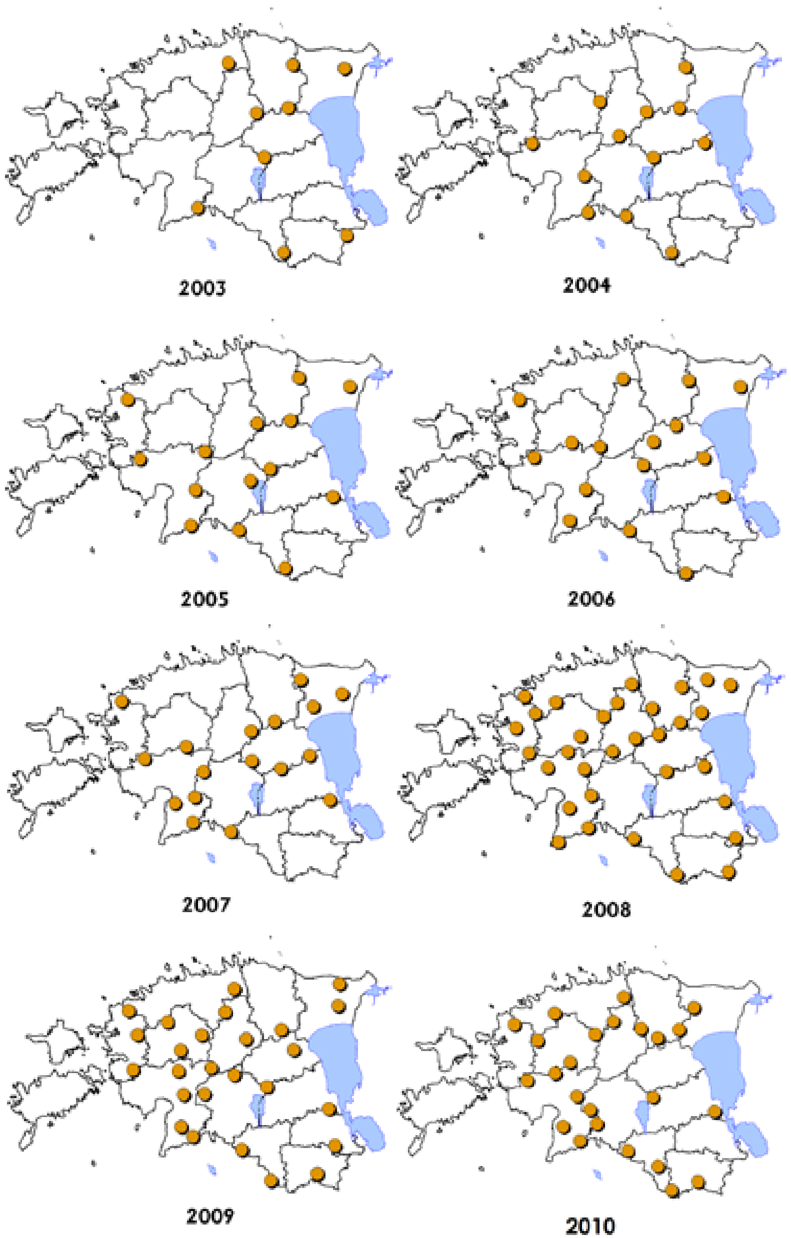

Figure 3. Distribution of wolf reproductive packs in 2003-2010.

stomachs of hunted wolves and formed 6.4% of the consumed biomass (Zunna et al., 2009).

Mortality, diseases and parasites.

The main mortality factor of wolf in Estonia is definitely hunting. In 2002–2010 altogether 28 wolves are known to be killed in traffic, 4 by other wolves and 1 by poaching. Of 20 wolves found dead in Sweden, 7 were killed in traffic, 4 by mange and 4 by poachers (Mörner et al., 2005). At present only sarcoptic mange mite (*Sarcoptes scabiei*) can be considered as a parasite which can affect wolf population increase. Mange has spread widely in Estonian wolf population in recent years. The main vectors of mange are foxes and raccoon dogs whose numbers have significantly risen with vaccination of wild animals against rabies (Jõgisalu & Männil, 2011, Jõgisalu et al., 2010). Sudden increase of fox population after vaccination has been observed also in Poland (Goszczynski et al., 2008) and Sweden (Lindström et al., 1994). Mange does not cause death of its host but weakens the organism and leads to secondary infections. Infected animals die of high energetic losses, starvation or hypothermia. Severely infected animal can be less afraid of people and is often killed as nuisance individual (Agren, 2005). Spread of mange in wolf populations is described also from Scandinavia (Mörner et al., 2005), Finland (Agren, 2005), Spain (Dominiguez et al., 2008) and North America (Pence & Ueckermann, 2002). In Estonia one dead wolf with signs of mange was found in 2006.

Rabies, a highly contagious and fatal viral disease was widely spread among European mammals, including humans, until recent times. Vectors of the disease have been found to be mainly red fox and later also raccoon dog (Singer et al., 2009). This virus has affected wolves relatively rarely, but attacks of rabid wolves on humans have lead to serious injury or, in earlier centuries, certain death (Kaal, 1983; Rootsi, 2003). Wolf attacks on humans have been caused in most cases by this condition, but nowadays they have become (with an exception of some Asian countries) extremely rare. By the beginning of current millennium successful oral vaccination of wild animals has wiped out rabies in the whole Europe (Linnell et al., 2002). In Estonia the vaccination was introduced in 2005 and in recent years only some cases of wild animal rabies have been reported from vicinity of the eastern border. At the same time rabies risk is still not excluded as the disease is widely spread in Russia (Niin, 2011).

Canine parvovirus has been the only viral disease to significantly affect wolf population size in America (Mech et al., 2008). Presence of parvovirus in European wolf population was first discovered in Italy (Martinello et al., 1997), then in Spain (Sobrino et al., 2008) and Portugal (Santos et al., 2009). Both canine distemper and parvovirus antibodies have been found in wolves, indicating spread of those diseases in wild populations. Effect of both parvovirus and mange may be expressed in reduced recruit rates, as young individuals are significantly more susceptible to the aforementioned diseases (Kreeger, 2003).

Thirteen different species of helminths, including the tapeworm *Echinococcus granulosus*, fatally dangerous to humans, have been found in Estonian wolf population (Moks et al., 2006). Roundworms of genus *Trichinella* have also been detected in Estonian wolves (Pozio et al., 1998).

Numbers and distribution

Wolf has been the most widely spread terrestrial mammal until recent times, inhabiting Eurasia, America and Japan in the Northern hemisphere. As a result of global eradication campaign, wolf distribution area has significantly shrunk by today. Wolves inhabited most of Europe still in the 19th century, while after the World War II in the 20th century they were removed from almost all countries of Central and Northern Europe. By 1960-ies small remnant populations were still present in Portugal, Spain, Italy, Greece and Finland. In Eastern Europe local populations were bigger. During last couple of decades wolf distribution area has been expanding again, both within countries and across borders (Boitani 2000).

The Baltic wolf population is part of Eurasian metapopulation distributed in Estonia, Latvia, Lithuania, northeast Poland, Byelorussia, northern Ukraine and Leningrad, Novgorod, Pskov, Smolensk, Bryansk, Moscow, Kaliningrad, Kursk, Belgorod and Orel Districts (Oblasts) of Russia (Fig. 1). The total population size is estimated to be around 3600 individuals (Linnell et al., 2008). In closest neighbour states to Estonia, approximately 300 wolves can be found in Latvia (Ozolins et al., 2008) and 200 in Lithuania (Balciauskas, 2008). In Russian territories adjacent to Estonia, 350 wolves have been counted in Leningrad Oblast and 175 in Pskov Oblast. Mean population density has fluctuated between 0.27 and 0.58 ind/ 100 km² in 2002–2010 with 0.37 ind /100 km² for 2008 and 2009. In 2009 135 and 118 wolves were hunted in Leningrad and Pskov Oblasts, respectively (Borisov et al., 2004, Gubar, 2011).

In long time-frame wolf wellbeing in Estonia depends on their population status in Russia, where core part of Baltic wolf population can be found (Salvatori & Linnell, 2005), so in addition to local monitoring, changes in neighbouring populations need to be followed. Existence of common population are confirmed

by matching fluctuations in population sizes of Estonian , Latvian and Russian populations close to Estonia (Fig. 2.). Probably population densities in those named areas are rather similar.

In Estonia, wolf abundance has fluctuated widely since turn of the last century. The biggest depressions were in 1930-ies and 1960-ies, when only 10–20 individuals were counted in Estonia. Population peak of around 1000 individuals was found in 1950-ies (Kaal, 1983). The next population peak was in mid 1990-ies, when approximately 700 wolves were counted. It was followed by new depression early this century. In 2002 and 2003 only nine wolf reproductive packs were registered in Estonia, three of which were located at border with Latvia, thus the total population in autumn did not exceed 75 individuals. Restrictions on hunting contributed to population rise, as already in 2004 the number of packs was 11 and the estimated total population size about 100. Wolf population continued to increase, peaking in 2008 with 32 packs, and respectively, approximately 300 individuals in autumn population. Since then wolf numbers have slightly fallen, in 2010 number of packs was estimated to be 24 and relevant autumn population to be around 230 individuals (Fig. 3).

1.2. Lynx

General characteristics

Eurasian lynx (*Lynx lynx*) belongs to the family *Felidae* (cats) of the order *Carnivora*. In addition to Eurasian lynx, Europe is inhabited by another species, highly endangered Iberian lynx (*Lynx pardinus*), who has survived in two small and decreasing populations (altogether about 200 specimens) in the southern parts of Spain (Palomares et al., 2011). Coloration of pelage of lynxes inhabiting Estonia is yellowish red, often with dark spots of variable size and shape. Chin and abdomen are light grey. Adult females' average body length is 97 cm, back height 59 cm and weight 17 kilograms, respective measurements for males are 102 cm, 63 cm and 22 kg. Sexual dimorphism is thus clearly expressed in adult specimen while not measurable during the first year of life.

Habitat selection

Lynx is related to forest habitat within the whole species distribution range, with an exception of Central Asian subspecies *L. l. isabellinus* , who is staying in open landscapes. In Europe, lynx inhabits all forest types from the Mediterranean broad leaved forests to boreal forests of the North. Female lynxes establish their

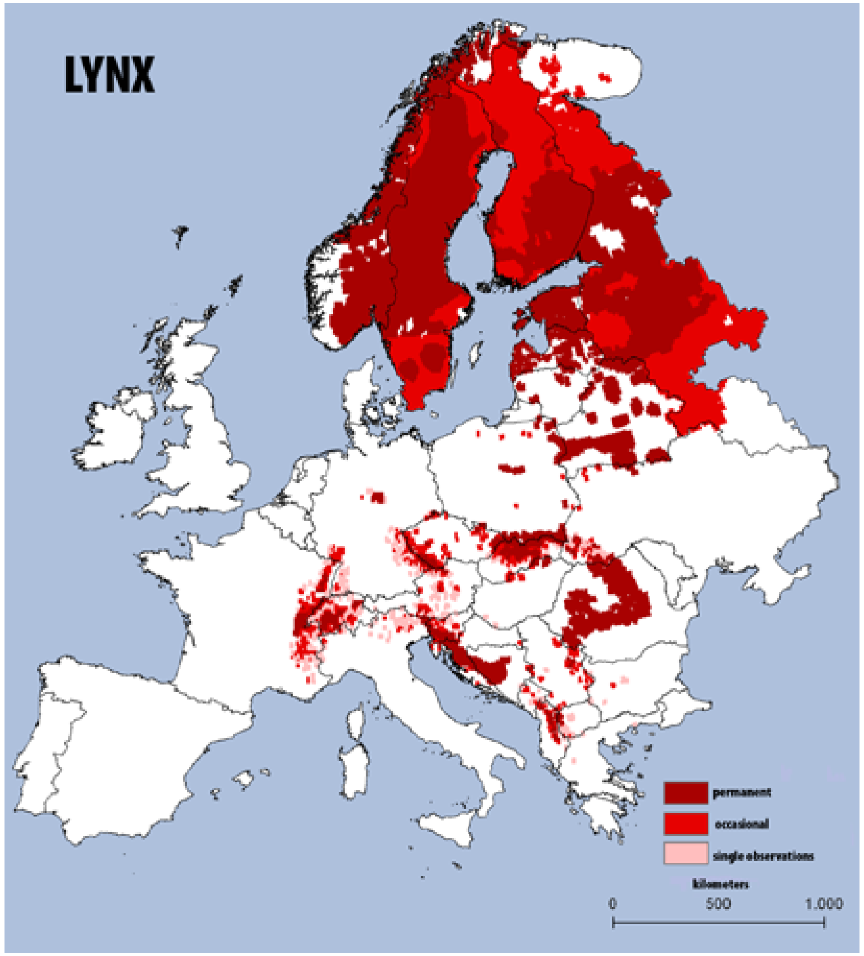

Figure 4. Distribution of lynx in Europe (source: www.lcie.org)

home territories according to habitat type and availability of food for rearing their offspring, male lynxes according to presence of females (von Arx et al., 2004). In Estonia, lynxes inhabit all forest-related habitats.

Social structure and territoriality

Lynx is a solitary, territorial animal. Stable groups are formed only by females with offspring less than one year of age. Temporary assemblies containing several adult individuals are formed only during rutting season in March and early

April. In Norway, winter home ranges of females with pups has fluctuated between 319–832 km^2 (Linnell et al., 2001) in Poland 82–101 km^2 (Schmidt et al., 1997) and in Estonia 64–161.8 km^2 (Männil, 2007). Home range of adult male lynxes in Estonia has been in late spring – early summer between 124 and 160 km^2 (Kont et al., 2009), in Poland 102–195 km^2 (Schmidt et al., 1997) and in Norway over 1000 km^2 (Linnell et al., 2001). Territories of individuals of the same sex usually do not overlap or the overlap is very limited, whereas territories of individuals of opposite sex can overlap significantly (Schmidt et al., 1997). Home range dimensions depend on availability of suitable habitats and prey (roe deer) density (Schmidt, 2008a; Herfindal et al, 2005).

Reproduction and dispersal of young lynxes

Lynx is a polygamous species, as one male attempts to fertilise several females. Pairs are formed only during breeding period and only female takes care of young. Rutting season starts in late February and early March in Estonia and lasts for about a month. Pups (1–4, usually 2–3) are born mostly in May and they stay with their mother until the next rutting season when they are 10–11 months old. Young lynxes start to disperse from their birth area and establish new home territories in the following year (Schmidt, 1998). Although half of female lynxes become sexually mature during their first year of life they are not physically fit for breeding and they give birth to their first litter usually in the second year of life (Kvam, 1990). In Estonia, mean number of cubs in the litter at the beginning of winter varies between 1.7 and 2.1.

Of the two radio-collared male subadults lynx, marked in Tipu research area (Pärnu county, Saarde parish) in spring 2009, one was shot 33 kilometres from marking site next winter and the other was spotted in May 2011 in Tartu county 115 kilometres away. Last data from the transmitter in October 2009 originates from the same area. In Poland, dispersal distance (distance between the centre of mothers home territory to the centre of established new territory) has been measured to be 11–129 kilometres (n=4) for males and 5–9 kilometres (n=2) for females (Schmidt, 1998), in Sweden respective distances were 50–450 and 30–150 kilometres (Liberg 1998 in Salo, 2007).

Demography

Lynx population demographic structure in Estonia can be described using hunting statistics. In the hunting bag during years 2006–2010 an average 30 % (25–37) of were juveniles, 21% subadults and 49% adult individuals. In the Polish

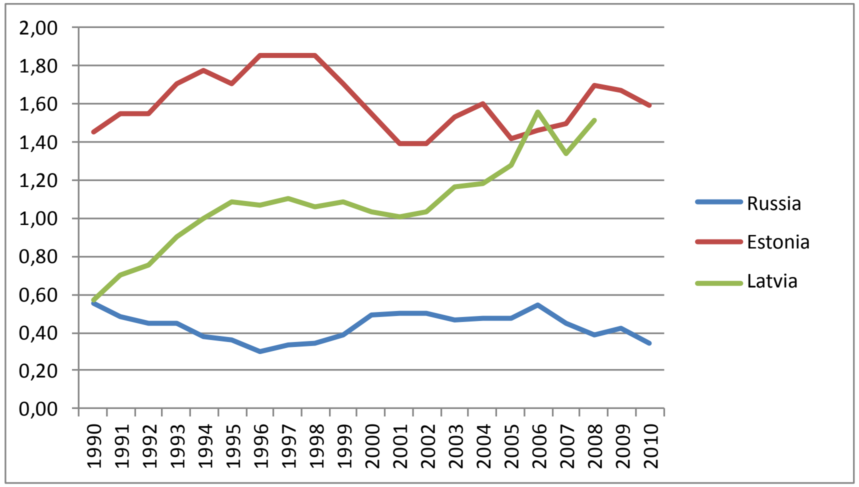

Figure 5. Lynx population densities (individuals per 100 km^2) in Estonia, Latvia and Russia (Leningrad, Pskov, Novgorod, Tver and Smolensk Oblasts) in years 1990-2010. As the methodology for assessing population abundance is different in every area and the precision of results remain unknown, trends can be compared rather than absolute numbers.

statistics the relevant proportions are 35% of pups, 12% of subadults and 53% of adult lynxes (von Arx et al., 2004) and in Latvia 33.7%, 12.4% and 53.9 %, respectively (Ozolins et al., 2007).

The proportion of females among juveniles in hunting bag during years 2006–2009 was 50%. Slight majority of females in the same segment have been recorded in Russia (Danilov et al., 2003). Among adults the proportion of females has been 39 % for Estonia. In Poland the same characteristic is according to telemetric results 44 % (von Arx et al., 2004). In Estonia, the proportions of females in juvenile and adult segment do not necessarily reflect the real content of the population as hunting rules do not allow killing females with pups. So the hunting pressure on solitary individuals is higher than on reproductive groups. This is confirmed also by higher proportion of sub-adults in hunting bag compared to Latvian and Polish populations.

Diet

In majority of Europe lynx mostly feeds on small and medium-sized ungulates, which make 52–92% of lynx prey (Jedrzejewski et al., 1993; Jobin et al., 2000; Sunde et al., 2000, Valdmann et al., 2005). Regional variation in proportion of ungulates

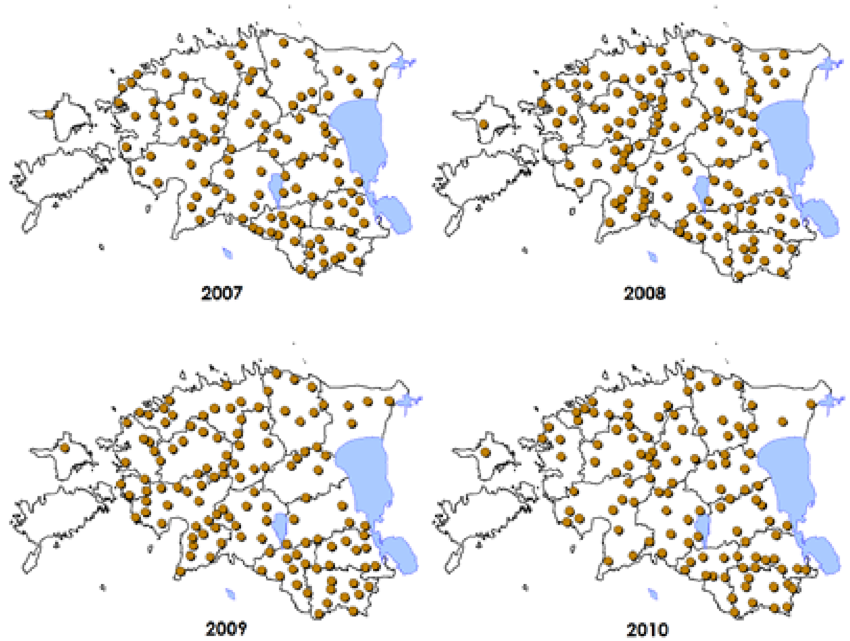

Figure 6. Distribution of lynx in Estonia in years 2007-2010. Points on map indicate different reproductions.

in lynx diet depends on availability of alternative prey, mainly hares, whose importance as lynx prey is increasing from south to north (Jedrzejewski et al., 1993). In Finnish Karelia where roe deer density is low or the species is not present, main prey item for lynx is mountain hare (Pulliainen, 1981). Additionally, grouse (Sidorovich, 2006) and red fox (Valdmann et al., 2005) have been reported as alternative prey.

Everywhere in Europe where lynx distribution overlaps with roe deer, it is lynx main prey species (Nowicki, 1997). Importance of roe deer as prey item is clearly demonstrated also by Norwegian studies where, with significantly lower roe deer densities compared to high numbers of sheep, lynxes maintained the preference to feed on roe deer (Odden et al., 2006). Stomach content of specimens hunted in Estonia also revealed dominance of roe deer as prey, followed by hare and fox (Valdmann et al., 2005). Lynxes, followed by telemetry and winter tracking (Männil, 2007; Kont et al., 2009; Kont, 2010b) killed mostly roe deer. From other species mountain hare, beaver, crane and moose calves were represented. Raccoon dog and polecat have been found killed but not eaten by lynx.

Mortality, diseases and parasites

The main reason for lynx mortality in Estonia is hunting. In years 2002–2010, road incidents killed 20 lynxes and one lynx has been hit by train, 8 rabid lynxes have been terminated (last in 2006), six abandoned pups and five mange victims have been found dead or terminated, one individual has been killed by another lynx. Annual non-hunting mortality in Estonia is considered to be in an average 13%. In Sweden, Norway and Switzerland the main reason for adult lynx mortality is poaching (Andrén et al., 2006; Schmidt-Posthaus et al., 2002). From Estonia there is no data on poaching mortality. In Switzerland it was established that 18% of lynxes die from infections while the proportion among telemetrically followed individuals was even 40% (Schmidt-Posthaus et al., 2002).

Sarcoptic mange (infection by mite *Sarcoptes scabiei*) has reached Estonian lynx population in recent years, first two cases were recorded in 2010 and followed by four recorded cases in 2011 (Jõgisalu & Männil, 2011). Also in Latvia the first lynxes affected by mange were found in 2011 (Ozolins, pers. comm.). The infection has most probably taken place through contacts with infected raccoon dogs or foxes. Cases of mange in lynx have been recorded also in Swiss lynx population (Ryser-Degiorgis et al., 2002), Finland (Ågren, 2005), Sweden (2002 Ryser-Degiorgis et al., 2002) and Norway (Holt & Berg, 1990). In Switzerland infection by cat mange mite (*Notoedres cati*) has been recorded in lynx, although this parasite is distributed mainly among domestic cats (Ryser-Degiorgis et al., 2002).

Eight lynxes with rabies were registered in Estonia in 2002–2006, in two of those cases the lynxes were aggressive, attacking dog in one case and a car in the second. Last time when rabid lynx was reported in Estonia was in 2006 (data: Food and Veterinary Board). Several other viral diseases are found in lynx. As lynxes are solitary animals, source of infectious diseases named above are probably raccoon dogs and foxes. Way of life also hinders spread of disease in lynx populations compared to infection rates in more social (e.g. several canids) species populations.

Seven different species of helminths have been found in Estonian lynxes (Valdmann et al., 2004), for Latvia the respective number is six (Bagrade et al., 2003). Estonian lynxes are also carrying nematodes from genus *Trichinella* (Pozio et al., 1998).

Numbers and distribution

In earlier history whole Europe, except the Pyrenean Peninsula, islands, bare coastal areas and northern Scandinavia, were inhabited by lynx. As a result of human influence lynx distribution was reduced to its minimum in 1950'ies. Due to conservation measures in the second half of 20th century, population size and range started to recover. Today lynx population is almost continuous in the Nordic countries and Russia and is also represented by smaller, isolated populations in the Central and Western Europe (Breitenmoser et al., 2008).

The Baltic lynx population is a part of Eurasian metapopulation which spreads quite uniformly in Estonia, Latvia, Byelorussia and Leningrad, Novgorod, Pskov, Tver and Smolensk Oblasts of Russia. Fragmented subpopulations can be found in Lithuania, northeast Poland, north Ukraine and Kaliningrad Oblast of Russia (Fig.4). Total population size of Baltic population of lynx is estimated to be 3400 individuals (Linnell et al., 2008).

In Estonia's proximate neighbourhood, there are about 900 lynxes counted in Latvia (Ozolins et al., 2007) and 100 in Lithuania (Balćiauskas, 2004). In Russian regions close to Estonian borders 270 lynxes were counted in Leningrad Oblast and 134 in Pskov Oblast in 2010, mean population density in districts (Leningrad, Pskov, Novgorod, Tver, Smolensk) neighbouring to Estonia has fluctuated between 0.3–0.5 ind/100 km^2, in years 2008 and 2009 the respective value was 0.34 ind/100 km^2 (Fig. 5.). According to official statistics 8 lynxes were hunted in Leningrad Oblast and only 1 in Pskov Oblast in 2010 (Borisov et al., 2004, Mosheva 2011).

In longer perspective Estonian lynx population is dependent on species status in Russia where the core of the Baltic population resides. So in addition to local population, trends in Russian population need to be followed (Linnell et al., 2008).

In Estonia lynx population was in depression since the end of the 19th century and starting in 1937 the species was protected by law (Randveeer, 2003). In 1954, the first year with official hunting statistics, 275 lynxes were counted in Estonia. A decline in population followed, leaving only 60individuals in 1960. Since then the population started to increase with maximum number in years 1997–1998. The rise was followed by another decline and positive trend was again observed in 2005. After that the population has stabilized between 700 and 850 lynxes in autumn and 500 lynxes in spring. Today, lynx distribution covers whole Estonia (Fig.6.) and in 2002 to 2010 breeding was not documented only in Saare County .

1.3. Brown bear

General characteristics

Brown bear (*Ursus arctos*) belongs to family *Ursidae* (bears) of order *Carnivora*. Brown bear is the most widely distributed bear species in the world that lives in various habitats of Europe, Asia and North America from Arctic tundra to arid desert areas in the south (Swenson et al., 2000). In Europe, including Estonia, the species is represented by subspecies Eurasian brown bear (*Ursus arctos arctos* L.). The pelage colour of Estonian brown bears varies from pale brown to blackish brown, mostly the bears are dark brown. In the first year of life bears have a white spot or collar on their neck, it can show later as a pale area compared to general coloration of fur. While walking, bears are putting down their heels and hence their definition as "sole walkers" (Kaal, 1980). Estonian adult female bears' average body length is 172 cm (160–186, n= 8), shoulder height 86 cm (73–97) and they weigh 167 kilograms (130–200). Respective values for males are 199 cm (173–250, n=20), 107 cm (83–140) and 226 kilograms (150–350). Average width of the front paw for females is in 12.8 cm (12–13.5) and for males 15.1 cm (13–17). There is distinctive sexual dimorphism in adult individuals while the differences are not clearly observable among juveniles.

Habitat selection

Bears live in various habitats of boreal Europe, which offer sufficient food basis, shelter and wintering conditions (Danilov, 2005; Swenson et al., 2000). Population density of bears is positively correlated to abundance of food (Swensson et al., 2000). Studies carried out in Greece revealed that during active foraging period, in autumn, bears prefer diverse landscapes where forests mix with agricultural landscapes. Prior to hibernation they move to forest habitats that are rich in shelter and vegetal food (Kanellopoulos et al., 2006). Thus the shelter is, in addition to foraging conditions, an important factor as bears generally avoid human activities, cities and recreational areas (Nelleman et al., 2007). Wintering bears keep away from big roads (Elfström et al., 2008; Linnell et al., 2000). In Estonia, wintering bears prefer various wet mixed forests with spruce, far from human settlements and roads (Ermel, 2007). Spruce forests are preferred winter habitats also in European part of Russia (Danilov, 2005).

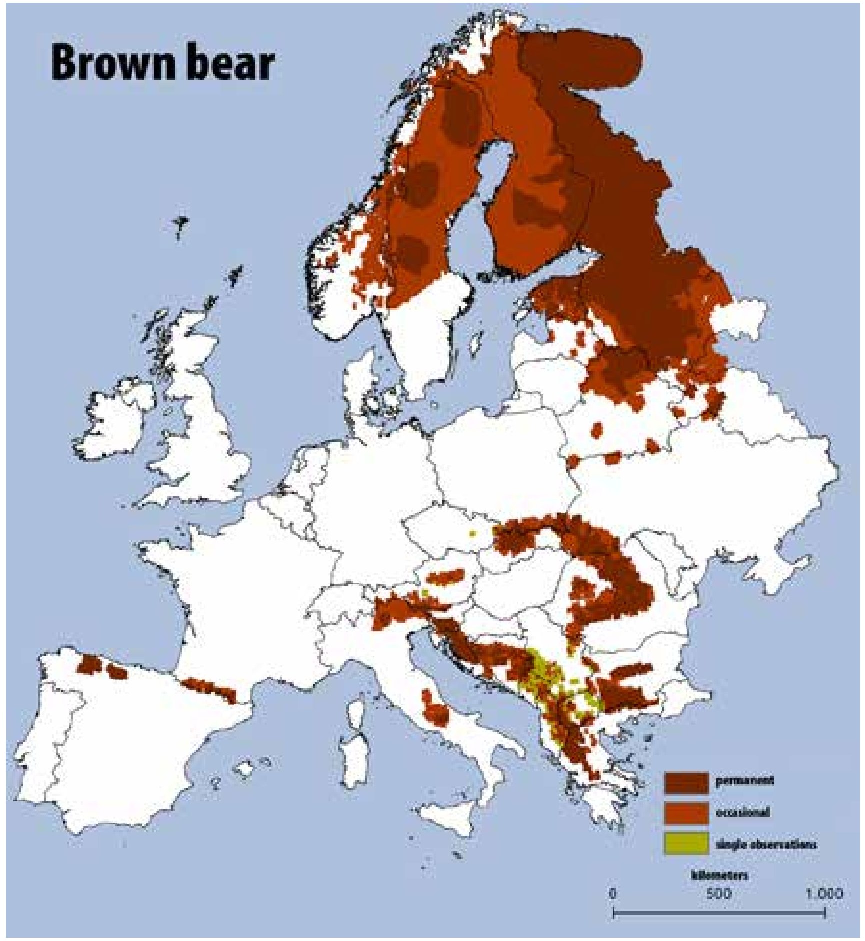

Figure 7. Distribution of brown bear in Europe (source: www.lcie.org)

Hibernation

Bears hibernate from late autumn to early spring and the hibernation is seen as an adaption to survive winter as a season with poor food availability (Swenson et al., 2000). In Estonia, bears fall into hibernation usually in November and come out of their winter dens from March to May. The dens are first abandoned by adult males and females with cubs-of-the-year are the last to come out. Females give birth to their young during hibernation and, usually stay with them also during next winter. In southern part of brown bear distribution range the species is active all year round.

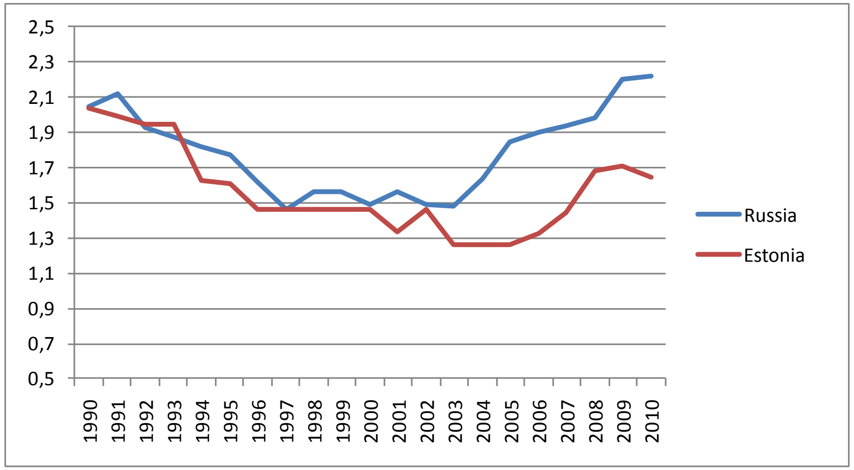

Figure 8. Brown bear population density (individuals per 100 km²) in Estonia, Latvia and Russia (Leningrad, Pskov, Novgorod, Tver and Smolensk Oblasts) during years 1990-2010. As the methodology for assessing population abundance is different in every area and the precision of results remain unknown, trends can be compared rather than absolute numbers.

Social structure and territoriality

Brown bear is a solitary territorial animal. At the same time bears form certain regional social structures with mutual relations and information exchange (Pazhetnov, 1990). Stable groups involve mother and her cubs up to 1.5 years of age (Dahle and Swenson, 2003a). Young independent individuals can form temporary groups and may even join females with cubs. Such temporary social relations are probably formed by close relatives by maternal line whose home ranges overlap (Støen et al., 2005). From the end of May to early July, breeding pairs can also form temporary groups.

In south Sweden, where habitat conditions are relatively close to those in Estonia, brown bear average home range sizeis 1055 (95% MCP) km² for adult males (range 314–8264), 217 km² for single adult females (range 81–999) and 124 km² (range 46–478) for females with cubs-of-the-year. Home ranges are significantly smaller in areas with high bear population density and habitats rich in food sources (Dahle & Swenson, 2003b). In Croatia mean home ranges for male bears is 128 km² and for females 58 km² (Huber & Roth, 1993). Home range size of Estonian bears has not been studied.

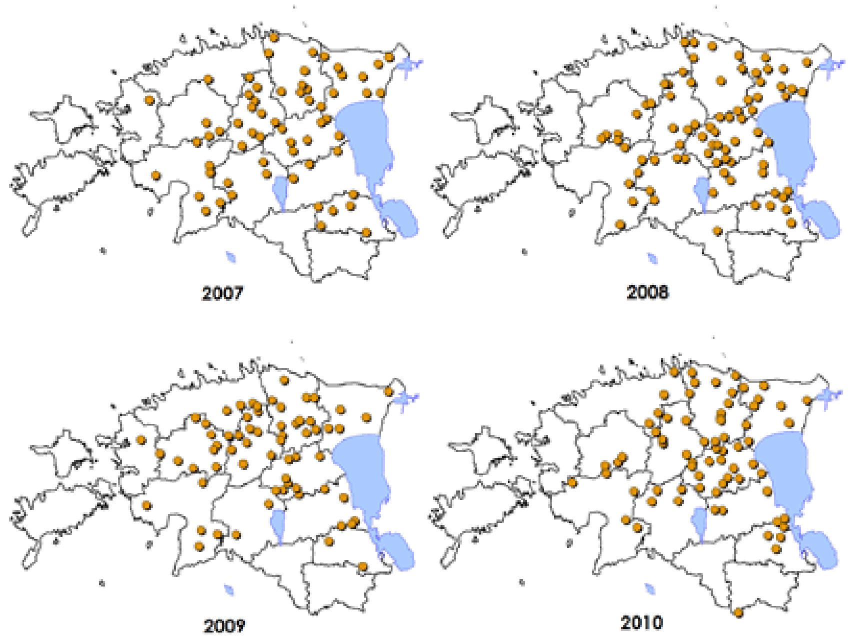

Figure 9. Brown bear distribution in Estonia in years 2007-2010. Points on map indicate different reproductions (females with cubs-of-the-year).

Reproduction and dispersal of young bears

Brown bear is a polygamous species and one male can attempt to fertilize several females. Pairs are formed only during breeding season and only female takes care of the young. Compared to other large carnivores in Estonia, reproductive capacity is relatively low due to late sexual maturity and long reproductive cycles. In Estonia the rutting season lasts mostly from the end of May until the beginning of July. Cubs (1–5, usually 2–3) are born mostly in late December or early January and they stay with their mother until onset of next rutting season, approximately 1.5 years later. So the female bears breed usually after every second year. In Sweden the mean age of females giving birth to their first litter is 4.4 years, average interval between litters is 2.4 years and mean litter size is 2.4 cubs (Swenson et al., 2000). According to national monitoring data in Estonia the mean number of offspring is 2.1. This is probably an underestimate as not all cubs are seen, particularly in autumn. It is also confirmed by a Swedish comparative study where observational data resulted in litter sizes 2.08 in spring, 1.81 in autumn and 2.02 in average, while telemetric study produced respective values as 2.27, 2.25 and 2.26 (Zedrosser & Swenson, 2005). In Novgorod and Pskov Oblasts in Russia mean litter size is 2.23 (Vaisfeld & Chestin, 1993).

Dispersal of young bears leaving maternal territory and dispersion distance depends on the individuals' sex, age and population density. Male young bears disperse in significantly higher rate than females who stay in, or in proximity to their maternal territory (Swenson et al., 1998). In addition to higher proportion of emigrating males, also distances are greater – in Sweden mean distance of dispersal was108 kilometres (max. 467) for males and 16 (max 90) for females (Støen et al., 2006). Dispersal of females is positively related to increase in population (Swenson, et al., 1998; Kojola & Laitala 2000). Bears leave their birth sites irreversibly in second to fourth year of life, males do it slightly earlier than females (Støen et al., 2006).

Demography

Little is known about age structure of Estonian bear population, as selective hunting provides poorer data than is available for wolves and lynxes. Among hunted adult animals (three or more years old) 57% are males and proportion of sub-adults (1–2 years old) in hunting bag is 63%. According to Pazhetnov (1990), natural structure of population is approximately as follows: single bears 62%, females with cubs 13%, cubs of the year 15% and yearlings 10%. Growing populations in Scandinavia and Finland show a difference in demographic structures of core distribution area (where brown bear has been for long time) and edges of distribution (inhabited recently by bear). Proportion of females is higher in core distribution area while young males are predominant close to edges of distribution range (Kojola et al., 2003; Kojola & Laitala 2000; Swenson, et al., 1998).

Diet

Regardless of its inclusion to the order *Carnivora* brown bear is a typical omnivore in terms of food preference, set of teeth and digestive duct. Although majority of bear food is vegetal, bears are not able to decompose cellulose while they can acquire plant sugars and majority of vegetal proteins (Swenson et al., 2000). The annual diet cycle has three main phases: poor period in spring after hibernation, normal foraging period in summer and active foraging period in autumn when winter reserves are collected (Swenson, 2000, Pazhetnov, 1990). Plants are predominating in spring and summer while in late summer and autumn food

of higher energy content, e.g berries, fruits and grain is consumed (Vulla et al., 2009). Meat, in form of kill and carrion is easily digestible and high-energy food and is thus an important addition to the main diet in spring and autumn. Bears are not very effective predators compared to e.g. wolf and lynx (Swenson et al., 2000). Majority of animal food consist of invertebrates, especially ants (Vulla et al., 2009, Swenson et al., 1999b). At the same time moose can locally form substantial proportion of bear diet. For example, this has been found in central Sweden (Swenson et al., 2007) and northern Norway (Persson et al., 2001) where bear densities are high.

As the energy content of vegetal food is declining in autumn from south to north, animal food forms bigger proportion of bear diet in northern part of the distribution range (Vulla et al., 2009). Of mammals, cattle, pig, wild boar, roe deer and raccoon dog have been registered in brown bear diet (Vulla et al., 2009). What proportion of those animals were killed, found dead or consumed in game feeding pits is not known. Bears get used to additional feeding and, subsequently, to human activities. This increases the probability of development of nuisance individuals (Dećak et al., 2005).

Mortality, diseases and parasites.

Main human caused adult bear mortality in Estonia is most probably hunting. In years 2002–2010 eleven bears have been hit by cars and one by train, four bears have been shot in self-defence, 5 have been killed by other bears and 3 by poachers. In three cases partly decomposed carcasses did not allow to establish circumstances of death. At least 7 abandoned cubs are found dead and 14 have been taken to wildlife rehabilitation centre in Nigula. Main reasons for abandonment have been hunting or forestry activities in proximity of wintering lair. In Sweden (Mörner et al., 2005) out of the 96 dead bears 41 were shot in self-defence during moose hunt, 16 have been killed by another bear and five bears perished in road accidents. Disease and parasites have not been registered as cause of death for bears neither in Estonia nor elsewhere. Two species of helminths have been found in Estonian bears (E.Moks & I.Jõgisalu unpubl.), 50 bears studied in Sweden were free of helminths (Mörner et al., 2005). Estonian bears are also carrying nematodes from genus *Trichinella* (Pozio et al., 1998).

Numbers and distribution

In earlier times brown bear inhabited most of Europe, being absent only from bigger islands like Ireland, Iceland, Gotland, Corsica and Sardinia. With increase of human population bear disappeared from many parts of its previous range driven by turning forests into agricultural land and increase in hunting pressure. Today brown bear has continuous distribution in Scandinavia, Finland, Russia and Estonia. Large, but isolated populations can be found in the Carpathians and in Balkan countries, there are some other small isolated populations in Europe (Swenson et al., 2007, Fig. 7).

Baltic population of brown bear is a part of the Eurasian metapopulation which includes Estonia, Latvia, Byelorussia and Leningrad, Novgorod, Pskov, Tver, Smolensk, Brjansk, Moscow, Kaliningrad, Kaluzh, Tula, Kursk, Belgorod and Orel Oblasts of Russia. Total population size is estimated to be about 6800 individuals (Linnell et al., 2008).

In close neighbourhood of Estonia, there are approximately ten bears in Latvia who live close to Estonia or Russia. There is no proof of breeding bears in Latvia so far (Pilats & Ozolins, 2003, Ozolins pers. comm.). In Russia, 2200 bears have been counted in Leningrad Oblast and 1160 in Pskov Oblast in 2010. Mean population density has fluctuated between 1.47 and 2.22 ind/100 km² during the period 2002–2010, with maximum of 2.22 in 2010. Ninety-one and twenty-one specimen were hunted, respectively, in Leningrad and Pskov Oblasts in 2010 (Borisov et al., 2004; Gubar 2011b; Fig. 8). Perspective developments in Estonian bear population are dependent on situation in Russia where core of the Baltic population can be found. It is important to follow trends in Russia in addition to monitoring of brown bear in Estonia (Linnell et al., 2008). Existence of common population is confirmed by matching population fluctuations in Estonia and adjacent Russian territories (Fig.8).

In Estonia bear numbers were continuously declining since middle of the 19th century up to beginning of the 20th century. Population depression lasted until 1950-ies. During that period the species survived only in forest massifs of Northeast-Estonia (Kaal, 1980). Starting in 1954, brown bear has been regularly counted and official hunting statistics is kept and records showed a positive trend up to year 1990 when population numbers stabilized. In the period of 2002–2010 brown bear population has fluctuated between 500 and 700 individuals. Today, the species is present in all Estonian continental counties but breeding has not been registered in Valga and Võru counties (Figure 9).

1.4. State of prey species populations

Current chapter deals with main mammal prey species of Estonian large carnivores or other species potentially contributing to their well-being. The main prey for lynx is roe deer, secondary hare and perhaps red deer on islands, alternative important species can be beaver, fox and raccoon dog. Main prey species for wolf are roe deer, wild boar and moose with the same alternative species as lynx. Mammals do not belong to main diet of Estonian bear, but moose and wild boar may be important in some periods. Assessments of prey populations are based on the game monitoring report by the State Environment Agency in 2011 (Männil & Veeroja, 2011). Population size indexes are summarized in Table 1.

During the observed period **roe deer** population had its maximum in 2007 and had a severe decline in 2010, which probably continued also in 2011. The reasons for the decline were snowy and cold winters, which made foraging difficult with simultaneous predation and hunting pressure. In 2011 roe deer population was, as a source of food for predators, in poor condition.

Wild boar population was increasing until stabilization in 2009. Severe winters in 2010 and 2011 increased wild boar mortality, but additional feeding largely compensated it. Wild boar abundance and reproductive potential are still high, thus providing plentiful resource for predators.

Moose population has maintained high numbers and high reproductive potential throughout the observed period.

Red deer populations are strong in Saaremaa and Hiiumaa and are gradually increasing in areas close to Latvia – in Pärnu, Viljandi and Valga counties.

Beaver abundance has been high throughout the whole period, providing considerable food basis for large carnivores of continental Estonia.

Hares are distributed in continental Estonia, but falling trend of their populations have lasted for tens of years and the tendency has not changed during last decade. Although hares, particularly mountain hare, are still in menu of wolves and lynxes they cannot be considered as a significant alternative food source due to low population densities and falling trend of abundance.

Fox abundance is high and **raccoon dog** abundance very high compared to beginning of the last decade and also to the average over several tens of years.

Table 1. Population size and trend in relative abundance of main prey species of Estonian large carnivores in years 2002–2011. L – cumulative of hunters estimates by hunting districts, individuals. TI – winter track counts in monitoring squares, tracks per one kilometre of transect; H – number of hunted individuals.

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
ROE DEER	L	35000	41000	49000	55000	61000	63000	63000	63000	48000	35300
	TI					5,19	4,35	4,54	4,15	2,27	1,31
	H	5009	5460	7669	10215	13833	19643	18006	15716	5075	
WILD BOAR	L	13000	16000	17000	17500	19400	20500	21200	23500	22600	22600
	TI					2,24	2,25	1,95	2,60	1,21	1,30
	H	5660	7003	8122	11332	12225	13818	19757	20072	17028	
MOOSE	L	10500	11700	11700	12000	12000	11000	11000	11180	11740	12500
	TI					1,02	0,97	0,79	0,90	0,83	0,82
	H	3438	3848	4075	4582	4931	4911	4133	4031	4255	
RED DEER	L	1300	1300	1500	1700	1800	2200	2200	2570	2830	3290
	TI					0,24	0,23	0,19	0,25	0,16	0,19
	H	148	139	123	129	140	220	300	403	497	
BEAVER	L	16000	16000	17000	17500	17400	18600	18000	17900	17000	17000
	H	3689	2957	4384	5758	7368	6083	5631	6657	6592	
EUROPEAN HARE	TI					0,62	0,57	0,50	0,56	0,46	0,29
	K	1423	1356	1306	1221	1058	791	897	711	650	
MOUNTAIN HARE	TI					0,42	0,7	0,26	0,33	0,32	0,30
	H	485	491	391	344	333	296	196	114	119	
FOX	TI					1,36	1,10	1,20	1,88	1,68	1,27
	K	7461	4376	6184	7806	5856	5986	12712	7472	9656	
RACCOON DOG	TI					0,07	0,17	0,27	0,38	0,19	0,31
	H	4945	4124	3516	3992	5842	7994	8728	9495	12600	

1.5. Review of research in Estonia

The large carnivore research in Estonia has been rather modest due to limited funding and human resource. In 2002–2011 two doctoral theses are defended in University of Tartu: Harri Valdmann in 2005 and Egle Tammeleht in 2011. Applied research is organized by the Estonian Environment Agency and funded by the Environment Investment Centre. Fundamental research has been funded by the Estonian Science Fund (2012 – renamed to Estonian Research Council). In following the main research areas are reviewed with reference to published materials, most of which are used to compose various chapters of current plan.

Wolf and lynx **diet** has been studied in late 1990ies and early 2000s (Valdmann et al., 1998; Kübarsepp & Valdmann, 2003), the last paper was published by Valdmann et al. in 2005. Bear diet has been studied in mid 2000-s with MSc theses defended in University of Tartu by Egle Vulla and Marju Korsten. The research has been published in 2009 by Vulla et al. Popular scientific articles have been published in Eesti Loodus (Estonian Nature) by Tammeleht et al. (2010b, 2011), one manuscript of scientific paper is in preparation by Keis et al.

Wolf and lynx **parasitology** has been focused on helminths, main findings are published in the middle of last decade by Moks et al. (2006) and Valdmann et al. (2004). Since 2009 spread of mange in Estonian wolf population has been followed, with papers published by Jõgisalu et al. (2010) and Jõgisalu & Männil (2011).

Impact of carnivores on prey species. Lynx and roe deer interrelations have been studied since 2008 by using data from 8 GSM/GPS telemetry devices. MSc thesis has been defended by Raido Kont (2010) and a paper published by Kont et al. in 2010.

Territoriality and habitat use by wolf and lynx have been studied since 2004 by winter tracking and radio-telemetry. In addition to aforementioned lynxes, first wolf was marked with GSM/GPS device in 2011. As the studies are long-term and ongoing there are no results published yet. Technical reports are available on web page of the Estonian Environment Agency (www.keskkonnainfo.ee). In 2005 a bear was tracked using radio collar and results of the work are included in Egle Vulla MSc thesis in University of Tartu (2006).

Genetic studies involve all three species, but as a rule wider geographical area and population have been involved. In cooperation with scientists from other countries population structure or phylogeography have been in focus of research. Genetic studies involving Estonian material have been published on brown bear (Davison et al., 2011; Tammeleht et al., 2010a; Korsten et al., 2009; Ho et al., 2008; Saarma et al., 2007) and lynx (Hellborg et al., 2002; Schmidt et al., 2009, Ratkiewicz et al., 2012). Wolf genetics, particularly wolf-dog hybridisation have been discussed in one paper by Hindrikson et al. (2012) while second paper, dealing with population genetics of wolves in Estonia and Latvia is in preparatory phase. Hybridisation is also discussed in a popular scientific magazine Eesti Loodus (Estonian Nature) by Hindrikson et al. in 2009.

Main research results have been regularly reflected in Estonian hunters magazine Eesti Jahimees (Estonian Hunter).

A comparative study on the capacity of meeting the targets of large carnivore **management** by recreational hunters has been carried out in Estonia, Latvia and Norway. The results are published in Bishof et al. (2012).

Interactions of large carnivores **with man** have been studied both from historical sources and by contemporary sociological inquiries. Ilmar Rootsi has used archives to study relations of wolves and man through centuries, he published a book "Tuli susi soovikusta" (There came a wolf from mire) in 2005, also he received doctoral degree in history (2011). He also has published research papers on man-eating wolves of 19th century (Rootsi, 2001) and rabies in Estonian wolf population in 18th and 19th centuries (Rootsi, 2003). In years 2003–2006 a cooperative study "Large carnivores in northern landscapes: an interdisciplinary approach to their regional conservation", financed by the Norwegian Research Fund was carried out by Norwegian, Estonian, Latvian, Lithuanian and Polish researchers. In addition to their final report (Linnell et al., 2006) the results of the study have been published also in scientific literature (Balćiauskas et al., 2010; Randveer, 2006; Balćiauskas et al., 2005). Tiit Randver has studied attitudes of people towards wolves (Randveer, 2001).

Tipu research area is a territory in northern part of Kilingi-Nõmme hunting district, which is in use by the State Forestry Management Centre and Soomaa National Park. The area has functional status as here the State Environment Agency has carried out majority of recent large carnivore studies. Scientists in a letter to the Minister of Environment have motivated the need for legal status covering the area in 2009. Doing various studies (incl. experimental) in parallel with intensive monitoring of a restricted area facilitates achievement of high quality scientific results. As every single research adds to other efforts, conditions are created to explore ecological interrelations (direct and indirect) between species. Scientific experimentation and/or manipulations should be allowed according to the aims of studies and hence hunting activities in the area should follow those scientific designs. There is international interest towards this research area due to its uniqueness in Europe.

In the Tipu research area wolves have been studied since 2005 and lynxes since 2008 (all 9 GSM/GPS tagged lynxes originate from there) with parallel intensive monitoring of their prey by winter tracking and pellet counts along permanent transects in spring. Since 2008 three roe deer, four wild boar and one wolf have been radio-collared in the area. In 2011trail cameras were used to study breeding mortality of capercaillie. Aim of the study was to register nest (and experimental artificial nest) predators. At the same time, scientific research bears a conflict with interests of manager of the hunting region. The State Forestry Management Centre acts according to its constitution as profit-orientated company and limitations set to the hunting activities are seen to reduce potential profits. Hence the area needs clear functional status, which excludes the conflict between research and economic objectives in future.

2. ROLE OF LARGE CARNIVORES IN ECOSYSTEM

Many papers have been published on the role of top predators in the ecosystem. Their importance has been proven in securing biodiversity and hampering spread of diseases or invasive species, even in maintenance of physical and chemical conditions of soil, air and water (Estes et al., 2011). In current chapter we discuss present and expected direct and indirect influences of large carnivores on ecosystem from perspective of situation in Estonia.

2.1. Impact on prey species

Predator-prey interactions have gained a lot of attention from researchers and different studies have been carried out in wide variety of world ecosystems. At the same time there are significant regional differences in species diversity and climate conditions. In addition, predation impact depends predominately on specific species densities in the region which in turn can be strongly influenced by hunting activities. Due to ecological differences and wide variability of anthropogenic pressure, the results are in most cases not directly applicable to other regions and predator-prey interactions will probably stay in research focus also in the future.

Ungulates form the major part in wolf and lynx diet (Jedrzejewski et al., 1993; Okarma, 1995; Valdmann et al., 2005) and most of predation studies also concentrate on ungulate populations. In Europe the proportion of ungulates in brown bear diet is significantly smaller (Vulla et al., 2009) although in northern region predation by brown bear can form a substantial part of moose calf mortality (Swenson et al., 2007).

Capability of large carnivores to reduce ungulate abundance has been shown by several studies, which involve removal or reintroduction of predators in certain areas (Jedrzejewska et al., 1997; White & Garrott, 2005). In parts of Europe, which are not inhabited by large predators, roe deer densities are significantly higher (average 1485 ind/100 km².) than in areas where wolf or lynx are present (average 605 ind/100 km²). Where both of the mentioned predator species are present, the density is even lower (average 167 ind/100 km²; Melis et al., 2009).

Regulating effect of wolves on moose population (situation where predators can maintain prey population on a constant low level) has been detected in Northern America (Messier, 1994). In several other studies a limiting effect predation has been detected which means that predators lowered notably prey abundance, but were not able to change its long-time trend. Predation impact is also different for various prey species. For example in Bialowieza, Poland, wolf and lynx predation reduced significantly small ungulate, like roe deer and red deer, abundance whereas wild boar, moose and bison populations were mainly limited by food availability and climate (Jedrzejewska & Jedrzejewski, 2005).

Wolf

Wolf has wide diet spectre, which includes prey of different sizes. In North America where moose is main prey species for wolves and additionally bears prey on moose calves, predators have kept the prey population in a constant low level (< 0.65 ind/km²; Messier 1994). In Europe, where wolf diet involves, depending on region, 1 to 4 species of ungulates, mostly limiting effect on prey species abundance has been detected (Jedrzejewski et al., 2002; Sand et al., 2008). Although wolves prey opportunistically on all available species they show preference towards certain species (Okarma, 1995). In Bialowieza, Poland, 63% of wolf prey was red deer, 28 wild boar and 4% roe deer. The frequency of taking red deer was higher and roe deer was lower, than predicted by their proportional abundance in nature. Wolf pack killed new animal after every two days and altogether wolf predation formed 12% of summer population size. Wolves were the limiting factor on population growth, consuming 32–47% of annual recruits. At the same time, only 3 and 6 per cent of roe deer and wild boar summer population size, respectively, were taken by wolves and their populations were limited by other factors (lynx predation for roe deer and food availability for wild boar; Jedrzejewski et al., 2002). There are examples from southern Europe, where ungulate fauna consists of wild boar, red deer and roe deer. Wolves prefer wild boar as main prey species, taking predominantly young animals (89.5% of prey are individuals less than one year old; Mattioli et al., 2011). Although wild boar can be locally wolfs main prey item, influence of predation on its population dynamics is marginal, compared to food availability or severity of winters (Melis et al., 2006).

In Scandinavia wolves are mostly preying on moose, which makes over 95% of the consumed biomass (Sand et al., 2005). In an average a wolf pack takes two specimens a week that is 30–110% more than presented by several North American studies (Liberg et al., 2010). The reason lies in high population density of Scandinavian moose (>1 ind/km²) and absence of behavioural adaptations to avoid predator attacks. Predation mortality affected mostly young individuals;

depending on wolf pack proportion of calves was 39–93%. In majority of regions, wolf predation did not exceed 50% of annual recruits (Liberg et al., 2010).

Roe deer, wild boar and moose are important prey species for Estonian wolves, but their proportion in wolf diet can vary seasonally and regionally (frequency percentage of remains in faeces: roe deer 12–59, wild boar 17–37, moose 12–31; Kübarsepp & Valdmann, 2003; Kübarsepp & Kont, 2008). Strength of wolf predation on prey populations has not been thoroughly studied in Estonia. At the same time, simple correlative comparisons indicate, that in hunting regions which are permanently inhabited by wolf, proportion of calves is lower in hunting bag and observational data shows higher amount of single cows than in the wolf-free regions (Veeroja, 2007). Also in case of wild boar, proportion of piglets in hunting bag is lower and number of sounders without piglets is higher (according to the hunters questionnaires) in areas where wolves are present. Still, this analysis does not separate predation from other key factors as habitat quality and hunting pressure, thus drawing firm conclusions is problematic.

Lynx

European lynx feeds mostly on small and medium size ungulates which make up to 92% of consumed biomass (Jedrzejewski et al., 1993; Jobin et al., 2000; Sunde et al., 2000; Valdmann et al., 2005). Lynx is considered to be an effective predator, in moderate winter conditions lynx predation is next to hunting one of the main factors which limit roe deer populations (Jedrzejewska et al., 1997; Melis et al., 2010). Lynx increases adult roe deer mortality. They prefer red deer calves and avoid adult males (Okarma et al., 1997). For example in Bialowieza, Poland, lynx took a roe deer or red deer in an average in every 5.4 days. With lynx densities as high as 2.4–3.6 ad. ind/ 100 km² , annually 110–169 roe deer were killed per 100 km², which forms 26% of roe deer population in the area (Okarma et al., 1997).

In Switzerland, where lynx densities are lower (0.9–1.0 sp. 100/km²) and killing rate the same, lynx took annually 9% of roe deer and 11 % of chamois (*Rupricapra rupricapra*) summer populations (Molinari-Jobin et al., 2002).

Lynx killing rate depends on individual sex, age and reproductive status. The value is the highest for females with pups and the lowest for subadults, 1–2 years in age (Okarma et al., 1997; Jobin et al., 2000). Thus predation pressure is determined by lynx population structure and proportion of females with pups.

In Estonia, data from eight telemetrically followed lynxes can be used to assess the predation pressure. Annual predation loss to lynx was calculated using

killing rate and roe deer population density (Kont 2010). With high population density of lynx for Estonia (2.0 ind./100 km²) 134 roe deer were taken per 100 square kilometres which makes 28% of the total amount of roe deer and reduces significantly the species abundance. At the same time it must be noted, that in the study period roe deer numbers were very high (in the study area appr. 482 ind/100 km²) and abundance of alternative species in the area was low. In conditions of low roe deer abundance the predation frequency is obviously lower.

Brown bear

Brown bear is an omnivore with broad diet spectre, whose food composition depends on seasonal availability. In deficit of vegetal food, especially in spring, meat can be a valuable source of nutrients and energy for bear (Persson et al., 2001).

Proportion of meat in bear diet is higher in northern populations, whilst it may vary individually within a population (Zager & Beecham 2006; Vulla et al., 2009). In addition it remains unclear how much bears kill and how much they feed on carrion. For example, in North America it has been estimated that only 30% of meat consumed by bears originates from predation (Mattson, 1996). In general, bears target predominantly young ungulates as for couple months after birth those are abundant and easily accessed by bears (Zeger & Beecham 2006). For example, in certain regions of Scandinavia bears took an estimated 26% of moose calves, whereas in 92% of the cases the calves were less than one month old (Swenson et al., 2007). Predation was partly compensated in the next breeding season by higher fertility of the cows that lost their offspring.

Dietary studies in Estonia have not resulted in finding moose remains in bear faeces, also presence of wild boar is modest (Tammeleht et al., 2010b). Although animal food formed over a half of energetic content of bear diet, ungulates seem not to belong to their favoured prey items. At the same time, proportion of moose calves can be underestimated as the samples were collected in autumn, when predation by bear has marginal role in mortality of moose calves (Tammeleht et al., 2010). Although there is no exact data, influence of predation by bears in Estonia can be considered marginal in comparison to other mortality factors.

2.2. Large carnivores as keystone species

Reduction of medium sized predator abundance

Large carnivores kill smaller predators for food as well as to remove competitors for their food resource. In the latter case the kill is not eaten and the process is called intra-guild predation. Often the intra-guild predation rate is higher than proportion of individuals of the target species taken for food. Several studies indicate how various top predators reduce significantly numbers of medium sized predators. In addition to direct predation, presence of a large carnivore alters behaviour and habitat selection of medium sized predators, which in turn may influence their mortality (Palomares & Caro, 1999). It has been estimated, that increasing large carnivore abundance brings about a disproportional (about fourfold) drop in related medium sized predator abundance (Richie & Johnson, 2009).

Many published studies refer to disappearance of large predators, with consequent increase of medium sized predator pressure as a reason for depletion, depression or low population numbers for several species (Palomares & Caro, 1999). Even if large and medium predators use the same food basis, intra-guild predation effect is positive to prey because number of predators and their direct impact on prey species are lower (Prugh et al., 2009).

Studies, carried out in Norway have confirmed intra-guild predation of lynx on fox (Sunde et al., 1999). In Sweden it was estimated that about 50% of adult fox mortality is formed by predation by lynx (Helldin et al., 2006). Foxes influence significantly reproduction of grouse (Kauhala et al., 2000), ducks (Kauhala, 2004), European hare (Panek et al., 2006), mountain hare (Kauhala & Helle, 2000), European and mountain hare (Lindström et al., 1994) and roe deer (Lindström et al., 1994; Jarnemo & Liberg, 2005), so high lynx abundance should favour recovery of several prey species of fox. Interrelations between lynx, fox and hares have been studied in Finland and it has been found that in times of high lynx abundance fox numbers have been low and hare abundance high (Elmhagen et al., 2010). Impact of wolf and lynx predation on racoon dog has not been studied, but observational data from Estonia indicates, that wolves can suppress raccoon dogs at least locally with consequent positive effect on species which are influenced by raccoon dogs. Low population densities of fox and raccoon dog help also to restrict wide spread of several viral infections like rabies, canine distemper, canine parvovirus and parasitic diseases like mange.

Impact on crop and forest damage caused by ungulates and beaver

Large predators can have significant influence on ungulate abundance and consequently on rates of damage caused by them to agriculture and forestry.

The main limiting factor for moose abundance in Estonia has been hunting and hunters have been effective in this role. Thus, manipulating the quotas has mitigated the damages and role of predators is secondary. Still, during high winter concentrations of moose to certain areas predation and harassment by wolves may locally have significant effect on forest damages.

Wolf and lynx predation exceeds the limiting effect of hunting for roe deer populations. Roe deer damage in young pine stands is the severest during high abundance periods, but hunting quotas have been adjusted to this damage with a 2–3 year delay when the populations have turned to decrease due to other reasons. Wolf and lynx predation have probably significantly influenced increase rates of roe deer population with consequent effect on forest damage during the rise period.

Wild boar is mostly regulated by hunting and wolves may be important locally and temporarily. At the same time it is also the hunters' interest to maintain high wild boar abundance and reproductive rates.

Lynx and wolves have been observed to be important beaver abundance and damage regulators in Estonia. Definitely this influence increases in periods when main prey species are less abundant and need for alternative food source is therefore higher.

Increase of food basis for other predators and omnivores

Wolf and lynx kill are attractive to several other species. The dietary studies of lynx in Estonia have revealed usage of the roe deer which are taken by lynx also by wolves, wild boar, fox, raccoon dog, pine marten and several bird species. Wolf and lynx kill can serve as vital food alternative for several species during severe winters when thick snow cover restricts access to main prey items (e.g. small rodents). The carrion contributes to diet of protected eagles, some owls and bear in spring.

3. LARGE CARNIVORES AND MAN

Throughout history relations between man and large carnivores have been very complicated and contradictory. Wolves have been domesticated and used in hunting which lead to evolution of dogs. Large predators have firm place in folklore, also they have been cult species. Teddy bears contribute to individual development of many children. At the same time, large carnivores are food competitors for hunters; they prey on livestock and have occasionally killed people. This has led to persecution of large predators throughout many centuries and there have been attempts to remove them by all means. Only in recent decades scientific studies have led to evaluation of large carnivores as a vital component of ecosystems and also as aims of nature and hunting tourism.

3.1. Review of history

Interrelations of man and large predators date back several millennia, but they were tensioned when man settled and started to breed livestock. Since then, livestock has been the main source of conflict between man and predators. Wolves with their adaptive foraging, plasticity and high reproductive rate have been the main competitors to man in temperate regions throughout history. The anti-wolf "war" dates back to the ancient times. According to Rootsi (2011), first bounties were paid for killed wolves already 500 y.b.p. In Europe, bounties were paid up to 1970-ies, in Estonia up to 1990-ies and in Russia it is an ongoing practice. Wolves have not only damaged livestock but killed people too. Man-eating wolves are considered to have been exceptional, specialised individuals. How many of them were actually dogs, hand reared wolves (very common in earlier days) or dog-wolf hybrids remain unknown. Last fatal wolf attack on man was registered in Estonia in 1873 (Rootsi, 2001, 2011).

Bear and lynx have never deserved similar human attention. Still, attempts have been made to suppress also those species together with wolf. By 1930-ies abundance of all three species was very low in Estonia. In 1937 lynx was protected by law (Kaal & Randla, 1984), but already in 1954 Harry Ling described lynx as harmful pest who, allegedly, destroys valuable fur animals as raccoon dogs and foxes alongside with wildfowl, roe deer and mountain hare (Ling, 1954). In 1980-ies hunting season and quota were established for lynx. Yet the quota was later abolished.

Wolf abundance rose quickly after the WW II, but introduction of poisoning and wolf hunting squads brought the population down where it stayed for a decade

in 1961–1971. Since 1971 the population was growing until 1995, followed by a steep decline until 2003. First hunting quotas were set to the practically outlaw wolf as late as in 2001.

Brown bear was protected by law in 1958 (Kaal , 1980), but regular hunting was introduced again in early 1980-ies. Since 1970-ies bear abundance has constantly increased up to mid 1990-ies, when population overestimate led to overhunting, which reduced abundance. Bear population remained stable until mid 2000s.

3.2. Hunting

Large carnivores as competitors with man

The main targets for hunters are various ungulates which provide both meat and trophies. Large carnivores, particularly wolf and lynx, use the same species for food and in this way compete with hunters for the resource. They increase ungulate mortality and in certain conditions are able to suppress ungulate populations and maintain them on low levels. In areas inhabited by large carnivores, sustainable hunting quotas of ungulates must account also predation which reduces the hunters' share. Competition for resource is currently substantial source of conflict next to damage and it adds to pressure of increasing quotas and to poach. Hunters are among the stakeholders who determine future of large carnivores.

Hunting of large carnivores

Hunting is a major contributor, in addition to habitat destruction, to disappearance of wolves in most of Europe (Breitenmoser, 1998). Today sustainable, scientifically motivated hunting management with an aim to secure viable populations is replacing persecution.

Trophy hunting is gaining bigger proportion in large carnivore hunt. Wolf, lynx and bear skulls are evaluated according to standards approved by the International Council for Game and Wildlife (CIC). Locally large predator hunting is providing additional income for game tourism cluster.

One of the management aims in national strategic documents is optimal population size. For example, in the large carnivore management plan for period 2002–2011 (Lõhmus, 2001), the parameter for wolf population is set at 100–200 individuals. This presumes not only prevention of exceeding the hunting quota, but also state responsibility for fulfilment of quota. Hence practical capacities of hunting should be accounted in management efforts (Bishof et al., 2012).

Hunting pressure

In Estonia hunting is the main mortality factor for wolf, lynx and brown bear. Impact of hunting on a population is defined as hunting pressure. It is expressed as proportion of hunted individuals from total population size in percents (Fig. 10). Maximum sustainable yield (MSY) is the rate of hunting pressure which maintains the population on the same level as it was in previous season, thus it is equal to the reproductive rate of the population.

MSY is dependent on population reproductive rate and non-hunting mortality, including both natural (diseases, intra-specific and inter-specific predation) and man-made (traffic, poaching) causes. As natural reasons and also human induced mortality (mainly poaching) are specific to region and species, data from other countries cannot be used to define MSY. MSY varies also annually as it depends on fluctuation in yearly reproductive rates.

Long time average MSY for wolf in Estonia has been estimated to 44–47% , for lynx approximately 17% and for bear 6.2% (Lõhmus, 2001). Bear MSY in Sweden has been estimated to be 7% (Swenson et al., 1994) and in Finland 10% (Kojola, 2007). It can be seen in Figure 10, that in 2003–2007 wolf and lynx has been hunted below MSY, which led to continuous population increase and since 2008 wolf hunt is exceeding MSY with subsequent decline in population size. MSY is important for hunting management according to population condition and set long-term aims.

3.3. Depredation on livestock

Large carnivore depredation on livestock is among main sources of conflict between the predators and man. Depredation occurs to larger or smaller extent everywhere, where human and large carnivore ranges overlap. The extent of damages depends in one hand from predator abundance, their habits and availability of natural prey, and in the other hand from abundance and availability of livestock and domestic animals. The least concern mostly measures taken to avoid predator damage. Those measures are often related to traditions of livestock breeding. In Estonia the depredation cases has been regularly registered in conjunction of damage compensation since 2007.

Bear depredation occurs mostly in form of bear raids on apiaries, killing of livestock is extremely rare. The depredation on livestock is surprisingly low with the present bear abundance and livestock availability, compared to several other regions in Europe (Kaczensky, 1999; Mykrä, 2007; Dećak et al., 2005). Relatively

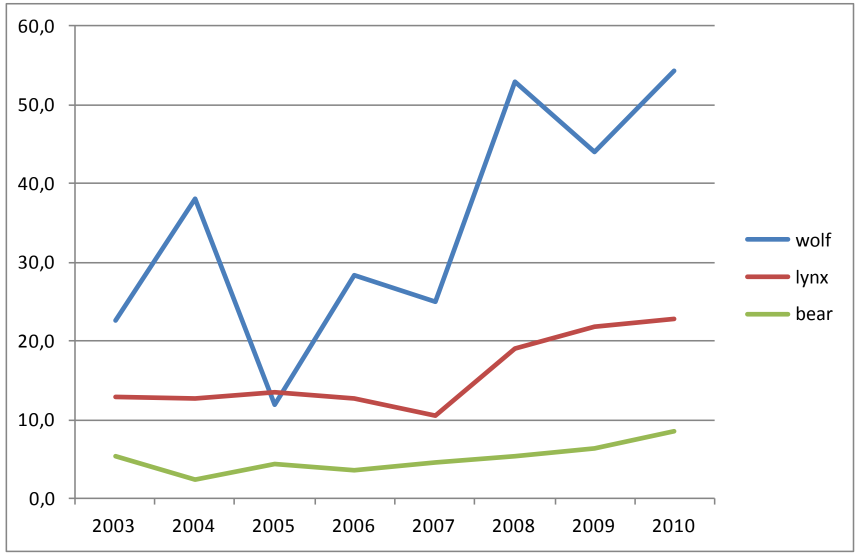

Figure 10. Hunting pressure (% of individuals hunted from autumn population size) for wolf, lynx and bear in years 2003-2010.

Table 2. Numbers of depredation cases of bear, wolf and lynx, amount of damaged beehives or killed livestock and compensations paid (based on data of Environmental Board)

		2007	**2008**	**2009**	**2010**
	Cases	33	24	32	50
BEAR	Beehives	170	66	78	106
	Sum €	20 150	9000	10 150	12 350
	Cases	34	77	72	108
WOLF	Livestock	148	446	496	565
	Sum €	8000	40 000	34 000	43 000
	Cases	0	3	5	10
LYNX	Livestock	0	6	39	14
	Sum €	0	500	2850	450

wide variation in annual damage rates to apiaries (Table 2) is explained by yearly variation in natural food for bears in autumn.

Wolf depredation is in major part related to killing of sheep, taking cattle or dogs is relatively rare. So far years 2003–2005 have been exceptional, as then several dogs were taken in three Estonian regions (Männil, 2005). Increase of damage in 2010, regardless of decline in wolf population, can be related to constant increase in abundance of sheep and collapse of the main prey species –roe deer – population in 2010. Proportion of livestock in wolf diet is more dependent on the abundance of game ungulates and wolf population size (Sidorovich et al., 2003). Current predation pressure on livestock is still not comparable to historical levels: for example in 1823 over 30 000 domestic animals were taken by wolves in historic Livonia (Rootsi, 2011).

Lynx depredation is, compared to wolf and independently from the significantly higher lynx abundance, related only to sheep. Kaczensky (1999) compared predator damages in 13 countries of Europe by amount of killed livestock per one predator during one year. Lynx took from 0.15 units in Sweden up to 9.5 units in Norway, while in Estonia the relevant value is 0.02 for 2010. Low numbers of sheep killed by lynx are registered also in Finland (Liukkonen & Härkönen, 2007). Outstandingly high number is presented for year 2009 in Table 2. Here an expert in two cases wrongly determined the predator and other two cases are a sum of longer periods.

Problem individuals and occasional kills

Based on their personal experience, large carnivores can turn into specialist individuals who take livestock more frequently than average (Linnell et al., 1999). Probably the wolves that killed dogs in three separate regions of Estonia in 2003–2005 belong to this kind (Männil, 2005). This suggestion is confirmed by the fact that after removal of the suspected wolves (single males in two regions), similar rates of dog killings have not occurred any more. Several bears can also be specialised as the apiary damages are also concentrated to certain, limited areas. At the same time, livestock can be occasionally killed by all large carnivores (Linnell, et al., 1999). In Estonia this type of taking is predominantly involving sheep.

Taking sheep by lynx is usually not related to low abundance of natural prey – it is more frequent in areas with high roe deer numbers. This evidence indicates that killing is rather occasional, but evolving of specialists who prefer sheep is also possible (Odden et al., 2008; Stahl et al., 2002; Stahl et al., 2001). Positive correlation between killing livestock and abundance of natural prey has been also established for wolf in Canada (Muhly et al. 2010).

Effect of mitigation methods on damage

The direct relationship between livestock breeding traditions, protective measures and damage has been discussed in several thematic publications. Conservation of large carnivores in areas with intensive livestock breeding is considered to be impossible without effective damage mitigation measures. Change in farming practices is definitely one of the reasons for elevated sheep damage rates. Earlier sheep herds were usually small and they were traditionally kept in shelters overnight, today size of herds is significantly increased while the sheep are kept at open around the year. Such large herds can be effectively protected from predators with electric and net fences (Levin 2002, see also other articles in the special issue) and guard dogs (Smith et al., 2000; Otstavel et al., 2009). A study, carried out in Sweden, shows that after an attack probability of a repeated attack to the same farm is 55 times higher than to any other farm in the vicinity of one kilometre in the same area. Repeated attack respectively by wolf, lynx and bear took place within a week in 32%, 47% and 24% of cases and within five weeks in 60%, 63% and 50% of the cases (Karlsson & Johansson., 2010). It was concluded, that implementation of mitigation measures after first attack is vital to avoid further damage.

Compensation of damage

Compensation of large carnivore damage by state is considered to be an effective conservation measure, which improves public opinion towards large carnivores and nature conservation as a whole, especially in countries where large carnivores are among partially or totally protected species. Compensating damage is widely spread in Europe, from countries neighbouring to Estonia it is not implemented in Latvia and Russia. At the same time, compensating damage and subsidies for mitigation measures are the most costly segments of large carnivore conservation. Fourli (1999) has presented costs of large carnivore conservation in some European countries (Table 3). As a comparison: in Estonia cost of damage per one wolf is 170, per one bear 18 and per one lynx 1.7 Euros.

Table 3. Cost (Euros) of damage per individual in 1997 (according to Fourli, 1999)

	Austria	**France**	**Greece**	**Italy**	**Spain**	**Portugal**
WOLF	-	3892	2833	2434	1160	1163
BEAR	346	3501	1091	448	882	-

In Estonia damage compensation and mitigation subsidies were introduced in 2007. The paid sums are presented in Table 2. In LCIE guidelines for compensation mechanisms it is recommended to subsidise mitigation and compensate for damage only if owner has taken appropriate mitigation measures.

3.4 Attacks on humans

In modern time, bear attacks are the only concern. Wolf attacks have stayed in early history and lynx attacks have not been registered.

Bear can attack human for self-defence or for defence of its cubs when a human accidentally happens to become too close to her offspring. In such cases bear shows aggression and rarely attacks. European brown bears are considered to be the least aggressive in the world, frequency of attacks is higher elsewhere. Swedish scientists studied altogether 114 human encounters with bears. Four per cent of the studied cases ended with fake attacks but none with physical contact. In Scandinavia 7 encounters, ending with trauma, have been registered for past 20 years, while in six cases these events were related to hunting and in five of the cases bears had been wounded (Swenson et al., 1999a). Also in Estonia there have been cases where people were injured in bear attacks. Most of such cases took palace in hunting situations and involved wounded animals. Although in the world and in Europe there have been lethal outcome to involved people. Such cases are not known from Estonia. In the last 10 years three episodes of bear attack and consequent injury have been registered. In one case wounded bear was involved and the attack would not have taken place, as far as the circumstances are known, without the shooting incident.

Fear for bear attack plays a key role in bear conservation. There are eight known cases from Estonia when bears have been shot in self-defence from short distance while four of them were wintering females with cubs. In none of those cases bears had actually attacked people.

3.5 Nature tourism.

Large carnivores are popular tourism objects due to their low numbers and restricted ranges. In several countries, where predator abundance is relatively high, this form of tourism has been practiced for years while in Estonia such activities have been carried out only during couple of recent years. The main object is brown bear, which can be, differently from wolf and lynx, attracted

with artificial feeding for observations, filming and photography. Exposition of wolves is mainly possible by tracking, responses to imitated howls. Lynxes can only be tracked in nature. In Estonia one bear observation hide is established in Eastern part of the country, in Finland this branch of tourism is more widely spread (Mykrä, 2007). Large predator tourism provides not only financial resource for organisers but also raises awareness through experience and education. Large carnivore tourism is a considerable alternative to hunt and hunters, as one specimen or group of animals can be sold, differently from hunting tourism, for several times.

At the same time, there are some problems related to this form of tourism, which need to be considered while developing relevant activities. One aspect is adaption of bears to artificial feeding and man, which reduce the ability of those individuals to survive in the wild and also loss of shyness to man (Mykrä, 2007, Dećak et al., 2005). In the other hand, excessive disturbance, e.g. in form of frequent howl imitation, may alter wolf natural behaviour and interfere with rearing the young.

3.6. Development of infrastructure

There are two significant aspects in the infrastructure development, which concern large carnivores. First is territoriality, as their home ranges are, compared to other species, relatively large and physical barriers may force carnivores to alter or reduce their territories. Those changes may lead to conflicts between territorial (adult) specimen with consequent elevated adult mortality rates or drop in reproduction rates. The second aspect is dispersal of young specimen from their maternal territories in search of new habitats. Here physical barriers may hinder free exchange of genetic material with resulting higher mortality of young and negative inbreeding effects to species fitness (Jedrzejewski et al., 2009).

Road or other infrastructure development in Estonia has not created physical barriers to large carnivores so far, but the next phase of building Tallinn-Tartu road may bring about such problems. To mitigate possible negative influence, a manual containing various alternatives has been compiled for road constructors (Klein, 2010). Also fencing forest massifs to create cattle or game farms can pose a problem to large carnivores.

3.7. Hand reared large carnivores

In history rearing wolves and bears by people was rather common, domesticated wolves or dog-wolf interbreeds were successfully used in hunting. Still, those animals were considered to be more dangerous to people as they lacked the natural fear of man (Rootsi, 2005). Today it is prohibited to hand-read or cross-breed large carnivores in most countries. At the same time, developments in animal welfare have advanced wild animal rehabilitation schemes where injured or orphaned animals are kept in captivity for certain periods and later released to the wild. Of large carnivores, bears are most frequently rehabilitated due to the fact that females abandon their pups if disturbed in their winter den. In Estonia 40 bears have been rehabilitated in years 1998–2010, mostly in the Nigula Game Sanctuary. In 2010 the sanctuary was closed. The main problem with the released individuals is their loss of shyness, most of them develop into problem individuals who are not afraid of people and see them as feeders rather than a threat. Presence of individuals habituated to humans worsens, as a rule, public attitude towards bears and may bring about increase in poaching and public pressure to reduce bear abundance (Huber, 2005). Negative impact on conservation of natural population by those individuals has been pointed out also by LCIE guidelines (Linnell et al., 2008). Rehabilitation and release have conservational justifications only in the case when status of a population is so poor that every specimen contributes to improvement of the situation. In other cases resource should be allocated to conservation of natural population and prevention of abandonment of pups by female bears (van Dijk, 2005; Huber, 2005).

4. LEGISLATION

Current legal status of large carnivores in Estonia is defined by the Hunting Law and regulated by several European Union legal acts and international conventions, which Estonia has ratified. The subdivisions of this chapter, dealing with international legislation, are based mainly on Trouwborst (2010) and Linnell et al. (2008).

4.1. Estonian legislation

According to the Hunting Law, wolf, lynx and bear are species of large game that require a special licence for each hunted individual. The hunting season and conditions are defined by the Hunting Regulation (Table 4).

Table 4. Seasons and conditions for bear, wolf and lynx hunting in Estonia

	Status	Season	Allowed methods	Additional conditions
BEAR	Large game	01.08.–31.10.	Hunting from hides, stalking	Allowed in areas with bear damage to mitigate damage, prohibited to shoot females with cubs
WOLF	Large game	01.11.–28.02.	Hunting from hides, stalking, drive hunting, hunting with dogs and flaudry	-
LYNX	Large game	01.12.–28.02.	Hunting from hides, stalking, drive hunting, hunting with dogs	Prohibited to shoot females with pups

In addition to the conditions given in Table 2 bears can be hunted only using bullets, for hunting with rifle minimum calibre must be at least 6.5 mm and bullet minimum weight 9.0 grams. In case of damage and for scientific research, the Environmental Board can issue special licenses outside the hunting season.

In case of poaching, the Government Regulation “Rates of penalties for damages caused by illegal killing of game animals or destruction of their habitat” sets the penalty for bear at € 2000, for lynx at € 960 and for wolf at € 385. In case of pregnant females the given sums are tripled.

According to the Nature Conservation Law, bear winter habitats and area inside the radius of 300 metres are defined as species protection site where restrictions to forestry and hunting activities apply up to 15th of April of the ongoing wintering season.

According to the Nature Conservation Law and the Ministry regulation “Methodology for evaluation of the damage caused by wild animals, rules for damage compensation and mitigation subsidies”, damages caused by wolf, lynx and brown bear are compensated by state and mitigation measures are partially subsidised.

4.2. International conventions

Estonia ratified Bern Convention or The Convention on the Conservation of European Wildlife and Natural Habitats in 1992. The principal aims of the Convention are to ensure conservation and protection of wild plant and animal species and their natural habitats, to increase cooperation between contracting parties, and to regulate the exploitation of those species. To this end the Convention imposes legal obligations on contracting parties. The species with high priority to which conservation schemes must be applied are enlisted in three appendixes. Wolf and bear can be found in Appendix II – Strictly Protected Fauna Species and lynx in Appendix III – Protected Fauna Species.

In European wolf, lynx and bear management plans there is foreseen also a need for national management plans (Boitani, 2000; Breitenmoser et al., 2000; Swenson et al., 2000). In addition there are several other rules and requirements regarding large carnivores. Differently from several other countries Estonia did not apply exceptions for wolf and bear in the Appendix II, so those exceptions have to be motivated annually to the convention office.

Estonia ratified the **Washington convention (CITES)** or the Convention on international Trade in Endangered Species of Wild Fauna and Flora in 1992. The convention aims are protecting endangered species and regulating their import and export. The species covered by the convention are enlisted in three annexes according to their conservational status. Wolf, lynx and bear are included in the Annex II as species “which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival”.

Convention on Biological Diversity was adopted in Rio de Janeiro in 1992 with Estonia participating. The convention aims at conservation of biological

Table 5. Status of large carnivore conservation or conservation and management plans in countries neighbouring to Estonia.

	WOLF	**LYNX**	**BEAR**
Latvia	Yes	Yes	Yes
Lithuania	Under compilation	No	No
Poland	Under compilation	Under compilation	Under compilation
Byelorussia	Yes	No	No
Russia	No	No	No
Finland	Yes	Yes	Yes

Table 6. Legal status of large carnivores and international conventions (according to Linnell, 2008) in countries neighbouring to Estonia.

		National status	**EU Habitat Directive (Appendix)**	**Bern Convention**	**CITES**	**Biodiversity Convention**
Russia	WOLF	Hunted		-	+	+
	LYNX	Hunted		-	+	+
	BEAR	Hunted		-	+	+
Latvia	WOLF	Hunted	V	+	+	+
	LYNX	Hunted	IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Lithuania	WOLF	Hunted	V	+	+	+
	LYNX	Protected	II, IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Poland	WOLF	Protected	II, V	+	+	+
	LYNX	Protected	II, IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Byelorussia	WOLF	Hunted		-	+	+
	LYNX	Protected		-	+	+
	BEAR	Protected		-	+	+
Ukraine	WOLF	Hunted		+	+	+
	LYNX	Protected		+	+	+
	BEAR	Protected		+	+	+
Finland	WOLF	Hunted	IV, V*	+	+	+
	LYNX	Hunted	IV	+	+	+
	BEAR	Hunted	IV	+	+	+
Sweden	WOLF	Protected	II, IV	+	+	+
	LYNX	Hunted	II, IV	+	+	+
	BEAR	Hunted	IV	+	+	+

* reindeer breeding areas

diversity and sustainable use of its components. The convention defines sustainable use as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations."

4.3. European Union legislation

The European Union Habitats Directive (92/43 EU) aims at conservation of biodiversity in the territory of European Union by measures that conserve, and where necessary, restore favourable conservation status of species and habitats of community interest. The conservational status of species is defined by three appendixes: Annex II enlists animal and plant species of community interest whose conservation requires designation of special areas of conservation, Annex IV the species of community interest in need of strict protection and Annex V species whose taking in the wild and exploitation may be subject to management measures. Wolf, bear and lynx are enlisted in Annexes II and IV. The directive allows geographical exceptions to countries. Thus Estonian large carnivores are excluded from Annex II while wolf and lynx are moved from Annex IV to Annex V. According to Article 16 it is allowed, under special exceptional conditions, take or keep also species enlisted in Annex IV. Those conditions are applied in Estonia to bear hunting. According to Article 17 member states are obliged to report every six years on population status and its changes.

European Union CITES regulation (338/97 EC) regulates international trade of natural species covered by the Washington Convention (CITES). Large carnivores are enlisted in Appendix A. The convention, with some exceptions, prohibit purchase, offer to purchase, acquisition for commercial purposes, display to public for commercial purposes, use for commercial gain and sale, keeping for sale, offering for sale or transporting for sale of enlisted species. For importing or exporting the enlisted specimen, their body parts or products a special permit is issued by the Ministry of Environment.

Guidelines for population level management plans for large carnivores in Europe (Linnell et al., 2008) is not a legal document but a set of recommendations and propositions for gaining and maintaining favourable population status of large carnivores. Since large carnivores do not follow national borders their populations are shared by several countries and effective long-term conservation is possible only in international cooperation. The guidelines also present the

Table 5. Status of large carnivore conservation or conservation and management plans in countries neighbouring Estonia.

	WOLF	LYNX	BEAR
Latvia	Yes	Yes	Yes
Lithuania	Under compilation	No	No
Poland	Under compilation	Under compilation	Under compilation
Byelorussia	Yes	No	No
Russia	No	No	No
Finland	Yes	Yes	Yes

Table 6. Legal status of large carnivores and international conventions (according to Linnell, 2008) in countries neighbouring Estonia.

		National status	EU Habitat Directive (Annex)	Bern Convention	CITES	Biodiversity Convention
Russia	WOLF	Hunted		-	+	+
	LYNX	Hunted		-	+	+
	BEAR	Hunted		-	+	+
Latvia	WOLF	Hunted	V	+	+	+
	LYNX	Hunted	IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Lithuania	WOLF	Hunted	V	+	+	+
	LYNX	Protected	II, IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Poland	WOLF	Protected	II, V	+	+	+
	LYNX	Protected	II, IV	+	+	+
	BEAR	Protected	II, IV	+	+	+
Byelorussia	WOLF	Hunted		-	+	+
	LYNX	Protected		-	+	+
	BEAR	Protected		-	+	+
Ukraine	WOLF	Hunted		+	+	+
	LYNX	Protected		+	+	+
	BEAR	Protected		+	+	+
Finland	WOLF	Hunted	IV, V*	+	+	+
	LYNX	Hunted	IV	+	+	+
	BEAR	Hunted	IV	+	+	+
Sweden	WOLF	Protected	II, IV	+	+	+
	LYNX	Hunted	II, IV	+	+	+
	BEAR	Hunted	IV	+	+	+

* reindeer breeding areas

LCIE (see www.lcie.org) policy recommendations, which are based on recent ecological and sociological studies in combination with knowledge and experience of scientists working with large carnivores, conservationists and game managers across Europe. The guidelines are designed for policymakers and managers on state levels whose responsibility area covers large carnivores. The recommendations include large carnivore hunting, sustainable forestry, large carnivore reintroduction, wolf and dog hybridisation, release of captive bred specimen, damage compensation and population monitoring.

4.4. Legislation in neighbouring countries

Statuses of large carnivore management plans and species legal status in countries which share common large carnivore Baltic populations with Estonia are summarized in table 5 and 6. In addition there is data from Finland and Sweden. The legal status section involves also populations which are protected by law but based on exceptions are hunted with regularly set quotas. In Russia, winter hunt in dens was kept as a long time tradition despite the criticism from international organizations. In 2010 presidential regulation was adopted prohibiting this type of hunting (E.Sitnikova, pers.comm.)

5. CURRENT STATUS OF CONSERVATION AND MANAGEMENT

5.1. Assessment of the former plan

Fulfilment of the aims

The former plan defined the main aims as securing lynx and bear population at minimum level of 500 individuals and maintaining wolf population between 100 and 200 individuals. Fulfilment of the named aims has brought up two problems:

1. In year 2001, large carnivore population estimates were based on summing of estimates provided by hunters while since 2002 a special monitoring methodology is applied. The results differ substantially and are incomparable to earlier estimates;
2. The plan does not specify whether the reference population sizes are based on earlier census results or true population sizes. If the latter is the case, it is not specified whether spring (after the hunting season) or autumn (before the hunting season) population size serves as a basis. This is relevant, above all, to wolf whose high reproductive potential leads to almost twofold difference between those population sizes.

Regardless of the above-mentioned problems it can be said that with all monitoring methods lynx and bear population sizes have exceeded the set limit population levels. The situation is more complicated with wolf whose autumn population size was, according to monitoring results, only 75 individuals in 2002–2003 and it exceeded 100 individuals by 2004. Spring population size reached one hundred individuals probably by 2008 but then autumn population was already close to 300 individuals. To avoid further confusion in current plan, aims are related to number of reproductions which is also the parameter which is being monitored.

Fulfilment of activities

Majority of key activities were fulfilled already during the first year of the plan. A post of large carnivore conservation and management coordinator was established with the Ministry of Environment, working group was founded to fulfil conservation and management aims, monitoring method was developed and implemented, wolf and lynx were given the status of large game, wolf hunting season was determined and quotas were set for wolf and lynx hunting according to the monitoring results and aims in the management plan.

In the next stage an important achievement was the system for registration, assessment and compensation of large carnivore damage which was developed in 2007 and implemented in 2008.

Activities related to applied research, awareness raising and shaping the public opinion have been started, accomplished or partially fulfilled.

Table 7. Fulfilment of former large carnivore management plan for years 2002–2011 with planned activities, priority rank (PR) and current status.

1 Nr	2 Activity	3 PR	4 Status	5 Remarks
Changing and improvement of legal acts				
I-1	Changing and improving hunting regulations	A	Fulfilled	2001, 2002 and later
I-2	Changing and improving nature conservation legislation	A	Fulfilled	2004
I-3	Changing penalty fees for illegal killing	B	Fulfilled	2003
I-4	Modernisation of management plan	A	Under Work	
Development of infrastructure				
II-1	Establishment of a post for large carnivore management coordinator	A	Fulfilled	2002
II-2	Establishment of working group for large carnivore management	A	Fulfilled	2002
II-3	Training of large carnivore experts	A	Fulfilled	2002 and later
II-4	Training of hunters in description and sampling of killed large carnivores	B	Fulfilled	2002 and later
II-5	Improvement of control over actions with large carnivores	C	Fulfilled	2004
Monitoring and information systems				
III-1	Improvement of hunting statistics	A	Fulfilled	2002, 2006
III-2	Development of monitoring methods and concept	A	Fulfilled	2002
III-3	Monitoring		Fulfilled	Since 2002
III-4	Registration of rabies cases		Fulfilled	Continuous
III-5	Establishment of system for bear wintering site registration		Fulfilled	2004
III-6	Updating of CITES database		Fulfilled	2004

1 Nr	2 Activity	3 PR	4 Status	5 Remarks
Applied studies				
IV-1	Official census error estimation		Fulfilled	Part of monitoring method
IV-2	Study of demography and population growth potential		Under Work	Continuous since 2006
IV-3	Genetic study of dog-wolf crossbreeds		Fulfilled	Only case in 2008
IV-4	Study of locations and quality of large carnivore habitats		Partially Fulfilled	Bear wintering sites, wolf habitat
IV-5	Evaluation of disturbance effect for wintering bear population		Not Fulfilled	No need, register kept
IV-6	Evaluation of traffic impact on large carnivore populations		Fulfilled	2010
IV-7	Estimation of lynx influence on roe deer population		Under Work	Started 2008
IV-8	Sociological study about bear		Fulfilled	2004–2005
IV-9	Feasibility study of areal hunting limitations		Under Work	Started 2011
Habitat protection				
V-1	Seasonal protection of bear wintering sites		Fulfilled	2007
V-2	Conservation of traditional bear wintering sites		Not Fulfilled	Study shows no need
Control and rehabilitation				
VI-1	Regulated hunting		Fulfilled	Started 2002
1	2		4	5
VI-2	Removal of dog-wolf cross-breeds		Fulfilled	Only case in 2008
V-3	Removal of large carnivores with rabies		Fulfilled	Since 2006 no need
V-4	Rehabilitation of abandoned bear cubs		Fulfilled	Finished in 2010
VI-5	Additional feeding of bears		Fulfilled	No need
Dealing with damage caused by large carnivores				
VII-1	Establishment of order for informing about damage		Fulfilled	2008

1 Nr	2 Activity	3 PR	4 Status	5 Remarks
VII-2	Registration and verification of damage		Fulfilled	2007
VII-3	Development of compensation mechanisms		Fulfilled	2008
Increasing of awareness and moulding of public attitudes				
VIII-1	Publishing of folders on large carnivores		Partially Fulfilled	2009 leaflet on bear encounters with man
VIII-2	TV series about large carnivores		Fulfilled	Several programs produced
VIII-3	Publishing shortened version of action plan		Fulfilled	2001
VIII-4	Compilation and administration of web-page		Partially Fulfilled	Reports publicly available in web
VIII-5	Organisation of information events		Fulfilled	Several events

5.2. Current conservation and management practices

Current management scheme for large carnivores was initiated in 2003 and it involves collecting and analysing the monitoring data, statistics of hunted individuals and giving out a hunting quota which follows the aims set in the large carnivore conservation and management plan. Estonian Environment Agency is the state institution under Ministry of Environment that collects and analyses the monitoring data and compiles a report each year about the current status of large carnivore populations. Based on the current population numbers and growth prognosis Environment Agency then submits a proposal for maximum allowed hunting quota for each species and also the distribution of quota between different counties which then goes for supervision to the large carnivore working group hosted by Ministry of Environment. The working group consists of representatives of different stakeholders and state institutions and it is called together to discuss the quota proposal, makes suggestions and eventually agree on the final decision. After that the hunting proposal goes to the Environmental Board which is the managing body who gives out the hunting permissions regionally. Every hunting district is obliged to report about a hunted large carnivore to Environmental Board within 24 hours.

The population estimate of each species is based on number of reproductive units (family groups) registered during previous winter (wolf, lynx) or summer (bear). In case of wolves family group is defined as a group of 4 or more individuals consisting juveniles and moving together. In case of lynxes and bears the family group represents females with young of the year. The number of family groups is derived by separating individual reproductive units from track observations and visual sightings made by hunters and by analysing the spatial distribution of hunted juveniles and reproductive females (mainly in case of wolves).

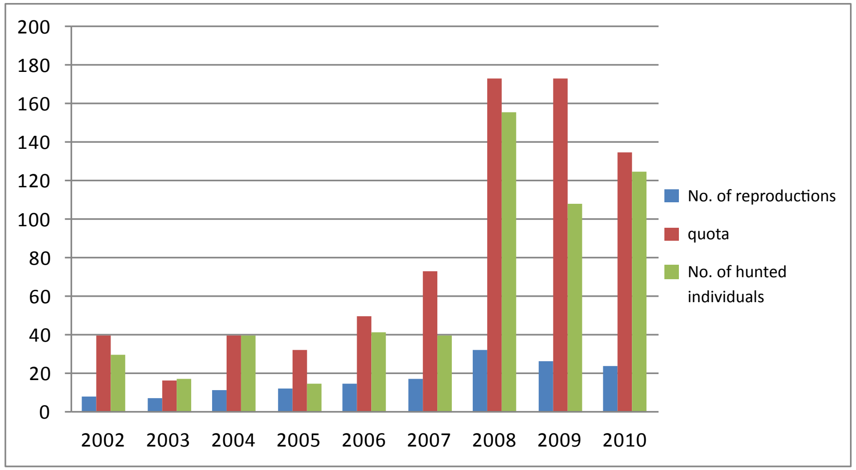

Figure 11. Number of wolf reproductive packs, hunting quota and number of hunted individuals in 2002-2010.

As the derived number of family groups for all species applies to population size before or during the previous hunting season then to set the quota limit for the forthcoming season it is important to correctly predict the current population growth and numbers. In case of wolf and lynx the population growth is forecasted by the number of reproductive units in last winter as well as bag size and demographic composition in the previous hunting season (especially the proportion of juveniles and reproductive females). In case of lynx the mean litter size in previous winter is also taken into account. With wolf and bear an additional important parameter when dividing the quota regionally is the number and distribution of damage events (attacks on livestock and ruined beehives) and with lynx the estimated size of regional roe deer population.

Wolf low numbers and high reproductive rate make it difficult to forecast the annual population growth and placement of new reproductive packs which is why the annual wolf quota is divided into two subsets. First precautionary subset is put together prior the hunting season in autumn and it is based on the minimum value

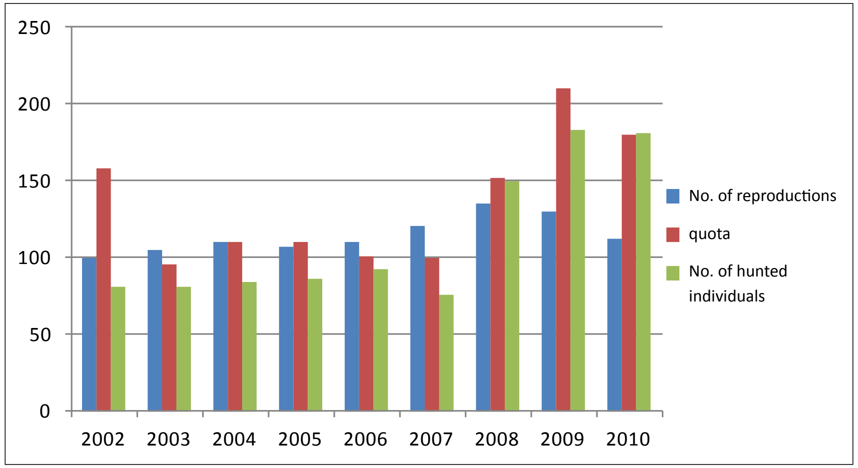

Figure 12. Number of lynx reproductions, hunting quota and number of individuals hunted.

of population growth prognosis. The second subset of quota is usually given out in the middle of winter after an up to date population estimate is obtained. Such division has proven to fit well with the specifics of the species. Lynx quota has so far been given out as one single quota with no adjustments during the hunting season.

As wolf abundance was very low in 2002–2011, the quota was divided between groups of hunting districts according to the number and placement of wolf packs in the area. The aim of such approach was to facilitate the increase of wolf population and expansion of the distribution area. Since 2008 the system was changed to county-based division with respective distribution of hunting licenses. This scheme also has its shortages as wolf territories cross county borders. In the future, the development and implementation of area and habitat-based management regions should be considered. Since 2010 there have been applied also hunting restrictions to wolf packs inhabiting large sparsely populated forest areas. On one hand this helps to secure the number and natural structure of these packs and on the other hand it shifts hunting pressure to areas with higher proportion of agricultural lands where the probability for damages to livestock is higher.

Estonian brown bear population is enlisted in Annex IV in the EU Habitat Directive which means that the conditions for bear hunting are more restrictive compared to wolf and lynx and the distribution of hunting licences needs to be more thoroughly motivated. One parameter important for the distribution of bear

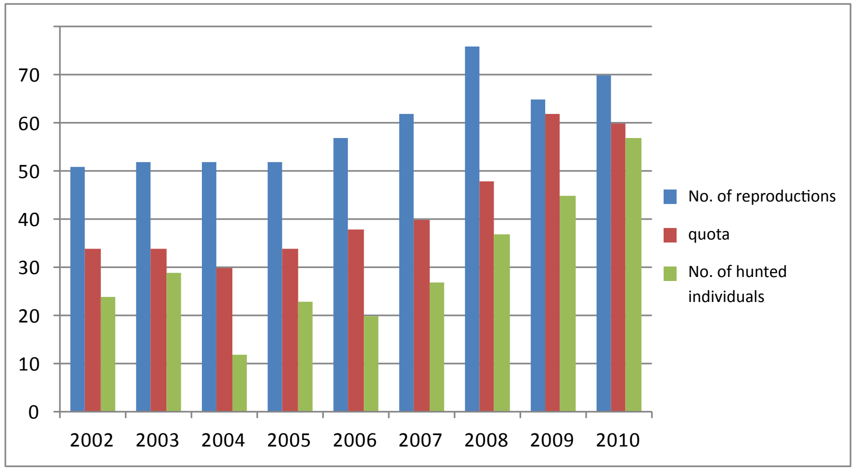

Figure 13. Numbers of bear females with cubs-of-the-year, hunting quota and number of individuals hunted.

licenses among counties has been the number of bear damages to beehives. To favour bear population expansion towards south restrictions have been implemented for bear hunting in the southern parts of Estonia since 2010. Special quota for female bears (which fulfilment means fulfilment of the total quota) has not been necessary so far.

5.3. Description of monitoring methodology in use

For assessing large carnivore species status in Estonia the following population parameters are observed:

- population distribution range (area with local breeding) ;
- population abundance (number of reproductions) and differences in local density;
- litter size (for bear and lynx);
- demographic structure;
- scope and distribution of damage;
- spread of disease in populations.

According to legislation, collection of initial monitoring data is done by users of hunting district (hunters). Environmental Board gathers the data from hunters and forwards it to Environment Agency whose task is to analyse the data and publish the results. Original data comes from four main sources, which are described in detail below together with description of the analysis. The used methodology follows LCIE guidelines (Linnell et al., 2008).

Track observations and visual sightings of individuals

Wolf, lynx and brown bear track observations and sightings of individuals are recorded in all Estonian hunting districts where these predators occur. The record sheet contains data on species, date and exact location on map, whether tracks or specimens were seen as well as number of adults and young individuals if they were distinguishable. In case of bear tracks the front paw width is also recorded. In case of lynx and bear only the sightings of multiple animals (>1 individuals together) are recorded while with wolves also single individuals are marked down.

The observation data is transferred to electronic maps by personnel from the Environment Agency and specific GIS layers are created. The following analysis defines and extracts the reproductive units by using dates and distance between observations, observed litter sizes and in case of bear also the width of the front paw. The bear females with cubs-of-the-year are then used for further analyses. The purpose of further analyse is to distinguish separate packs or family groups in observations. Size and overlap of maternal home ranges and movement distances of the species play key role in this spatiotemporal comparison. Data for evaluating these aspects comes mainly from studies performed elsewhere (Sunde et al., 2000; Schmidt et al., 1997; Linnell et al., 2001; Dahle & Swenson, 2003b; Ordiz et al., 2007; Linnell et al*,* 2007, Okarma et al., 1998) but also from currently ongoing local studies. Although Estonian data is sparse it is important to use knowledge from local populations in addition to other studies as the conditions between study sites can be very different.

The derived number of family groups is treated as a minimum estimate of the real number of reproductive units. This is mainly because observations may not "reveal" all reproductive units and analysis may falsely define spatially close units as one and the same. To get an estimation of the total population size ratio between numbers of family groups and population size has been set to 1:10 for bear and wolf and 1:6 for lynx (according to Swenson et al., 1994; Andren et al., 2002; Kojola, 2005; Solberg et al., 2006).

Data from hunted individuals

Hunters mark down the following data for each hunted individual: date and location of hunt, sex, approximate age, weight and body measurements and signs of disease or other anomalies. A root section of lower canine tooth from wolf and lynx and upper first premolar from bears are stored for further age determination. Also muscle tissue sample for DNA analysis and reproductive organs from all female individuals over one year in age are taken. Lynx and wolf juveniles can be visually determined by stage of closure of canine root apical foramen or thickness of the tooth dentine layer (Parker & Maxwell, 1986; Kvam, 1984). Exact biological age of adult individuals is determined according to the cement layers of canine roots in the Matsons Laboratory (Milltown, Montana, USA) (Klevezal & Kleinenberg, 1967; Matson, 1981). Reproductive status of hunted females is determined by Environmental Agency staff by counting the *corpus luteum*, *corpus albicans* and placental scars (Mowat et al., 1996; Hensel et al., 1969). The same enlisted basic data is gathered also from large carnivores which are found dead.

Expertise and mapping of large carnivore damages

Estonian Environmental Board carries out the expertise of large carnivore depredation events (attacks on livestock and beehives) and also the procedure for damage compensation. Sites where damages occur are visited by experts and each time a report is filled describing the exact circumstances (number of livestock killed, applied preventive measures etc.) and also the probable predator species is determined. All the damage cases are then marked to a GIS map layer. As the majority of wolf attacks occur between August and November this data can add significant knowledge about the placement of wolf packs prior the hunting season and this can be used in setting the quotas.

Winter track census in permanent transects

There are altogether >320 12 km (4x3 km) transect lines placed around Estonia so that each hunting district contains usually one transect. Track census is carried out once during the winter by local hunters when usually 24–72 hours after fresh snowfall all the tracks of different game species crossing the transect line are counted. Species abundance is then calculated as track index (average number of tracks per one kilometre transect). Wolf and lynx track indexes provide additional information on their distribution and indicate relative changes in large scale (country level) abundance and also local (county level) density. Studies in Norway have confirmed that with relevant transect densities the track index is applicable to assess the large scale changes in lynx abundance (Linnell et al., 2007). Winter transect track census is adopted in Estonia as the standard method by regulation of the Ministry of Environment.

Capacity of current monitoring for fulfilment of international obligations

According to Article 17 of the EU Habitat Directive it is an obligation of parties to report status and population changes of annex species, including wolf, lynx and brown bear, in every six years. Article 11 of the Directive obliges parties to carry out population monitoring to provide input for the report. According to the Bern Convention Estonia has to report annually hunting statistics and motivate hunting of wolf and brown bear. The report, submitted to the European Commission (for period 2007–2012) must contain following indicators:

1. Map of distribution range (10x10 ETRS 89 squares)
2. The size of distribution range
3. Short time trend (12 recent years) in the size of distribution change
4. Long time trend (24 recent years) in the size of distribution change
5. Favourable reference range
6. Population size
7. Short time trend (12 recent years) in population size
8. Long time trend (24 recent years) in population size
9. Favourable reference population size
10. Area of suitable habitat
11. Short time trend (12 recent years) in the size of suitable habitat
12. Long time trend (24 recent years) in the size of suitable habitat

In addition, the main risk factors and prognosis of their change should be included in the report. To describe the species range it is recommended to use the distribution of sexually mature individuals (Evans & Arvela, 2011).

The existing monitoring system produces data on spatial distribution of the reproductive segments of all three large carnivore populations. In case of wolf also a broader species range, which includes observations of single individuals is well evident from the data (track observations, hunting statistics, transect count, placement of depredations). The latter is less evident cases of lynx and bear as observations of single individuals are not recorded. Still the hunting statistics, transect count and distribution of depredations provide information about these species range in Estonia. GIS analyses of the given parameters allow reporting the required indicators 1–3 and 10–11 in the list above. Current monitoring methodology provides data on number of reproductions which can be used for further population size estimates. Based on this data the indicators 6–7 can be reported. Currently available data is still not sufficient for reporting indicators 4, 8 and 12 as monitoring methodology has substantially changed during the required period. Expert opinions are the only available source about possible changes during the past. Special studies are required for indicators 5 and 9. Theoretically the results can be derived from existing data with presumption that population is in favourable condition (Evans & Arvela, 2011). Risk factors and their prognoses are presented in the annual reports of the Environment Agency. Gathering the hunting statistics by current monitoring scheme is sufficient to fulfil the requirements of the Bern Convention.

5.4. International cooperation

Majority of European large carnivore populations inhabit territories of several countries, which calls for considering the trans-boundary aspects of population management (Linnell et al., 2008). Natural conditions, levels of knowledge of the population status, experiences and the monitoring and management systems vary in different European countries. Therefore it is important to cooperate and exchange the know-how and experience between different countries. Importance of such cooperation has been emphasised also by former European large carnivore management plans (Swenson et al., 2000; Boitani, 2000; Breitenmoser et al., 2000).

The main body for Pan-European cooperation of scientists and experts working with large carnivores is the Large Carnivore Initiative for Europe (LCIE, see www.lcie.org). LCIE is a working group for IUCN's Species Survival Commission (SSC). LCIE holds the best available competence on European large carnivores and is advising European large carnivore policies. Estonia is also represented in that working group. In addition Estonia has scientific and management cooperation with Finnish, Swedish, Norwegian, Latvian, Lithuanian, Polish and Russian colleagues. This has lead to elaboration of large carnivore monitoring methodology in cooperation with Finnish colleagues in 2002 and predator damage and compensation management scheme with help from Swedish colleagues in 2007. Regular information exchange regarding population sizes and hunting quota takes place with Latvia. A cooperative project to restore lynx population in Poland was launched in 2011 between WWF Poland and Estonian Fund for Nature. During the project there are lynxes caught in Estonia are released in Poland thus relocating of individuals within the Baltic population. Estonian representative(s) have participated regularly also in several international meetings related to large carnivore conservation and management e.g. conferences of International Union of Game Biologists, the Baltic Theriological Conferences and symposia in Russia related to dynamics of North European game animal populations.

6. DETERMINING CONDITIONS FOR FAVOURABLE CONSERVATION STATUS OF LARGE CARNIVORES

According to the EU Habitat Directive (92/43 EU) the member states must secure favourable conservation status (FCS) of species in the directive annexes. The status is achieved when:

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, and
2. the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
   - there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long term basis.

6.1. Viability of populations

As defined in the Habitats Directive, FCS is related to population viability. According to common criteria a population is viable if its extinction probability is less than 5% during at least one hundred years (Linnell et al., 2008). Evaluation of population viability consists of two main components: demographic and genetic viability (Bessinger & McCullough, 2002). Assessing demographic viability is based on population abundance, sex and age structure, dynamics of reproduction and mortality and management regime. If the analysis lacks demographic data then applied IUCN criterion D applies (Linnell et al., 2008). It is based on numbers of reproductive individuals and states that populations holding at least 1000 individuals can be considered viable. For smaller populations connections to neighbouring populations are evaluated to assess whether exchange of individuals has positive impact on survival of local population (Gärdenfors et al. 2000).

Genetic viability is related to genetic diversity, maintenance of evolutionary potential and prevention of inbreeding (Allendorf & Ryman, 2002). To avoid short time loss of genetic diversity, effective population size (size of genetically ideal population; N_e) must be larger than 50 individuals and in longer perspective at least 500–1000 individuals (Paetkau et al., 1998; Lynch & Lande, 1998). Among mammal populations the N_e is several times smaller than actual population size, constituting an average 10–11% of the whole population (Frankham, 1995). For example, Scandinavian bear population N_e is in the range of 6–14% from the total population size (Tallmon et al., 2004), which is close to the value for North American grizzlies (3.7–19%; Paetkau et al., 1998). For Yellowstone wolves N_e is in an average 30% and for Finnish wolves 42% of population size (Aspi et al., 2006; von Holdt et al., 2008). Since the N_e value shows that for securing genetic viability the population has to be much larger than in case of demographic viability, then in practice the management objective is to enable sufficient gene flow between populations.

The term ecological viability involves aspects of biological diversity and ecosystem functionality (Linnell et al., 2008). This means, that in addition to conservation of individuals, it is also important to conserve their interactions in the ecosystem (Soule et al., 2002; Tear et al., 2005). In case of large carnivores this means that their population size and distribution should be maintained on a level where they, to at least some extent, influence the abundance of their prey species. The term is based on a concept that conservation is more than merely saving species from extinction. Thus keeping minimum allowable amount of animals in isolation from their ecologic role is clearly not enough (Linnell et al., 2008).

6.2. Viability of large carnivore populations

Demographic viability

Populations survive when their ability to reproduce exceeds the processes which define the mortality. In addition to natural mortality European large carnivore populations are exposed to human induced mortality through direct killing (hunting, road kills) or indirectly by reducing their prey availability. Population growth of large carnivores is most sensitive to adult mortality (Sæther et al., 1998; Fuller et al., 2003), which in Europe is mostly caused by anthropogenic factors (Andren et al., 2006; Lovari et al., 2007). In Norway, annual mortality of adult lynxes increased from 2% without hunting to 17% with hunting present and hunting was in 88.5% of cases the cause of death of adult female lynxes (Andren et al., 2006). By this hunting reduced the population growth of Norwegian lynxes from 20% to only 2–4% per year. Potential growth rate of wolf populations is higher compared to lynx populations and it can reach to 50% (Fuller et al., 2003). At the same time, some North American wolf populations did not show any growth after 25% of the individuals were hunted (Creel & Rotella 2010). Recovery of small, protected populations can also be severely hindered by poaching

(Liberg et al., 2011). Most sensitive to this is the brown bear due to its low reproduction rate (average 4.5, max. 10.2% per annum; Kindberg et al., 2011). In addition, selective hunting may influence bear population structure and increase the mortality of young due to aggressive behaviour of males who replace the hunted individuals in their territories (Swenson et al., 2001a). Decrease in food availability can affect all the large carnivores, but as lynx is mainly dependent on one target species, the roe deer, it is presumably most affected by the decrease in prey abundance (Okarma et al., 1997).

Genetic viability

Impoverishment of gene pool is a serious problem in small and isolated populations. Several large carnivore populations in contemporary Europe are isolated and long distances or absence of distribution corridors hinders gene flow (Linnell et al., 2008). In addition, European large carnivores have suffered population depressions (so called "bottlenecks") during the past centuries, which were accompanied by intensive genetic drift and reduction of allele diversity (Waits et al., 2000; Hellborg et al., 2002; Aspi et al., 2006; Schmidt et al., 2009; Tammeleht et al., 2010a; Sastre et al., 2011). Reduction of allele numbers decreases the heterozygote frequency in the population and increases the proportion of homozygotes and unfavourable allele expressions. In general, large populations hold higher frequency of heterozygotes than smaller populations (Sastre et al., 2011; Schmidt et al., 2011; Swenson et al., 2011; Table 8). Low genetic diversity of large Scandinavian lynx population can also be explained by severe "bottleneck" and following isolation from other European populations in the beginning of the 20th century (Hellborg et al., 2002; Linnell et al., 2008).

Although reduced heterozygote frequency is considered to have negative impact on populations, there are only few empiric examples from the wild populations so far. Alaskan Kodiak bears do not show, in spite of low heterozygote frequency (H_e = 0,26), signs of lowered viability and the population maintains very high density (Paetkau et al., 1998). Also Iberian lynx population was numerous and widely spread in the Iberian Peninsula up to the 20th century despite of having only one mitochondrial haplotype for past 50 000 years (Rodriguez et al., 2011).

Inbreeding syndrome has been negatively expressed in small wolf populations which have been isolated for several generations. For example growth of the inbreeding coefficient by 0.1 units in Sweden wolves brought a fall in average litter size by 1.15 offspring and a reduction of population growth rate (λ)

Table 8. Heterozygote frequency and allele number in European large carnivore populations according to nuclear DNA microsatellite markers.

Location	Species	H_e	All/loc	Pop.size	Source
Russia	Bear	0.83	8.1	4900	Tammeleht et al., 2010
Sweden	Bear	0.71	6.8	3300	Waits et al., 2000
Estonia	Bear	0.68	7.4	700	Tammeleht et al., 2010
Spain	Bear	0.41	3.3	119	Perez et al., 2010
Russia	Wolf	0.78	8.9	1843	Sastre et al., 2011
Finland	Wolf	0.69	5.4	190	Aspi et al., 2006
Spain	Wolf	0.65	5.5	2000	Sastre et al., 2011
Sweden	Wolf	0.52	3.1	100	Flagstad et al., 2003
Scandinavia	Lynx	0.51	4.7	1500–2100	Hellborg et al., 2002
Estonia-Latvia	Lynx	0.60	5.3	900–1975	Hellborg et al., 2002
Estonia	Lynx	0.59	5.0	600	Schmidt et al., 2009
Latvia	Lynx	0.70	5.8	700	Schmidt et al., 2009
Finland	Lynx	0.62	5.3	700–800	Hellborg et al., 2002
NE Poland	Lynx	0.62	4.3	40–60*	Schmidt et al., 2009

* population estimate Jedrzejewski et al., 1996.

from 1.29 to 1.21 (with assumption that the inbreeding coefficient was equal in all packs; Liberg et al., 2005). In the insular Isle Royal wolf population, a mutated vertebra was found in 33% of individuals while only 1% among individuals who did not breed with close relatives (Räikkonen et al., 2009). In normally functioning populations wolves avoid inbreeding (von Holdt et al., 2008).

Conservation of genetic diversity in species with fragmented distribution requires exchange of individuals between populations. It has been assumed, that one to ten migrants per generation are needed to balance negative genetic effects evolving from isolation (Mills & Allendorf, 1996). For example, isolated wolf populations in the Rocky Mountains maintained high genetic diversity (heterozygote frequency 0.64–0.72; number of alleles 7.0–10.3) in conditions where an average of 5.4 migrants participated in breeding during each generation (von Holdt et al., 2010). Large carnivores are considered to be successful migrants who can cover long distances in search of suitable habitats. Dispersion distance of wolves in Finland is on average 99 kilometres (range 35 – 445 km; Kojola et al., 2006). Lynxes in Poland dispersed up to 129 kilometres from birth site (Schmidt, 1998). In bears, juvenile males migrate significantly more (probability of dispersal 94% in males vs. 41% in females; Zedrosser et al., 2007), but dispersal distance for specimens of both sexes is up to 90 km (Swenson et al., 1998).

For example in Sweden there was no exchange of females between populations that were 134 kilometres away from each other, while dispersion of males connected those populations to some extent (Taberlet et al., 1995; Waits et al., 2000). Gene flow can be restricted even in conditions where territorial animals inhabit geographically close territories (Aspi et al., 2009). In eastern Finland border areas are densely inhabited by wolf packs and this may serve as a distribution barriers for young wolves coming from Russia (Aspi et al., 2009).

6.3. Viability of large carnivores in Estonia

Between 2002–2011, the population size of all Estonian large carnivore species has increased: in case of wolf from 75 to 240 individuals, in case of lynx from 600 to 720 individuals and in case of bear from 500 to 700 individuals. Wolf and lynx inhabit in all suitable habitats in Estonia, while bear distribution range is slowly expanding to south, where plenty of unoccupied habitats can still be found.

Wolf and lynx populations are related to Latvian populations in the south and Russian populations in the east. If wolf abundance in Leningrad Oblast (altogether over 500 individuals; Mosheva, 2011) allows to presume that there is migration occurring in both directions, then lynx numbers in those regions are significantly lower than in Estonia (400 individuals altogether in Leningrad and Pskov Oblasts; Mosheva, 2011). This low population density does not allow presuming that the immigration from Russia has notable demographic contribution to Estonian lynx population. Bear abundance in Pskov and Leningrad Oblasts is high (altogether over 3300 individuals; Mosheva, 2011). At the same time the range of Estonian bear population remains north from Võru and Valga counties and reproductive females are not found in South-Eastern part of Estonia. Considering the empty space between bear distribution ranges in south-eastern Estonia and Pskov Oblast and also the potential distribution barrier (river Narva) in the north-east, it can be presumed that currently there is no significant gene flow between the populations. Absence of migration and relative isolation of Estonian bears is also confirmed by genetic studies (Tammeleht et al. 2010a).

Presuming that effective population size is about 10–20% of the total population size then the abundance of lynx and bear population in Estonia can be considered sufficient (N_e =~70–140 ind. for both species) for sustaining their short-term genetic viability. In addition Estonian and Latvian lynx populations are genetically closely related and they can be treated as one population (Schmidt et al., 2009). Relative isolation of bear population still calls for supporting the spread of the current bear distribution to south and south-east Estonia which is necessary to conserve the long term genetic diversity. This will on one hand reduce the effects of occasional genetic drift and on other hand lead to joining Estonian and Pskov bear populations in future. With current abundance the effective size of Estonian wolf population may be lower than 50 individuals which is necessary for securing the short time genetic diversity. At the same time wolf numbers are high in Latvia, Pskov and Leningrad Oblasts in Russia, whereas the absence of distribution barriers and high mobility of the species allows presuming the presence of sufficient gene flow between the populations. For example in Yellowstone, where wolf population size (N=169) is close to that of Estonian wolves, four immigrating breeders per year are considered to be sufficient to secure genetic diversity (von Holt et al 2008).

In conclusion based on the current abundance, distribution and management conditions of large carnivores, the conservational status of these species in Estonia can be considered to be favourable. Enabling of gene flow between populations is necessary to secure the long term genetic diversity. In the case of bear it means also expansion of the distribution range. In addition, continuous monitoring of population dynamics is needed to prevent possible deterioration of population status.

7. RISK FACTORS AND DETERMINANTS OF MANAGEMENT NEEDS

In the following chapter main risk factors affecting the favourable conservational status are outlined with assessment of their importance as minor, median or major. Also perspective changes in the factor importance, due to changes in current or future conditions, are evaluated. The determinants of management needs, which are indirectly related to risk factors, are also discussed. The chapter ends with a comprehensive table of the factors and strength of their force (Table 9).

7.1. Overhunting

Overhunting has been, together with destruction of habitats, one of the main historic reasons of large carnivore extinction in several countries. Although Estonian large carnivores have never been completely absent, their abundance has been very low during several periods of the last century. Also in the beginning of the 2000s overhunting has depressed lynx and wolf populations to relatively low level and several regions in Estonia with suitable habitats were vacated. Overhunting was possible mainly due to two reasons:

- national environmental strategy aimed at wolf population of 30–40 specimen and lynx population of 500 individuals;
- population size was estimated from so called "official count" which was actually a sum of hunters assessments of numbers of animals in their hunting district. In reality this method leads to severe overestimation due to overlap of several hunting districts with a single large carnivore territory.

By today the aims of the management strategy and also system for monitoring population status has been updated and the above-mentioned reasons have lost their significance. In future, potential reasons, which may lead to overhunting, can be as follows:

- Monitoring results are not used or are only partially used as a basis for annual hunting quota which leads is to overestimating the population growth.
- Monitoring system and -intensity is substantially changed which leads to producing unrealistic data for making management decisions
- Due to changes in other conditions (e.g. climatic) the current monitoring method produces inadequate results

- Public opinion towards large predators deteriorates significantly which leads to a change in management objectives and activities which do not secure the favourable population status in long perspective.

Today overhunting can be assessed to be a minor risk factor, but if any of the scenarios given above would become a reality the risk factor would become a major one.

7.2. Selective hunting

Selective hunting may influences natural population structure in a way which leads to changes in demography, reproduction and mortality and by this can have ecological and evolutional consequences over long time period (Fenberg & Roy, 2008). For large predators, selective hunting is most frequently used in trophy hunting of bears when larger specimens are targeted. Large adult males are predominantly hunted, as bears have strongly expressed sexual dimorphism and hunting females with cubs is prohibited. This breaks the established territorial social structure and could be followed by immigration of new males which could increase the juvenile mortality by infanticide (Swenson et al., 2001a; Swenson et al., 2001b). Bear has an expanding distribution in Estonia and the population demographic structure in sparsely inhabited peripheral areas where young males prevail over few adult females differs from the core distribution area. Incidental selective hunting of females in those peripheral areas hinders or stops population expansion (Swenson et al., 1994). Selective hunting of wolves can be related to preference of targeting larger packs where hunting success is potentially higher. Those large packs usually consist of adults with their young and killing of one or both parents increases mortality among offspring. The earlier it happens before winter, the higher is juvenile mortality. Wolves are very social animals and young individuals learn to catch prey side by side with adult members of the pack. This process lasts until young leave the pack or at least to the age of nine months (Packard, 2003). Young who have lost their parents early are not sufficiently prepared for successful taking of wild ungulates and may also develop into problem specimens. Therefore hunting of wolves is not recommended before the cubs are at least six months old (Brainerd et al., 2008). Selective hunting can be regarded as median risk factor for both bear and wolf.

7.3. Poaching

Data on poaching is sparse everywhere and only very few poaching events are directly confirmed. At the same time it is considered to be an important factor, restricting the expansion of large carnivores in Europe (Liberg et al., 2011; Kaczensky et al., 2011). In Estonia, only few cases of poaching have been proven, while the subject is quite often discussed semi-publicly. Reasons for poaching vary by species. In case of bears, poaching can happen also unintentionally by confusing the species in the dark during wild boar hunting from hides. Bear killings also include the "shooting in self defence", caused by fear of bear attacks.

The motivation for poaching of wolves can be caused by official quotas and the temporary hunting restrictions and is probably caused by the following reasons:

- the actual number of wolves is believed to be higher than given by monitoring results;
- to reduce the potential predatory effect of wolves to game ungulates
- wolf is believed to be a risk to hunting dogs
- to reduce livestock depredation

Poaching of lynx is caused mainly probably by following reasons:

- the actual number of lynxes is believed to be higher than given by monitoring results
- to reduce lynx predation on roe deer and hare populations.

In conditions of adequate monitoring and well managed hunting, poaching becomes a major factor only when the mortality from poaching hinders population growth. Wolf and lynx populations are currently stable and non-hunting mortality (including potential poaching) probably plays a modest role in the total mortality, thus the factor is of minor importance. Bear population is expanding with low population densities and biased social structure in the peripheral distribution areas. Hunters in those areas are not used to bears, which can also increase the probability of poaching. Those circumstances allow determining poaching as a median risk factor for bear.

7.4. Habitat destruction

Large carnivore habitat quality depends largely on size and connectedness of forest habitats. In Estonia proportion and connectedness of forest habitat is rather good, which is confirmed by the wide distribution of large carnivores in continental Estonia. As no major changes in proportions of forest and agricultural landscapes are foreseen, habitat destruction is a minor risk factor for all the three species. Situation is the same for Latvia (Ozolins et al., 2007), but not for the southern parts of Baltic population of lynx. Lynx habitat is strongly fragmented in Lithuania (Balčiauskas, 2004) and north-eastern Poland (Schmidt, 2008b) and fragmentation is considered to be one main risk to persistence of lynx populations there.

Current extent of forest management in Estonia can even have a positive influence on large carnivores by improving conditions for prey populations and thus prey abundance. Still winter forestry works can have a serious negative effect by disturbing denning bears.

Fencing of semi-natural habitats for cattle breeding for managing semi-natural landscapes or for game farming is an emerging potential problem. Fencing and cattle breeding have direct (fence as a physical barrier) and indirect (restricted access to food) negative effect to prey populations with consequent negative influence on predators. Extensive fencing is currently minor, but potentially growing risk factor to large carnivores.

7.5. Reduction in prey availability

Lynx is dependent on single prey species (roe deer) abundance, while wolves prey on several ungulate species and bear takes ungulates rather opportunistically during a short period in summer. Availability of ungulates may drop for several reasons: extreme climatic conditions, high predation rates (including cumulative effect of several predator species), spread of diseases and overhunting. Roe deer is the most vulnerable to all the mentioned factors and its abundance has fluctuated widely during previous decades. According to Lõhmus (2001), lynx abundance in last decades has depended on roe deer availability, while similar relations have not been established for other ungulate and predator species. Lynx reacts to notable drops in roe deer populations with significantly reduced reproduction. This has been recorded in studies in Poland (Okarma et al., 1997) and is evident also from Estonia when looking at roe deer abundance and lynx litter size in last years. Significant drop in roe deer abundance also increases the poaching risks of lynx. Simultaneous significant fall of several ungulate populations is necessary to influence wolf populations. Such scenario is relatively unlikely. Thus reduction of prey availability is a major risk factor for lynx, median for wolf and probably insignificant for bear.

7.6. Spread of diseases

Wide spread of diseases, with consequent significant impact on population abundance, has been registered only in case of large canids, as most of the diseases are family-specific and transfer freely among different canids. Currently in Estonia mange, carried by foxes and raccoon dogs is a present risk to wolves and also increasing risk to lynxes. The increase in spread of mange in both wolf and lynx populations has been registered in Estonia since 2009 (Jõgisalu & Männil, 2011; Jõgisalu et al., 2010). Influence of mange on wolf and lynx has not been specially studied, but relevant data is available from red fox and coyotes. For example the Swedish fox population suffered dramatically during a peak of mange. The population, which had increased after introduction of oral vaccination against rabies, collapsed 50 % (locally even 90%) after outbreak of mange (Lindström et al, 1994). A long time study of effects of mange to coyote population of Texas revealed, that only 1% of all infected specimen (n=271) showed signs of recovery. This is considered to indicate high lethality of the disease. At the peak of outbreak coyote mortality, caused by complications of the disease, was close to 70%. In addition to direct mortality, the reproductivity of infected specimens was lower (Pence & Windberg, 1994). Studies of red fox in Great Britain revealed that the longevity of specimens infected with mites reached only to one fifth of the uninfected specimen (Newman et al., 2002). Mange has not suppressed carnivore populations over long time periods, but in years of outbreak both the abundance and reproductivity may fall notably. Thus spread of mange can be considered as a median risk factor for lynx and wolf with a temporary contribution to mortality. Impacts of other diseases in Europe are not well known. According to present knowledge, spread of disease is an insignificant factor for bears.

7.7. Artificial distribution barriers

Ability to move freely between habitats and populations serves as a fundament for functioning of animal populations. Animal movements can be either inside established home ranges or longer seasonal and dispersional migrations (Jedrzejewski et al., 2009). Main artificial distribution barriers presently and in the foreseeable future are highways, which pose significant restrictions, especially to young individuals who leave their maternal territories. For adult specimens, barriers may alter shape of territories or interfere for finding partners outside their home ranges. Other restrictions to free movement of large carnivores, like fenced forest areas are also considerable distribution barriers. Presently artificial distribution barriers are minor risk factor to large carnivores in Estonia with a perspective to become a major factor in future.

7.8. Disturbance

Main disturbance factors to large carnivores are human settlements, traffic, forestry, hunting and nature tourism. Influence of a disturbance factor is dependent on its strength and duration – human settlements and traffic are constant, forestry, hunting and nature tourism are temporary disturbance factors (Lõhmus, 2001). Large carnivores select their habitats according to strength and distance of a constant disturbance factor and to certain extent may also adapt to the factor.

Temporary disturbance has stronger effect during rising of young, when the juveniles are not yet able to follow their mother. If wolf and lynx return to their offspring after disturbance and usually lead them to another site, then bear females that are disturbed in their winter lair usually abandon their cubs of the year. Also the offspring mortality of bears who need to change their wintering den during pregnancy due to disturbance, is higher than in other females (Swenson et al., 1997). There are 11 cases reported in Estonia in the last decade, when female bear with cubs of the year has been woken up from hibernation (in one case also shot by hunter) by hunting or forestry activities. Their cubs have either perished or hand-reared in Nigula wildlife shelter. In future also a growing disturbance to wolves by rapidly evolving nature tourism, which seems to peek during the summer when wolves are tied to the den with dependent young, can be foreseen to some extent. As a conclusion, disturbance can be considered as a minor risk factor for wolf and lynx but a major risk factor for bear.

7.9. Hybridization

Of the three large carnivore species in Estonia, only wolf has a potential for hybridization with domestic dogs. Both in Northern America and several parts of Europe hybrids of wolves and domestic dogs have been repeatedly registered. In Estonia the first case was proven by genetic analysis in 2008 (Hindrikson et al., 2011a; Hindrikson et al., 2009) and in Latvia in 2009 (Andersone et al., 2002). Hybridization affects the favourable population status through reduced adaptability, also it may increase aggressive behaviour and livestock depredation rates (Randi, 2011). Hybridization between wolf and dog is more likely when wolf population is significantly reduced by overhunting or due to other reasons.

Although hybridization of wolf and domestic dog does not pose an imminent danger to Estonian wolf population, it may have indirect consequences and thus the presence of hybrids in nature is not acceptable. According to Linnell et al. (2008) the hybrids should have the same legal status as wolves and at the same time all available legal methods should be applied to remove them from nature. Hybridisation can be considered as median risk factor for wolves in Estonia.

7.10. Unfavourable public opinion

Effective conservation of large carnivores depends much on the public opinion about these species, especially that of people in the rural areas. Unfavourable public opinion increases the probability of poaching and also puts pressure to politicians to increase the official hunting quotas. Therefore shaping the favourable public opinion is seen as one key component in successful large carnivore conservation.

Main reasons for negative attitudes of people towards large carnivores can be caused from:

- fear for personal and public security
- large carnivore depredation on livestock
- large carnivore predation on game animals

People attitude in Estonia is most negative towards wolves (Randveer, 2006) as all these three above mentioned reasons (first still mostly historically) apply to wolves. Lynx predation is believed to strongly affect the roe deer population. Bear is believed to pose danger to humans and they also cause negative attitudes by raiding apiaries.

Occurrence of livestock depredation and occasional killing of dogs are among the most important reasons causing negative attitudes among local people. Survey carried out by Tiit Randveer (2006) indicated that attitudes are more negative in areas where wolves have killed dogs in Estonia. Swedish studies show that state subsidies to damage mitigation efforts improve peoples' opinion about wolves (Karlsson, 2007). Still current legislation in Estonia favours compensating the damages instead of paying for mitigation measures and it does not help to prevent damages and improve the public opinion this way.

Fear of predators and danger to personal security is bigger in areas where interactions with large carnivores are sparse (Balciauskas et al., 2005). This may for example hinder the bear population expansion to southernmost parts of Estonia. In case of predating on game ungulates, the attitude is probably worst towards wolves but during times of low roe deer abundance this can be same also for lynx. Mostly attitudes which are related to predation on game ungulates are spread among hunters. According to a survey in Estonia (Randveer, 2006), but also by several other studies, the most negative attitude is carried by less educated and elderly people (Linnell et al., 2006; Viiburg, 2007). If in the first case the attitude can be related to insufficient knowledge, then in the second case the attitude comes from decades of perception of large carnivores as harmful species. As a conclusion, it can be said that for lynx and bear negative public opinion can be considered as a median risk factor while for wolf it is a major risk factor.

7.11. Deterioration of population status in neighbouring countries

The status of Baltic large carnivore populations can worsen, with consequences also to Estonian populations, independently from the conservation and management actions in Estonia. Main risks are related to Russia which harbours the major part of the large carnivore populations, as Russia has not joined the main agreements related to large carnivore management and is not obliged to fulfil the international conditions for securing favourable population status. In Russia bear population seems to be in good condition (Gubar, 2011a), whereas lynx densities are low and populations are in decline (Mosheva, 2011). Although wolf population seems to be in good condition, hunting of the species is still poorly regulated (Gubar, 2011a). Latvia lacks a permanent bear population and bear population density is also very low in the western regions of Pskov Oblast in Russia (Vaisfeld et al., unpublished), which leads to relative isolation of the Estonian bear population. Monitoring of lynx and wolf populations in Latvia is carried out with different methods and less parameters observed (Ozolins et al., 2008; Ozolins et al., 2007), which in turn increases the risk of overhunting. Still deterioration of population status in neighbouring countries can today be considered as minor risk factor with potential increase in the future.

7.12. Factors determining the management needs for large carnivores

Reducing the damages caused by large carnivores

Reducing livestock depredation, killing of dogs and also damages to beehives is important for improvement of the public attitudes towards large carnivores and also for saving the state resources that are used for compensating the losses. Legal hunting as one of the measures for reducing depredations involves keeping large carnivore abundance at desired levels, targeting hunting to the most

Table 9. Status of risk factors and determinants of management needs for large carnivores. Plus sign in the factor assessment indicates potential increase in importance; minus sign indicates absence of the risk in next 10 years, according to current knowledge.

Risk factor or management determinant	Importance to species		
	WOLF	LYNX	BEAR
Overhunting	Minor +	Minor +	Minor +
Selective hunting	Median	-	Median
Poaching	Minor +	Minor +	Minor +
Habitat destruction	Minor +	Minor +	Minor +
Reduction of prey availability	Median	Major	-
Spread of diseases	Median	Median	-
Artificial distribution barriers	Minor +	Minor +	Minor +
Disturbance	Minor +	Minor	Median
Hybridization	Median	-	-
Unfavourable public opinion	Major	Median	Median
Damage reduction	Major	Minor	Median
Maintaining favourable status of ungulate populations	Median	Major	-
Retaining shyness to man	Median	-	Major
Deterioration of population status in neighbouring countries	Minor +	Minor +	Minor +

severely affected areas and also hunting specific problem individuals who have specialised on taking livestock or pets. The importance of reducing damages is high for wolves, medium for bears and low for lynxes.

Maintaining favourable status of ungulate population

Favourable status (sufficient abundance and growth rate) of ungulate populations secures also the favourable status of large carnivores through sufficient natural food resource and also less negative attitude among hunters. Favourable status of ungulate population as determinant of management need is of high importance for lynx, medium for wolf and insignificant for bear.

Retaining shyness to humans

Retaining shyness of large carnivores to humans is important for achieving and maintaining the positive public opinion. Shyness reduces the probability of occurrence of conflicts between humans and large carnivores which can emerge from direct encounters or as damages to livestock. Retaining shyness to humans is of high importance for bear, medium importance for wolf and insignificant for lynx.

8. AIMS OF CONSERVATION AND MANAGEMENT

The main long term aim of large carnivore conservation and management in Estonia is to preserve the favourable conservation status of wolf, lynx and bear populations with the consideration of ecological, economical and social aspects. This is achieved by:

- securing sufficient abundance of large carnivores in Estonia with maximum distribution range in suitable habitats and with population demographic structure, behaviour, habitat and food sources as close to natural as possible, to maintain the population viability, ecological function and evolutionary potential;
- keeping large carnivore damages to livestock and other property at low level;
- keeping large carnivores in the list of game species as far as it is possible by population status and reproductive potential;
- increasing public awareness and promoting positive attitudes towards large carnivores
- considering Estonian large carnivores as a part of larger population and carrying out conservation and management actions with an aim to support the maintenance of favourable status of Baltic populations.

The aims for the period 2012–2021 are as follows:

- To keep 15–25 breeding packs of wolves in Estonia (total population size 150–250 individuals) in autumn before the onset of the hunting season. Within those defined limits the aim is reviewed annually, according to the monitoring results and depending on prey availability and damage extent. Wolf abundance is kept within these limits by hunting;
- To keep 100–130 annual reproductions of lynx in Estonia (total population size 600–780 individuals) in autumn before the hunting season. Within those defined limits the aim is reviewed annually according to monitoring results and depending on prey availability. Lynx abundance is kept within these limits by hunting. In extreme deficit of natural prey the number of reproductions is allowed to drop for a short period 30% below the set minimum value;
- To keep bear population at a level which leads to at least 60 annual reproductions (females with cubs-of-the-year, total population size

approximately 600 individuals). Maintain hunting to retain shyness to humans and mitigate the damages caused by bears. Expansion of bear population range southwards is favoured;

- To reduce damage inflicted by large carnivores by effective application of prevention measures and focusing of management to regions where damages occur;
- To increase public awareness and promoting positive attitude towards large carnivores.

In the current plan the target population level is expressed through numbers of reproductions and relevant total autumn population sizes. Numbers of reproductions is a directly monitored parameter and therefore it is more precise and applicable in management purposes than the previously used spring population abundance estimate.

9. ORGANISING LARGE CARNIVORE CONSERVATION AND MANAGEMENT

Conservation and management of large carnivores is organised during the forthcoming five years according to the actions outlined in this chapter (Table 10) which aims are to reduce the possible risks to populations' favourable status emerging from different factors.

Table 10. Conservation and management actions and related risk factors.

Management actions		Risk factors	
1.	Improvement of legislations	7.3.	Poaching
		7.4.	Habitat destruction
		7.7	Artificial distribution barriers
		7.9.	Hybridization
2.	Running and developing the monitoring system	7.1.	Overhunting
		7.2.	Selective hunting
		7.5.	Reduction of prey availability
		7.6.	Spread of diseases
		7.9.	Hybridization
		7.10	Unfavourable public opinion
3.	Applied research	7.1.	Overhunting
		7.5.	Reduction of prey availability
		7.6.	Spread of diseases
		7.10	Unfavourable public opinion
4.	Damage processing	7.1.	Overhunting
		7.3.	Poaching
		7.10	Unfavourable public opinion
5.	Management organization	7.1.	Overhunting
		7.2.	Selective hunting
		7.3.	Poaching
		7.5.	Reduction of prey availability
		7.6.	Spread of diseases
		7.9.	Hybridization
		7.10	Unfavourable public opinion
6.	Awareness rising and moulding of public opinion	7.1.	Overhunting
		7.3.	Poaching
		7.8	Disturbance
		7.10	Unfavourable public opinion
7.	International cooperation	7.11	Deterioration of population status in neighbouring countries

10. ACTION PLAN

Actions related to the aims of conservation and management are described below according to their priority class, biological motivation, legal basis and international practices. In prioritizing actions, following ranks are use:

- First (I) priority – inevitable action for achieving the aims in a given period;
- Second (II) priority – necessary action, which supports achieving the aims directly;
- Third (III) priority – recommended action, which supports achieving the aims indirectly.

10.1. Improvement of legislation

10.1.1. Amendment of legal acts, which regulate hunting (II)

Legal status of wolf-dog hybrids needs clarification in documents which are regulating large carnivore hunting. Also sampling procedures of hunted animals for biological studies needs to be improved to enhance the collection of samples. Hunters' proposal to shift the beginning of wolf hunting season to earlier date deserves attention. In general, authors of this plan do not see a need to change hunting seasons. If quotas cannot be fulfilled for several years and consequently wolf abundance stays above the recommended upper target level, hunting can be started in 1st of October (one month earlier). Previous season dates are restored when desired abundance is achieved.

- In hunting regulations and law, wolf-dog hybrids are equalised to wolf;
- Procedures and amounts of sampling of hunted animals will be defined by legal document(s);
- Wolf hunting season is not altered otherwise than according to the scenario described in this chapter.

10.1.2. Amendment of large carnivore damage compensation principles in nature conservation legislation (II)

Nature Conservation Act and ministerial regulation on large carnivore damage compensation need amendment in a way which motivates farmers more to focus on damage prevention so that the scope of damages would be reduced.

- Effective measures of large carnivore damage prevention (e.g. technical descriptions of fences, guard dogs) are described in legal documents together with conditions of state support for their acquisition.

- Compensation mechanism is tied to recurrence of damage, in a way that state support will decrease in case of recurring damage when the owner has taken no measures to prevent them.

10.1.3. Revision of penalty rates for illegal hunting (II)

The penalty rates for environmental damage, caused by illegal taking of game animals, is currently tied to their market value, rather than their abundance, ecological significance or conservation status. At the same time every individual of a rare species has notably higher value in ecosystem compared to an abundant species.

- The penalty for illegal killing of wolf and lynx is increased to the limit of € 2000 (equal to bear)

10.1.4. Renewing activities in the large carnivore action plan (I)

The composed plan defines conservation and management scheme for the period 2012–2021. As it is difficult to foresee all the possible changes in 10 years perspective and as several actions depend on the outcome of other activities, the chapters 6–12 will be reviewed in 2016. Necessary amendments are introduced if needed and new action plan with respective budget is composed for the next five-year period. The action plan for 2017–2021 includes also regular renewal of the plan in 2021.

- Chapters 6–12 are reviewed in 2016 and the action plan with necessary budget is prepared for 2017–2021.

10.2. Running and developing the monitoring system

10.2.1. Maintenance of large carnivore monitoring activities minimum at current level (I)

Management and conservation of large carnivores depends on reliable data of their population dynamics. This makes the maintenance of adequate monitoring system a priority which concerns securing the qualified staff, equipment and finances at least on the current level.

- Monitoring system is maintained at least in current scope and quality

10.2.2. Application of management system in large nature protection areas (II)

Ministerial regulation on large carnivore census is also valid for nature conservation areas which are not incorporated to any hunting district. So far the regulation is not applied in most of the larger nature conservation areas (Soomaa NP, Matsalu NP, Alam-Pedja NCA, Endla NCA) and the data about large carnivore abundance in these areas is clearly insufficient which leaves gaps also to the overall Estonian dataset. The most important monitoring activities are mapping the winter track observations and performing track census on fixed transects.

- Environment Agency develops specific large carnivore monitoring system for protected areas
- Area administrator is responsible for carrying out the monitoring scheme in protected areas.

10.2.3. Applying large carnivore monitoring methodology and gathering comparative abundance data from permanent census areas (II).

Although the user of each hunting district is obliged to mark down and forward the sightings of large carnivores which are the basic data for the current monitoring scheme, the amount of data acquired from different parts of Estonia can be very variable and depends much on the attitude and motivation of local hunters. Therefore it is important to also consider hiring professional field personnel for data gathering in addition to the current obligatory system. One possibility would be to designate 4 permanent census areas around Estonia where state employees or hired specialists would carry out winter census days and track counts in addition to local hunters' efforts. The data, obtained by using agreed methodology, would then allow assessing local changes in predator and prey abundance and also evaluate the reliability of the current data gathering system. Extra monitoring data would be collected for three seasons and subsequently the future need for this can be assessed.

- At least for three years independent collection of large carnivore monitoring data is carried out in selected areas.

10.2.4. Training of monitoring data collectors (II)

Reliability and quality of the initial data plays critical role in the application of current monitoring methodology. Main shortcomings in track observations are the wrong determinations of predator group size and in some cases confusion of species like wolf and lynx. Also with bears the determination of cubs' age (yearlings or cubs of the year) can be unclear. In case of material collected from hunted individuals the quality of female reproductive organs is most problematic as often a wrong organ or only a part of uterus is collected. Therefore training of people involved in track counts and collecting biological samples from hunted animals is necessary. As last relevant trainings date back to 2007 it is very likely that there are new people involved in the processes and a need for additional training has increased.

- A series of training events on large carnivore monitoring techniques is carried out for Estonian hunters and environmental institutions employees.
- Two educatory films are produced about large carnivore track counting and collecting samples from hunted animals.

10.2.5 Electronic information system for forwarding initial monitoring data (II)

One way to facilitate the collecting and forwarding spatial data about large carnivore observations among hunters is to create a relevant web-based GIS application. As a general system for hunting data is already foreseen in the existing forest register then the system for large carnivores' observations could be one of its organic parts.

- Electronic data forwarding system for initial large carnivore monitoring data is created.

10.3. Applied research

10.3.1. Assessment of adequacy and precision of current monitoring methods (II)

One positive side of the current monitoring methodology is the cost-effectiveness of data collection. At the same time the quality and precision of the collected data is hard to measure. A special study will analyse the adequacy, precision and cost-effectiveness of current monitoring methods and also compares them with methods used in neighbouring countries. Recommendations for improvement of the current monitoring methodology, suggestions for optimization and/or application of alternative methods are made. Also a suite of models for forecasting population dynamics according to improved methodology are proposed. Action 10.2.3 depends on the outcome of this action.

- An analysis of the adequacy and precision of the current monitoring methodology is carried out.

10.3.2. Assessment of lynx predation impact on roe deer population (II)

As roe deer is the main prey species for lynx in Estonia, strong predation pressure can be presumed in times of high lynx abundance. At the same time, lynx population growth is sensitive to the availability of prey and will also decrease with decreasing roe deer abundance. So far lynx predation impact has been assessed only in conditions when both species abundance is high, while recently the situation has notably changed and further changes can be foreseen. This justifies the need to continue the studies of lynx and roe deer predator-prey interactions, which were started during the period of previous management plan. The main aim of the study is to estimate the proportion of roe deer population consumed by lynx population and its dependency on both predator and prey abundance. During the study, 10–12 lynxes are equipped with GPS-GSM collars to follow their movements and locate their prey items while roe deer population density estimates are carried out simultaneously. Duration of the study is four years. Recommendations for roe deer population size necessary for lynx and the methods for its maintenance are based on the study results. The study is related to action 10.3.3.

- Study of lynx predation impact on roe deer population is continued.

10.3.3. Study about the habitat use and home range size of wolf and lynx (II)

Knowing the average home range size of territorial species enables to better distinguish between individuals or groups of individuals. Home range size is applied in analysing the wolf and lynx observations to separate different packs or family groups. This makes the reliability of the monitoring results directly dependent from this parameter. As home range size in territorial carnivores is dependent on both prey availability and species own density, it is necessary to carry out the study over prolonged period which involves various abundances of predator and prey populations. Studying home range size does not need special efforts as the necessary data comes already from studies 10.3.2 and 10.3.7.

- Studies of wolf and lynx habitat use and home range size are continued.

10.3.4. Study on feasibility of creating large carnivore management regions (II)

So far administrative regions (counties) have been used as management units for large carnivores' but using larger areas which are based on existing habitats and their natural borders should be considered instead for large carnivore and also moose management. This study will focus on locating different landscape-based management regions, their size and borders, along with recommendations for their possible use as game management units.

- Study is carried out to explore the feasibility of possible landscape based large carnivore management regions.

10.3.5. Sociological study on large carnivores (II)

Last sociological study of people's attitude towards large carnivores was carried out in 2005. To understand how the recent management and damage compensation regime has influenced public attitudes, a repetitive study using similar questionnaires is needed. Socioeconomic analyse is also necessary to find out the social reasons of negative attitudes towards large predators. The results of the survey could be then taken into account in the second half of the planning period for improving the attitudes.

- Sociological study on public attitude towards large carnivores is carried out.

10.3.6. Assessment of the wolf predation impact on prey populations (II)

Although in general with current abundance wolf predation impact on prey populations is probably of minor importance, it can still be significant locally in areas with continuous presence of wolf packs. Also the predation impact can vary significantly in different ecological systems according to the number and abundance of prey species. This is also why results from studies done elsewhere are not directly applicable to Estonian conditions. The study results of wolf predation impact can then be accounted also in management of other game species like moose or wild boar. During the study 10 wolves are equipped with GPS-GSM collars to follow their movements and locate their prey, with simultaneous study of prey abundance in the study area. Duration of the study is 5 years. Recommendations on necessary ungulate population sizes and their maintenance are based on the study results. The study is related to action 10.3.3.

- Study of wolf predation impact on prey species is continued.

10.3.7. Dividing the landscape to zones with different wolf management intensity (II)

The aim of the study is to investigate the spatial distribution of wolf density, livestock abundance and the number of depredation events caused by wolves in different parts of Estonia. Spatial analyses should reveal if there is a relationship between wolf density and magnitude of depredation events and if creating of zones with different wolf management intensity is possible. The purpose of this differentiation is to direct the hunting pressure to areas which suffer severe livestock losses while at the same time preserve wolf packs living in sparsely populated forest areas. Depending on the study results the map of zones with different management intensities are proposed.

- Study of spatial relationship between wolf density and magnitude of depredation events is carried out

10.3.8. Comparative study of bear population size using non-invasive genetic analysis (II)

Genetic analysis is widely used in Scandinavia to study bear population size and as a result it has been found that the real population size is almost two times bigger than the estimate provided by observations. Such a difference calls for a similar study in Estonia. Individuals could be separated by DNA samples collected from fur traps and a density estimate could then be derived and compared to the estimate obtained from observations of family groups. The study results would allow considering the application of genetic methods in bear monitoring. Study lasts for three years.

- A comparative study of bear abundance in a study area is carried out by using genetic analysis.

***10.3.9.* Using genetic methods to study wolf population status (III)**

As wolf-dog hybrids have been found in Läänemaa and Valgamaa counties in recent years, there is a risk of reduced fitness of wolf population. Hybridization may also lead to changes in wolf behaviour in the future. Thus, a genetic monitoring of hybridization rates all over Estonia is needed together with study of hybrid gene introgression (also using genetic methods), i.e. whether the F1 hybrids are breeding successfully. In addition to monitoring of hybridization level, the gathered material allows to define the following parameters like Effective population size and trans-boundary gene flow from Latvia and Russia. Effective population size (N_e) which is the number of individuals participating in reproduction is a primary population parameter from a conservation and management point of view. According to an internationally accepted rule, N_e has to be at least 50 for a viable population. If possible trans-boundary cooperation with relevant Russian state institutions should be launched to study the gene flow and migration rate between Estonian and Russian wolf populations. By knowing how many individuals move between the countries allows to estimate the connectedness of Estonian wolf population with neighbouring populations. Cooperation on this subject has already been established with Latvia. Genetic relatedness analyses allow separating the number of different reproductions from hunted juveniles. Combining this parameter with the spatial data allows assessing and enhancing the results of conventional monitoring methods.

- Genetic monitoring of wolves is continued.

10.3.10. Spread of parasitoses in wolf and lynx populations (III)

- Inventory of the species content and frequency of parasite fauna of wolf and lynx to follow its changes over time.

10.3.11. Study of location of suitable habitats and movement corridors (II)

Aim of the study is to map large carnivore habitat, core areas of their distribution as well as localize and assess the importance of movement corridors in securing the populations favourable status. The study summarises spatial data collected so far with observations and telemetry studies and measures the overlap of spatial distribution of large carnivores with existing ecological green network areas. Expected results should reveal the most important habitats and moving corridors for large carnivores and also suggest special conditions or restrictions which should be implemented in these areas (e.g. locations of ecoducts on fenced highways).

- Spatial analyses indicate large carnivore habitat requirements and the effectiveness of established green network areas as large carnivore habitat and movement corridors.

10.3.12. Establishing a game research area (II)

A game research area is established on the basis of one state hunting district suitable for complex ecological studies of large carnivores and their prey populations and its legal status is defined. Intensive monitoring and research of several game species is carried out in the area to create a possibility to study ecological relations (direct and indirect trophic interactions) along the food web. Specific scientific experiments and/or manipulations can be carried out in the area according to the needs of various studies, with a possibility to guide the hunting activities in the area according to the research needs.

- A game research area is established in a state-managed hunting district with definition of its function and status.

10.4. Damage management

10.4.1. Continuation of compensations for large carnivore damages and damage prevention measures (I)

The general principles of compensating the large carnivore damages are maintained, damages and prevention costs are partially compensated by state and in site expertise and damage processing is organised by the Environmental Board.

- Compensating the large carnivore damages and damage prevention measures is continued by state.

10.4.2. Training of experts inspecting large carnivore damage (II)

Large carnivore damage expertise has to be done by people who have passed special training and have relevant expertise. Thus annual training workshops are necessary where experts can exchange specific experience and perform practical activities as e.g. autopsy and external observations of livestock killed by predators. If possible, foreign lecturers, for example from Swedish Wildlife Damage Centre in Grimsö which has high level of competence in this subject, are invited.

- Training workshops for depredation experts are carried out at least once a year.

10.4.3. Compilation of a manual for large carnivore damage inspection

Detailed manuals have been composed for large carnivore damage inspection in countries where relevant expertise has been performed for long periods (e.g. in Finland and Sweden from nearby countries). A need for such material is also in Estonia. The manual should contain rules and procedures of expertise and a guide for identifying the predator (by visual inspection of the site, tracks and specific marks left on the kill etc.) with photographic illustrations. As an alternative to compilation of new manual, translation and adaption of Swedish or Finnish relevant materials can be considered.

- Manual for identifying the damaging agent is composed for large carnivore damage inspection experts.

10.4.4. Equipping the damage inspection experts with instrument kits and means for temporary prevention of repeated damage events (II).

Currently large carnivore damage inspection experts lack vital instruments like handheld GPS units for recording the exact location of the site. For identification of the damaging agent, trailcameras could be temporarily deployed in the area. In case of wolf there is also a significant risk of repeated attack on the same farm within next few days after the first attack. Deployment of flaudry by the expert serve as a suitable, quick and temporary mean to prevent recurrence of attacks in maximum 3–4 weeks and get some time for the livestock owner to apply more permanent damage prevention methods. Length of the needed flaudry line is in total 30 kilometres (2 kilometres per county), amount of GPS handsets and trailcameras is 12 sets (2 of each for every region of the Environment Board).

- Large carnivore damage assessment experts are equipped with necessary instruments and damage prevention means.

10.4.5. Web page for large carnivore damage inspection experts (II)

A web platform is created to the Environment Board website where large carnivore damage experts could insert the collected information and upload photographs about damage cases. This would facilitate the exchange of information between experts and hastens answering specific questions thus it also carries a function of additional training.

- A web page for exchanging information about large carnivore damage inspection is created.

10.4.6. Identification of the species responsible for livestock depredation by DNA analysis (II).

Compensation for large carnivore depredation is based on expert reports from the damage occurrence site where the overall appearance, animal tracks and wounds on the victim are used to identify the species that caused the damage. In some cases evidence do not allow determining the species with sufficient confidence and difficulties arise especially in distinguishing wolf attacks from attacks of the domestic dog. This is why the expertise presumes training. Superficial determination of the predator species may lead to unjustified compensation payments and also consequently to wrong management decisions. Training of the experts involves analysing several damage cases where the species causing depredation is confirmed. The most reliable method for this is DNA analysis of saliva collected from bite wounds on the victims. In first two years of the study (2012–2013) approximately 100 samples are foreseen and additional 50 samples are needed in 2015.

- DNA analysis of saliva samples from livestock kill sites is performed to confirm the predator species and train the experts.

10.5. Management of large carnivores

10.5.1. Maintenance of the general management principles in use (I)

The current principles for large carnivore conservation and management are maintained. The management decisions are based on recommendations derived from annual monitoring reports. The reports contain assessment of population status with the explanation of the possible reasons causing the observed changes in status and also prognoses for population growth rate. The large carnivore working group that consists of representatives of various stakeholders and state institutions and is hosted by Ministry of Environment continues its work. The ministry decides annually the measures necessary to achieve the aims and long term targets set in the management plan (outlined in chapter 8) and sets the overall hunting quotas, spatial distribution of the quota and if necessary also restrictions to hunting. The Environmental Board then implements these decisions.

10.5.2. Designation of large carnivore management regions (II)

Depending on the outcomes of activity 10.3.4., the management of large carnivores will be based on areas which are defined by habitat and landscape features rather than administrative borders.

- Large carnivore management is based on designated management regions

10.5.3. Arrangement of wolf management according to landscape zoning (II)

Depending on the outcome of activity 10.3.7., wolf hunting quota is distributed by the probability of damage occurrence in various landscape zones. Such approach secures lower wolf densities in agricultural landscapes and sustaining the number, social structure and reproductivity of packs inhabiting natural landscapes.

- Wolf hunting is organised according to the landscape zoning.

10.5.4. Hunting of wolf-dog hybrids (II)

In occurrence of wolf-dog hybrids state must take action for removing these litters from nature. In addition to the number of hunting permissions given to a local area, hunting permits outside official season and in special cases also use of additional methods for removing hybrids should be allowed.

- In the occurrence of wolf-dog hybrids state takes action for removing them from nature.

10.5.5. Creating an action plan for dealing with abandoned bear cubs (II)

A manual for state employees working on nature conservation and game management is compiled for using in cases when abandoned bear cubs are found. The manual contains possible actions in different situations in the principle context that the cubs are not rehabilitated for the release.

- Action plan is composed for cases when abandoned bear cubs are found.

10.6. Raising awareness and promoting the public opinion towards large carnivores

10.6.1. Publication of compressed version of large carnivore conservation and management plan in Estonian and English (II)

A shortened version of the plan is published in Estonian and English for wider audience. According to the earlier experience this can be done as a publication of Estonian Theriological Society in the series of Estonian Game.

- The conservation and management plan is published in Estonian and English for wider audience.

10.6.2. Short movies about large carnivores (III)

Short educational movie clips (5 min. long) are produced about large carnivores and their related legends. These clips are shown during the exhibition (action 10.6.5) and also in the public broadcast channels.

- Short movies about large carnivores are produced.

10.6.3. Informative events (II)

As a minimum, two informative events are arranged: one to accompany publication of the plan and second introducing possible changes in the second half of the management period. These events are targeted to wider public and by containing relevant information should help to achieve positive attitudes towards large carnivores. In addition, informative meetings are organised to livestock owners to discuss effectiveness of possible methods of large carnivore damage prevention (electric fences, guard dogs, night shelters) and explain the essence of state subsidies.

- Information events for livestock owners and wider public are carried out.

10.6.4. Exhibiting wolf, lynx and bear in Tallinn Zoo

Tallinn Zoo has annually more than 250 000 visitors, including many children. Hence the zoo has unique and so far only partially used potential to share the values of Estonian large carnivores together with their role in ecosystem with wider audience. Providing this presumes displaying species in their suitable natural environment and with adjacent information for several target groups. Currently only lynx can be seen in Tallinn Zoo thus the zoo cannot fulfil all the necessary functions in explaining the issues regarding large carnivores' conservation and management in Estonia. The action is recommendatory by the authors and is carried out by Tallinn Zoo.

- A joint exposition with all three species of Estonian large carnivores is created in Tallinn Zoo. The exposition focuses on presenting various aspects of large carnivore conservation and management. The way of presenting information should create positive emotions in visitors.

10.6.5. Compilation, printing and distribution of a leaflet introducing large carnivores (III)

A reprint of the informative leaflet "Meeting a bear" is foreseen to introduce bear habits and behaviour in unexpected encounters with people, also appropriate human behaviour in such cases for preventing conflicts and physical contact. After amendment of Nature Conservation Act with aspects of prevention and compensation for damages, a leaflet is released also about wolves as a potential risk to livestock with a description of legislation and suitable methods to prevent damages.

- Leaflets "Meeting a bear" and "Preventing large carnivore damage" are released.

10.6.6. Compilation and display of a travelling exhibition about large carnivores (III).

An exhibition in English, composed by the LCIE working group, is available in the form of 28 posters. It describes lynx, wolf, bear and wolverine, their conflicts and relations with people and also studies carried out in Europe. The exhibition covers a wide range of topics related to large carnivores and cannot be easily replaced by other publicity means. Costs of exhibition cover the translation, printing and stands for posters as well as transport costs.

- Exhibition about large carnivores is composed and displayed.

10.7. International cooperation

10.7.1. Continuation and enhancement of international cooperation.

As large carnivore populations cross state borders, successful conservation and management is possible only with international cooperation. This calls for maintaining and developing further scientific and management connections with other countries holding the Baltic population of large carnivores but also with other European countries. In addition to using knowledge from other areas it is also important to surpass our own experiences and take part in common development of large carnivore practices and policies in the European Union.

- Continue active participation in IUCN, SSG, LCIE and other international working groups;
- Continue and enhance cooperation with countries sharing a common Baltic population of large carnivores. Special attention is paid to cooperation with Latvia and Russia.

11. EVALUATION OF THE EFFECTIVENESS IN ACHIEVING THE SET VALUES

Current large carnivore conservation and management plan presents the best available knowledge about the status of large carnivores in Estonia. In the following ten (five) years the plan serves as the basis for large carnivore conservation and management. It is presumed that by following the proposed guidelines and using the monitoring results and data from applied research, the future management preserves the favourable population status of large carnivore species. Thus the favourable status is the best criterion for evaluating the current plan. At the same time, evaluating the effectiveness of various actions and their impact on favourable population status is necessary. Fulfilment of the plan is evaluated with different steps on different levels:

1. Game monitoring reports, with the description of the population status and changes therein, are issued annually. Reasons for those changes are discussed in the reports. The reports are composed by Estonian Environment Agency, whose constitutional obligation is to fulfil the monitoring programme and publish the monitoring results. This obligation is reflected in the annual work plan of its structural unit for wildlife monitoring. The reports present the assessment of population statuses according to the monitoring parameters outlined in section 5.3 of current plan. Reports are necessary for annual planning of harvest and conservation needs of the species. Parameters of wildlife monitoring are sufficient to fulfil the requirements in the EU Habitat Directive.
2. According to the EU Habitat Directive (92/43 EU) member states submit every six years a report on population statuses to European Commission on the species that are enlisted in the directive annexes. This involves also wolf, lynx and bear. The reports must contain distribution range (10x10 km ETRS 89 grid in ETRS LAEA 52 projection), sizes of population numbers and habitats with trends. In addition to those parameters, the risk factors and future population prognoses are presented. Reports must be based on monitoring results, not on expert opinions. EC composes species reports for EU based on member state submissions. During current planning period the years when the reports must be presented are 2013 and 2019.
3. The final assessment of the plan is performed in the end of the planning period by next large carnivore management plan in 2021. Interim evaluation of activities is performed during renewal of the plan in 2016.
4. Evaluation of specific actions is included in the final report of the action by performer of the actions.

12. REFERENCES

Ågren, E. 2005. Sarcoptic mange in wolves and lynx in Finland. Journal of Wildlife Diseases. Appendix: 41 (2).

Allendorf, F. W. & Ryman, N. 2002. The role of genetics in population viability. In Population viability analysis: 50–85. Beissinger, S. R. and McCullough, D. R. (eds.) University of Chicago Press, London.

Andersone, Z., Lucchini, V., Randi, E. & Ozolins, J. 2002. Hybridization between wolves and dogs in Latvia as documented using mitochondrial and microsatellite DNA markers. Mammalian Biology, 67: 79–90.

Andren, H., Linnell, J. D. C., Liberg, O., Andersen, R., Dannell, A., Karlsson, J., Odden, J., Moa, P. F., Ahlqvist, P., Kvam, T., Franzen, R. & Segerström, P. 2006. Survival rates and causes of mortality in Eurasian lynx (*Lynx lynx*) in multi-used landscapes. Biological Conservation, 131: 23–32.

Andren, H., Linnell, J.D.C., Liberg, O., Ahlqvist, P., Andersen, R., Dannell, A., Franzen, R., Kvam, T., Odden, J. & Segerström, P. 2002. Estimating total lynx *Lynx lynx* population size from censuses of family groups. Wildlife Biology, 8:4: 299–306.

Aspi, J., Roininen, E., Ruokonen, M., Kojola, I. & Vilà, C. 2006. Genetic diversity, population structure, effective population size and demographic history of the Finnish wolf population. Molecular Ecology,15:1561–1576.

Aspi, J., Roininen, E., Kiiskila, J., Ruokonen, M., Kojola, I., Bljudnik, L., Danilov, P., Heikkinen, S. & Pulliainen, E. 2009. Genetic structure of the north western Russian wolf populations and gene flow between Russia and Finland. Conservation Genetics, 10: 815–826.

Bagrade, G., Vismanis, K., Kirjušina, M. & Ozolinš, J. 2003. Preliminary results on the helmintofauna of the Eurasian lynx (*Lynx lynx*) in Latvia. Acta Zooloogica Lituanica, 13 (1): 3–7.

Balćiauskas, L., Kazlauskas, M. & Randveer, T. 2010. Lynx acceptance in Poland, Lithuania and Estonia. Estonian Journal of Ecology, 59 (1): 52–61.

Balćiauskas, L. 2008. Wolf numbers and distribution in Lithuania and problems of species conservation. Ann. Zool. Fennici, 45: 329–334.

Balčiauskas, L., Randveer, T. & Volodka, H. 2005. Influence of place of residence and possible property loss on large carnivore acceptance in Estonia and Lithuania. Acta Biol. Univ. Daugavpil., 5 (1): 47–53.

Balciauskas, L. 2004. Lithuania. In: Von Arx, M., Breitenmoser-Würsten, Ch., Zimmermann, F. & Breitenmoser, U. (eds.) 2004. Status and conservation of the Eurasian lynx (*Lynx lynx*) in Europe in 2001. KORA Bericht, 19: 140–145.

Bessinger, S. R. & McCullough, D. R. (eds.) 2002. Population viability analysis. University of Chicago Press, London.

Bibikov, D.I. (ed.) 1985. The Wolf. History, Systematics, Morphology, Ecology. Nauka Publishers, Moscow, 606 pp.

Bishof, R., Nielsen, E., Brøseth, H., Männil, P., Ozolinš, J. & Linnell, J. 2012. Implementing uncertainity when using recreational hunting to manage large carnivores. Journal of Applied Ecology, 49: 824–832.

Boitani, L. 2000. Action plan for the conservation of wolves in Europe. Nature and environment, No 113, Council of Europe Publishing.

Borisov S. S. et al 2004. Game resources of Russia. Analytic report. NIA-Priroda: 104 pp. (Борисов, С. С., Глушков, В. М., Гревцев, В. И., Думнов А. Д., Козловский И. С., Колесников В. В. , Машкин В. И., Пиминов В. Н., Рощупкина, Ю. В., Рыбальский, Н. Г., Сафонов, В. Г., Сергеев, А. А., Синицын, А. А., Снакин, В. В., Сотников, В. Н. & Шиляива, Л. М. 2004. Охотничьи ресурсы России. Аналитический доклад. НИА-Природа: 104 стр., in Russian).

Breitenmoser, U., Breitenmoser-Würsten, C., Okarma, H., Kaphegyi-Wallmann U. & Müller, U.M. 2000. Action plan for the conservation of Eurasian lynx in Europe. Nature and environment, No 112, Council of Europe Publishing, 69 pp.

Breitenmoser, U. 1998. Large predators in the Alps: the fall and rise of man`s competitors. Biological Conservation, 83 (3): 279–289.

Breitenmoser, U. & Haller, H. 1993. Patterns of predation by reintroduced European lynx in the Swiss Alps. J.Wildl. Manage., 57(1): 135–144.

Creel, S. & Rotella, J.J. 2010. Meta-Analysis of Relationships between Human Offtake, Total Mortality and Population Dynamics of Gray Wolves (Canis lupus). PLoS ONE 5 (9): e12918. doi:10.1371/journal.pone.0012918.

Dahle, B. & Swenson, J.E. 2003(a). Family brakeup in brown bears: are young forced to leave. Journal of Mammalogy, 84 (2): 536–540.

Dahle, B. & Swenson, J.E. 2003(b). Home ranges in adult Scandinavian brown bears *Ursus arctos*: effect of population density, mass, sex, reproductive status and habitat type. Journal of Zooloogy, 260: 329–335.

Danilov, P. I. 2005. Game animals of Karelia: ecology, resources, management, protection. Moscow, Nauka, 340 pp.

Danilov P. I., Rusakov O.S., Tumanov I. L., Belkin V.V. & Makarova O. A. 2003. The East European and Caucasian parts of lynx range (the western group of regions): the North-West of Russia. In: Matyushkin Ye.N. & Vaisfeld M.A.(eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow, Nauka: 31–52.

Davidson, J., Ho, S. Y. W., Bray, S., Korsten, M., Tammeleht, E., Hindrikson, M., Østbye, K., Østbye, E., Lauritzen, S-E., Austin, J., Cooper, A. & Saarma, U. 2011. Late-Quaternary biogeographic scenarios for the brown bear (*Ursus arctos*), a wild mammal model species. Quaternary Science Reviews, 30: 418–430.

Dećak, D., Franković, A., Grubešić, M., Huber, D., Ivićek, B., Kulić, B, Sertić, D. & Štahan, Ž. 2005. Brown Bear Management Plan for The Republic of Croatia. Ministry of Agriculture, Forestry and Water Management, Department for Hunting & Ministry of Culture, Department of Nature Protection, Zagreb, 90 pp.

Dominguez, G., Espi, A., Prieto, J. M. & de la Torre, J.A. 2008. Sarcoptic mange in Iberian wolf *(Canis lupus signatus)* in northern Spain. Veterinary record, 162: 154–155.

Elfström, M., Swenson, J.E. & Ball, J. P. 2008. Selection of denning habitats by Scandinavian brown bears *Ursus arctos*. Wildl. Biol., 14: 176–187.

Elmhagen, B., Ludwig, G., Rusthon, S.P., Helle, P. & Lindén, H. 2010. Top predators, mesopredators and their prey: interference ecosystems along bioclimatic productivity gradients. Journal of Animal Ecology, 79 (4): 785–794.

Ermel, T. 2007. Pruunkaru talvituskohad Eestis. Bakalaureusetöö. Tartu Ülikool Geograafia Instituut.

Estes, J.A., Terborgh, J., Brashares, J.S., Power, M.E., Berger, J., Bond, W.J., Carpenter, S.R., Essington, T.E., Holt, R.D., Jackson, J.B.C., Marquis, R.J., Oksanen, L., Oksanen, T., Paine, R.T., Pikitch, E.K., Ripple, W,J., Sandin, S.A., Scheffer, M., Schoener, T.W., Shurin, J.B., Sinclair, E.R.E., Soule, M.E., Virtanen, R. & Wardle, D.A. 2011. Trophic Downgrading of Planet Earth. Science, 333: 301–306.

Evans, D. & Arvela, M. (eds.) 2011. Assessment and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidlines for the period 2007–2012. Final Draft. 123 pp. http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2007-2012/reporting_guidelines&vm=detailed&sb=Title.

Flagstad, O., Walker, C.W., Vila, C., Sundqvist, A-K., Fernholm, B., Hufthammer, A.K., Wiig, Ø., Kojola, I. & Ellegren, H. 2003. Two centuries of the Scandinavian wolf population: patterns of genetic variability and migration during an era of dramatic decline. Molecular Ecology, 12: 869–880.

Fourli, M. 1999. Compensation for damage caused by bears and wolves in the European Union. Experiences from the LIFE-Nature projects. European Commission DG XI, Environment, Nuclear Security and Civil Protection, Bruxelles, 68 pp.

Fuller, T.K., Mech, L.D. & Cochrane, J.F. 2003. Wolf population dynamics. In: Mech, L.D., Boitani, L. (eds.) 2003. Wolves: Behavior, Ecology and Conservation. University of Chicago Press: 161–191.

Frankham, R. 1995. Effective population size / adult population size ratios in wildlife: a review. Genetical Research, 66: 95–107.

Goszczynski, J., Misiorowska, M. & Juszko, S. 2008. Changes in the density and spatial distribution of red fox dens and cub numbers in central Poland following rabies vaccination. Acta Theriologica, 52 (2): 121–127.

Gubar, U. P. 2011(a). The Wolf (*Canis lupus* L., 1758). – Hunting and game resources of Russian Federation 2011. State resource management, special issue 2011. Perm: 96–100. (Губарь, Ю. П. 2011(a). Волк (*Canis lupus* L., 1758). – Охота и охотничьи ресурсы Российской Федерации 2011. Государственное управление ресурсами, специальный выпуск 2011. Пермь: 96–100, in Russian).

Gubar, U. P. 2011(b). Brown bear (*Ursus arctos* L., 1758). – Hunting and game resources of Russian Federation 2011. State resource management, special issue 2011. Perm: 101–105 (Губарь, Ю. П. 2011(b). Бурый медведь (*Ursus arctos* L., 1758). – Охота и охотничьи ресурсы Российской Федерации 2011. Государственное управление ресурсами, специальный выпуск 2011. Пермь: 101–105, in Russian).

Gärdenfors, U., Hilton-Taylor, C., Mace, G. M. & Rodríguez, J. P. 2001. The application of IUCN red list criteria at regional levels. Conservation Biology, 15 (5): 1206–1212.

Hellborg, L., Walker, C.W., Rueness, E.K., Stacy, J.E., Kojola, I., Valdmann, H., Vila, C., Zimmermann, B., Jakobsen, K.S. & Ellegren, H. 2002. Differentiation and levels of genetic variation in northern European lynx (Lynx lynx) populations revealed by microsatellites and mitochondrial DNA analysis. Conservation Genetics, 3: 97–111.

Helldin, J.O., Liberg, O. & Glöersen, G. 2006. Lynx (*Lynx lynx*) killing red foxes (*Vulpes vulpes*) in boreal Sweden – frequency and population effects. Journal of Zooloogy, 270: 657–663.

Hensel, R. J., Troyer, W. A. & Erickson, A.W. 1969. Reproduction in the Female Brown Bear. Journal of Wildlife Management, 33 (27): 357–365.

Herfindal, I., Linnell, J.D.C., Odden, J., Nilsen, E.B. & Andersen, R. 2005. Prey density, environmental productivity and home-range size in the Eurasian lynx (*Lynx lynx*). J.Zool. Lond., 256: 63–71.

Hindrikson, M., Männil, P., Ozolins, J., Krzywinski, A. & Saarma, U. 2012(a). Bucking the Trend in Wolf-Dog Hybridization: First Evidence from Europe of Hybridization between Female Dogs and Male Wolves. PLoS ONE, 7(10): e46465. doi:10.1371/journal.pone.0046465.

Hindrikson, M., Remm, J., Männil, P., Ozolins, J., Tammeleht, E. & Saarma U. 2012(b). Spatial Genetic Analyses Reveal Cryptic Population Structure and Migration Patterns in a Continuously Harvested Grey Wolf (*Canis lupus*) Population in North-Eastern Europe. Submitted to PLoS ONE.

Hindrikson, M., Männil, P. & Saarma, U. 2009. Geneetiline analüüs tõestas hundi ja koera hübriidid Eestis. Eesti Loodus, 9: 6–13.

Ho, S. Y. W., Saarma, U., Barnett, R., Haile, J. & Shapiro, B. 2008. The Effect of Inappropriate Calibration: Three Case Studies in Molecular Ecology. PLoS ONE, 3(2): e1615 doi:10.1371/journal.pone.0001615.

Holt, G. & Berg, C. 1990. Sarcoptic mange in red foxes and other wild carnivores in Norway. Norsk Veterinærtidsskrift, 102 (6): 427–432.

Huber, D. 2005. Why not to Re-introduce „Rehabilitated“ Brown Bears to the Wild. Rehabilitation and Release of Bears. Zooloogishe Garten, Köln 2005: 28–34.

Huber, D. & Roth, H. U. 1993. Movements of European brown bears in Croatia. Acta Theriologica, 38 (2): 151–159.

Jarnemo, A. & Liberg, O. 2005. Red fox removal and roe deer fawn survival – a 14-year study. Journal of Wildlife Management, 69 (3): 1090–1098.

Jedrzejewska, B. & Jedrzejewski, W. 2005 Large Carnivores and Ungulates in European Temperate Forest Ecosystems: Bottom-Up and Top-Down Control. In: Ray , J. C. (ed.) Large Carnivores and the Conservation of Biodiversity. Island Press, Washington D. C.: 230–246.

Jedrzejewska, B., Jedrzejewski, W., Bunevich, A. N., Milkowski, L. & Krasinski, Z. A. 1997. Factors shaping population densities and increase rates of ungulates in Bialowieza Primeval Forest (Poland and Belarus) in the 19th and 20th centuries. Acta Theriologica, 42 (4): 399–451.

Jedrzejewski, W., Nowak, S., Kurek, R., Myslajek, R.W., Stachura, K., Zawadzka, B. & Pchalek, M. 2009. Animals and Roads. Methods of mitigation the negatine impact of roads on wildlife. Mammal Research Institute, Polish Academy of Sciences, Białowieźa. 94 pp.

Jedrzejewski, W., Niedzialkowska, M., Nowak, S. & Jedrzejewska, B. 2004. Habitat variables associated with wolf (*Canis lupus*) distribution and abundance in northern Poland. Diversity Distrib, 10: 225–233.

Jedrzejewski, W., Schmidt, K., Theuerkauf, J., Jedrzejewska, B., Selva, N., Zub, K. & Szymura, L. 2002. Kill Rates and Predation By Wolves on Ungulate Populations in Bialowieza Primeval Forest (Poland). Ecology, 83(5): 1341 – 1356.

Jedrzejewski, W., Schmidt, K., Theuerkauf, J., Jedrzejewska, B. & Okarma, H. 2001. Daily movements and territory use by radiocollared wolves (*Canis lupus*) in Bialowieza Primeval Forest in Poland. Can. J. Zool., 79: 1993–2004.

Jedrzejewski W., Jedrzejewska B., Okarma H., Schmidt K., Bunevich A. N. & Miłkowski L. 1996. Population dynamics (1869–1994), demography and home ranges of the lynx in Bialowieza Primeval Forest (Poland and Belarus). Ecography, 19: 122–138.

Jedrzejewski, W., Schmidt, K., Milkowski, L., Jedrzejewska, B. & Okarma, H. 1993. Foraging by lynx and its role in ungulate mortality: the local (Białowieża Forest) and the Palaearctic viewpoints. Acta Theriologica, 38(4): 385–403.

Jobin, A., Molinari, P. & Breitenmoser, U. 2000. Prey spectrum, prey preference and consumption rates of Eurasian lynx in the Swiss Jura Mountains. Acta Theriologica, 45(2): 243–252.

Jõgisalu, I. & Männil, P. 2011. Kärntõve levik suurkiskjate populatsioonides Eestis ja selle võimalik seos metsloomade marutaudivastase vaktsineerimisega. Eesti Jahimees, 3/4: 10–13.

Jõgisalu, I., Männil, P. & Kont, R. 2010. Spreading of sarcoptic mange in Estonian wolf population following anti-rabies vaccination programme. Вестник охотоведения, 7 (2): 372–376.

Kaal, M. & Randla, T. 1984. Ilvesest meie jahifaunas. Eesti ulukid III: 3–8.

Kaal, M. 1983. Hunt. Tallinn, Valgus.

Kaal, M. 1980. Pruunkaru. Tallinn, Valgus.

Kaartinen, S., Luoto, M & Kojola, I. 2010. Selection of den sites by wolves in boreal forests in Finland. Journal of Zoology, 281: 99–104.

Kaartinen, S., Kojola, I. & Colpaert, A. 2005. Finnish wolves avoid roads and settlements. Ann. Zool. Fennici, 42: 523–532.

Kanellopoulos, N., Mertzanis, G., Korakis, G. & Panagiotopoulou, M. 2006. Selective habitat use by brown bear (Ursus arctos L.) in northern Pindos, Greece. Journal of Biological Research, 5: 23–33.

Karlsson, J. & Johansson, Ö. 2010. Predictability of repeated carnivore attacks on livestock favours reactive use of mitigation measures. Journal of Applied Ecology, 47: 166–171.

Karlsson, J. 2007. Management of Wolf and Lynx Conflicts with Human Interests. Doctoral thesis, Swedish University of Agricultural Sciences, Uppsala. Acta Universitatis Agriculturae Sueciae, 59, 27 pp.

Kaczensky, P., Jerina, K., Jonozović, M., Krofel, M., Skrbinšek, T., Rauer, G., Kos, I. & Gutleb, B. 2011. Illegal killing may hamper brown bear recovery in the Eastern Alps. Ursus, 22 (1): 37–46.

Kaczensky, P. 1999. Large carnivore depredation on livestock in Europe. Ursus, 11: 59–72.

Kauhala, K. 2004. Removal of medium-sized predators and the breeding success of ducks in Finland. Folia Zool., 53 (4): 367–378.

Kauhala, K., Helle, P. & Helle, E. 2000. Predator control and the density and reproductive success of grouse in Finland. Ecography, 23: 161–168.

Kauhala, K. & Helle, P. 2000. The interactions of predator and hare populations in Finland – a study based on wildlife monitoring counts. Ann. Zool. Fennici, 37: 151–160.

Keis, M., Tammeleht, E., Martin, A-J., Lind, A., Männil, P., Valdmann, H. & Saarma U. 2011. Brown bear myrmecophagy in Estonia and comparison with other bear populations (manuscript).

Kindberg, J., Swenson, J., Ericsson, G., Bellemain, E., Miquel, C., & Taberlet., P. 2011. Estimating population size and trends of the Swedish brown bear Ursus arctos population. Wildlife Biology. 17 (2): 114–123.

Klein, L. (ed.) 2010. Loomad ja liiklus Eestis. Käsiraamat konfliktide määratlemiseks ja tehnilised lahendused meetmete rakendamiseks. Maanteamet, Tallinn-Tartu, 142 pp.

Klevezal, G. A. & Kleinenberg, S. E. 1967. Age determination of mammals by layer structure of tooth and bones. Moscow, Nauka, 144 pp. (Клевезаль, Г. А. & Клейненберг, С. Е., 1967. Определение возраста млекопиающих по слоистым структурам зубов и кости. Москва, Наука, 144 ctp., in Russian).

Kojola, I. 2007. Biology of the bear and the current status of the bear population. In: Management Plan for the Bear Population in Finland. Ministry of Agriculture and Forestry, 2b/2007: 10–17.

Kojola, I., Aspi, J., Hakala, A., Heikkinen, S., Ilmoni, C. & Ronkainen, S. 2006. Dispersal in an expanding wolf population in Finland. J. Mammal., 87 (2): 281–286.

Kojola, 2005. Status and development of the wolf population in Finland. In: Management Plan for the Wolf Population in Finland. Ministry of Agriculture and Forestry, 11b/2005: 8–14.

Kojola, I., Huitu, O., Toppinen, K., Heikura, K., Heikkinen, S. & Ronkkainen, S. 2004. Predation on European wild forest reindeer (*Rangifer tarandus*) by wolves (*Canis lupus*) in Finland. Journal of Zooloogy, 263: 229–235.

Kojola, I., Danilov, P.I., Laitala, H-M., Belkin, V. & Yakimov, A. 2003. Brown bear population structure in core and periphery: Analysis of hunting statistics from Russian Karelia and Finland. Ursus, 14(1): 17–20.

Kojola, I. & Laitala, H-M. 2000. Changes in the structure of an increasing brown bear population with distance from core areas: another example of presaturation female dispersal? Ann. Zool. Fennici, 37: 59–64.

Kont, R., Kübarsepp, M. & Männil, P. 2009. Ilvese telemeetrilised uuringud II. Uuringu aruanne. Metsakaitse- ja Metsauuenduskeskus & MTÜ Therio, 17 pp.

Kont,R., Männil, P., Kübarsepp, M. & Remm, J. 2010. Preliminary results of lynx predation rate on its main prey species roe deer in Estonia. Вестник охотоведения, 7 (2): 183–186.

Kont, R. 2010(a). Ilvese kisklusmäär ja mõju metskitse populatsioonile. Magistritöö. Tartu Ülikool Ökoloogia ja Maateaduste Instituut, 40 pp.

Kont, R. 2010(b). Ilvese pesakondade jäljevaatlused Tipu uurimisalal 2010 a talvel. Uuringu aruanne. MTÜ Therio, 10 pp.

Kreeger, T. J. 2003. The Internal Wolf: Physiology, Pathology, and Pharmacology. In: Mech, L.D., Boitani, L. (eds.) 2003. Wolves: Behavior, Ecology and Conservation. University of Chicago Press: 192–217.

Kvam, T. 1990. Population biology of the European lynx (*Lynx lynx*) in Norway. Dr. Scient. thesis, University of Trondheim, 34 pp.

Kvam, T. 1984. Age determination in European lynx *Lynx l. lynx* by incremental lines in tooth cementum. Acta Zoologica Fennica, 171: 221–223.

Kübarsepp, M. & Kont, R. 2008. Hundiasurkonna rakenduslikud uuringud Kikepera uurimisalal 2007/2008. aastal. Uuringu aruanne. Metsakaitse- ja metsauuenduskeskus.

Kübarsepp, M. & Valdmann, H. 2003. Winter diet and movements of wolf (*Canis lupus*) in Alam-Pedja Nature Reserve, Estonia. Acta Zooloogica Lithuanica, 13 (1): 28–33.

Levin, M. 2002. How to Prevent Damage from Large Predators with Electric Fences. Carnivore Damage Prevention News, 5: 5–8.

Liberg, O., Chapron, G., Webakken, P., Pedersen, H.C., Hobbs, N.T. & Sand, H. 2011. Shoot, shovel and shut up: cryptic poaching slows restoration of a large carnivore in Europe. Proc. R. Soc. B, doi: 10.1098/rspb.2011.1275.

Liberg, O., Aronson, A., Brainerd, S. M., Karlsson, J., Pedersen, H.–C., Sand, H. & Wabakken, P. 2010. The Recolonizing Scandinavian Wolf Population: Research and Management in Two Countries. In: Musiani, M., Boitani, L. & Paquet, P. C. (eds.) The World of Wolves: New Perspectives on Ecology, Behaviour and Management. University of Calgary Press, Alberta: 175 – 205.

Liberg, O., Andrén, H., Pedersen, H-C., Sand, H., Sejberg, D., Wabakken, P., Akesson, M. & Bensch, S. 2005. Severe inbreeding depression in a wild wolf (*Canis lupus*) population. Biological Letters, 1: 17–20.

Lindström, E.R., Andren, H., Angelstam, P., Cederlund, G., Hörnfeldt, B., Jäderberg, L., Lemnell, P-A., Martinsson, B., Sköld, K. & Swensson, J.E. 1994. Disease reveals the predator: sarcoptic mange, red fox predation, and prey populations. Ecology, 75 (4): 1042–1049.

Ling, H. 1954. Huntide ja ilveste hävitamine. Tallinn, 61 pp.

Linnell, J., Salvatori, V. & Boitani, L. 2008. Guidlines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared to the European Commission (contract 070501/2005/434162/MAR/B2), 84 pp.

Linnell, J.D.C., Fiske, P., Herfindal, I., Odden, J., Brøseth, H. & Andersen, R. 2007. An evaluation of structured snow-track surveys to monitor Eurasian lynx *Lynx lynx* populations. Wildl. Biol., 13: 456–466.

Linnell, J.D.C., Skogen, K., Andersone-Lilley, Z., Balciauskas, L., Herfindal, I., Kowalczyk, R., Jedrzejewski, W., Männil, P., Okarma, H., Olszanska, A., Ornicans, A., Ozolins, J., Poltimäe, R., Randveer, T., Schmidt, K. & Valdmann, H. 2006. Large carnivores in northern landscapes: Final report. Status survey, conflicts, human dimensions, ecology and conservation of bears, lynx and wolves in Estonia, Latvia, Lithuania and Poland. NINA, Trondheim, Norway, 116 pp.

Linnell, J.D.C., Andersen, R., Andersone, Z., Balciauskas, L., Blanco, J.C., Boitani, L., Brainerd, S., Breitenmoser, U., Kojola, I., Liberg, O., Løe, J., Okarma, H., Pedersen, H.C., Promberger, C., Sand, H., Solberg, E.J., Valdmann, H. & Webakken, P. 2002. The fear of wolves: A review of wolf attacks on humans. NINA Oppdragsmelding, 731: 1–65.

Linnell, J. D. C., Andersen, R., Kvam, T., Liberg, O., Odden, J. & Moa, P. F. 2001. Home Range Size and Choice of Management Strategy for Lynx in Scandinavia. Envir. Management, 26 (6): 869–879.

Linnell, J.D.C., Swenson, J.E., Andersen, R. & Barnes, B. 2000. How vulnerable are denning bears to disturbance? Wildl. Soc. Bull., 28 (2): 400–413.

Linnell, J. C. D., Odden, J., Smith, M. E., Aanes, R., & Swenson, J. E. 1999. Large
carnivores that kill livestock: do «problem animals» really exist? Wildl. Soc. Bull., 27: 698–705.

Liukkonen, T. & Härkönen, S. 2007. Financial losses caused by lynx. In: Management plan for the lynx population in Finland. Ministry of Agriculture and Forestry, 1b/2007: 24–26.

Lovari, S., Sforzi, A., Scala, C. & Fico, R. 2007. Mortality parameters of the wolf in Italy: does the wolf keep himself from the door? Journal of Zoology, 272: 117–124.

Lõhmus, A. (ed.) 2001. Action plan for conservation and management of large carnivores in Estonia in 2002–2011. Ministry of the Environment, 67 pp.

Lynch, M. & Lande, R. 1998. The critical effective size for a genetically secure
population. Animal Conservation, 1: 70–72.

Martinello, F., Galuppo, F., Ostanello, F., Guberti, V. & Prosperi, S. 1997. Detection of canine parvovirus in wolves from Italy. Journal of Wildlife Diseases, 33 (3): 628–631.

Mattioli, L., Capitani, C., Gazzola, A., Scandura, M.& Apollonio, M. 2011. Prey selection and dietary response by wolves in a high-density multi-species ungulate community. European Journal of Wildlilfe Research, 57: 909–922.

Matson, G. M. 1981. Workbook for cementum analysis. Matson`s Milltown, Montana.

Mattson, D. J. 1997. Use of Ungulates by Yellowstone Grizzly Bears Ursus arctos. Biological Conservation, 81: 161 – 177.

Mech, D.L., Goyal, M.S., Paul, J.W. & Newton, E.W. 2008. Demographic effects of canine parvovirus on free-ranging wolf population over 30 years. Journal of Wildlife Diseases, 44 (4): 824–836.

Mech, L.D. & Boitani, L. 2003(a). Wolf Social Ecology. In: Mech, L.D., Boitani, L. (eds.) 2003. Wolves: Behavior, Ecology and Conservation. University of Chicago Press: 1–34.

Mech, L.D. & Boitani, L. 2003(b). Ecosystem Effects of Wolves. In: Mech, L.D., Boitani, L. (koost.) 2003. Wolves: Behavior, Ecology and Conservation. University of Chicago Press: 158–160.

Melis, C., Jedrzejewska, B., Apollonio, M., Barton, K. A., Jedrzejewski, W., Linnell, J. D. C., Kojola, I., Kusak, J., Adamic, M., Ciuti, S., Delehan, I., Dykyy, I., Krapinec, K., Mattioli, L., Sagaydak, A. Samchuk, N., Schmidt, K., Shkvyrya, M., Sidorovich, V.E., Zawadzka, B. & Zhyla, S. 2009. Predation has a greater impact in less productive environments: variation in roe deer, Capreolus capreolus, population density across Europe. Global Ecology and Biogeography, 18 (6): 724–734.

Melis, C., Szafranska, P., Jedrzejewska, B. & Barton, K. 2006. Biogeographic variation in the population density of wild boar (*Sus scrofa*) in western Eurasia. Journal of Biogeography, 33: 803–811.

Messier, F. 1994. Ungulate Population Models with Predation: A Case Study with the North American Moose. Ecology, 75(2): 478–488.

Mills, L. S. & Allendorf, F. W. 1996. The one-migrant-per-generation rule in conservation and management. Conservation Biology, 10:1509–1518.

Moks, E., Jõgisalu, I., Saarma, U., Talvik, H., Järvis, T. & Valdmann, H. 2006. Helminthological survey of wolf *Canis lupus* in Estonia, with an emphasis on the tapeworm *Echinococcus granulosus*. Journal of Wildlife Diseases, 42: 359–365.

Molinari-Jobin, A., Molinari, P., Breitenmoser-Wursten, C. & Breitenmoser, U. 2002. Significance of lynx *Lynx lynx* predation for roe deer *Capreolus capreolus* and chamois *Rupicapra rupicapra* mortality in the Swiss Jura Mountains. Wildlife Biology, 8 (2): 109–115.

Mosheva, T. S. 2011. The lynx (*Felis lynx* L., 1758). – Hunting and game resources of Russian Federation 2011. State resource management, special issue 2011. Perm: 59–64 (Мошева, Т. С. 2011. Рысь (*Felis lynx* L., 1758). – Охота и охотничьи ресурсы Российской Федерации 2011. Государственное управление ресурсами, специальный выпуск 2011. Пермь: 59–64, in Russian).

Mowat, G., Boutin, S. & Slough, B. G. 1996. Using placental scar counts to estimate litter size and pregnancy rate in lynx. Journal of Wildlife Management, 60 (2): 430–440.

Muhly, T., Gates, C.C., Callaghan, C. & Musiani, M. 2010. Livestock Husbandry Practises Reduce Wolf Depredation Risk in Alberta, Canada. In: Musiani, M., Boitani, L. & Paquet, P. C. (eds.) The World of Wolves: New Perspectives on Ecology, Behaviour and Management. University of Calgary Press, Alberta: 261 – 286.

Männil, P., Veeroja, R. & Tõnisson, J. 2011. Ulukiasurkondade seisund ja küttimissoovitus 2011. Aruanne. Keskkonnateabe Keskus, 69 pp.

Männil, P. 2007. Ilvese pesakonna kodupiirkonna suurus talvel II. Uuringu aruanne. Metsakaitse- ja Metsauuenduskeskus, 12 pp.

Männil, P. 2005. Miks hundid murravad koeri? Eesti Jahimees, 3: 12–13.

Mörner, T., Eriksson, H., Bröjer, C., Nilsson, K., Uhlhorn, H., Ågren, E., Hård af Segerstad, C., Jansson, D. S., & Gavier-Widén, D. 2005. Diseases and mortality in free-ranging brown bear (*Ursus arctos*), gray wolf (*Canis lupus*), and wolverine (*Gulo gulo*) in Sweden. Journal of Wildlife Diseases, 41(2): 298–303.

Mykrä, S. 2007. Economic and social significance of the bear population. In: Management Plan for the Bear Population in Finland. Ministry of Agriculture and Forestry, 2b/2007: 18–21.

Nelleman, C., Støen, O-G., Kindberg, J., Swenson, J., Vistnes, I., Ericsson, G., Katajisto, J., Kaltenborn, B. P., Martin, J & Ordiz, A. 2007. Terrain use by an expanding brown bear population in relation to age, recreational resorts and human settlements. Biological Conservation, 138(1–2): 157–165.

Newman, T.J., Baker, P.J. & Harris, S. 2002. Nutritional condition and survival of red foxes with sarcoptic mange. Can.J.Zool., 80: 154–161.

Niin, E. 2011. Muutused rebaste ja kährikute küttimises marutaudivastase vaktsineerimise järelkontrolliks. Eesti Jahimees, 7/8: 34–37.

Nowak, S., Mysłajek, R.W., Kłosinska, A. & Gabrys, G. 2011. Diet and prey selection of wolves (*Canis lupus*) recolonising Western and Central Poland. Mammal. Biol., doi:10.1016/j.mambio.2011.06.007.

Nowak, S., Myslajek, R.W. & Jedrzejewska, B. 2005. Patterns of wolf Canis lupus predation on wild and domestic ungulates in the Western Carpathian Mountains (S Poland). Acta Theriologica, 50 (2); 263–276.

Nowicki, P. 1997. Food habits and diet of the lynx (*Lynx lynx)* in Europe. J Wildl Res., 2: 161–166.

Odden, J., Herfindal, I., Linnell, J.D.C. & Andersen, R. 2008. Vulnerability of Domestic Sheep to Lynx Depredation in Relation to Roe Deer Density. Journal of Wildlife Management, 72 (1): 276–282.

Odden, J., Linnell, J. D. C. & Andersen, R. 2006. Diet of Eurasian lynx, *Lynx lynx*, in the boreal forest of southeastern Norway: the relative importance of livestock and hares at low roe deer density. European Journal of Wildlife Research, 52 (4): 237–244.

Okarma, H., Jedrzejewski, W., Schmidt, K., Sniezko, S., Bunevich, A.N. & Jedrzejewska, B. 1998. Home ranges of wolves in Bialowieza Primeval Forest, Poland, compeared with other Eurasian populations. J. Mammal., 72 (1): 842–852.

Okarma, H., Jedrzejewski, W., Schmidt, K., Kowalczyk, R. & Jedrzejewska, B. 1997. Predation of Eurasian lynx on roe deer in Bialowieza Primeval Forest, Poland. Acta Theriologica, 42 (2) :203–224.

Okarma, H. 1995. The trophic ecology of wolves and their predatory role in ungulate communities of forest ecosystems in Europe. Acta Theriologica, 40: 335–386.

Ordiz, A., Rodriguez, C., Naves, J., Fernandez, A., Huber, D., Kaczensky, P., Mertens, A., Mertzanis, Y., Mustoni, A., Palazon, S., Quenette, P.Y., Rauer, G. & Swensson, J.E. 2007. Distance-based criteria to identify minimum number of brown bear females with cubs in Europe. Ursus, 18(2): 158–167.

Ozolinš, J., Žunna, A., Pupila, A., Bagrade, G. & Andersone-Lilley, Ž. 2008. Wolf (*Canis lupus)* conservation plan. Environmental Ministry of Latvia, 40 pp.

Ozolinš, J., Bagrade, G., Ornicâns, A., Pupila, A. & Vaiders, A. 2007. Action plan for the conservation of Eurasian lynx (*Lynx lynx)* in Latvia. Environmental Ministry of Latvia, 42 pp.

Otstavel, T., Vuori, K.A., Sims, D.E. & Valros, A.2009. The first experience of livestock guarding dogs preventing large carnivore damages in Finland. Estonian Journal of Ecology, 58 (3): 216–224.

Packard, J.M. 2003. Wolf Behavior: Reproductive, Social, and Intelligent. In: Mech, L.D. & Boitani, L. (eds.) 2003. Wolves: Behavior, Ecology and Conservation. University of Chicago Press: 35–65.

Paetkau, D., Waits, L. P., Clarkson, P. L., Craighead, L., Vyse, E., Ward., R. & Strobeck, C. 1998. Variation in Genetic Diversity across the Range of North American Brown Bears. Conservation Biology. 12(2): 418–429.

Palomares, F., Rodriguez, A., Revilla, E., López-Bao, J. V. & Calzada, J. 2011. Assessment of the Conservation Efforts to Prevent Extinction of the Iberian Lynx. Conservation Biology, 25 (1): 4–8.

Palomeras, F. & Caro, T. M. 1999. Intraspecific Killing among Mammalian Carnivores. The American Naturalist, 153 (5): 492–508.

Panek, M., Kaminieniarz, R. & Bresinski, W. 2006. The effect of experimental removal of red foxes *Vulpes vulpes* on spring density of brown hares *Lepus europaeus* in western poland. Acta Theriologica, 51 (2): 187–193.

Parker, G. R. & Maxwell, J. W. 1986. Identification of Pups and Yearling Wolves by Dentine Width in the Canine. Arctic, 39(2): 180–181.

Pazhetnov, V. S. 1990. Brown bear. Moscow, Nauka: 215 pp. (Пажетнов, В. С. 1990. Бурый медведь. Москва, Наука: 215 стр., in Russian).

Pence, D. B. & Ueckermann, E. 2002. Sarcoptic mange in wildlife. Revue Scientifique et Téchnique – Office International des Epizooties, 21 (2): 385–398.

Pence, D. B. & Windberg, L. A. 1994. Impact of a sarcoptic mange epizootic on coyote population. J. Wildl. Manag., 58: 624–633.

Persson, I-L., Wikan, S., Swenson, J. E. & Mysterud, I. 2001. The diet of the brown bear *Ursus arctos* in the Pasvik Valley, northeastern Norway. Wildl. Biol., 7: 27–37.

Pilats V. & Ozolinš J. 2003. Status of brown bear in Latvia. Acta Zoologica Lituanica, 13 (1): 65–71.

Pozio, E., Miller, I., Järvis, T. Kapel, C.M.O. & La Rosa, G. 1998. Distribution of Sylvatic Species of *Trichinella* in Estonia According to the Climate Zones. Journal of Parasitology, 84 (1): 193–195.

Prugh, L. R., Stoner, C. J., Epps, C. W., Bean, W. T., Ripple, W. J., Laliberte, A. S. & Brashares, J. S. 2009. The Rise of the Mesopredator. BioScience, 59 (9): 779–791.

Pulliainen, E. 1981. Winter diet of *Felis lynx L*. in SE Finland as compared with the nutrition of other northern lynxes. Zeitschrift Fur Saugetierkunde-International Journal of Mammalian Biology, 46 (4): 249–259.

Randi, E. 2011. Genetics and conservation of wolves *Canis lupus* in Europe. Mammal Review, 41 (2): 99–111.

Randveer, T. 2006. The attitude of Estonians towards large carnivores. Acta Zooloogica Lituanica, 16 (2): 119–123.

Randveer, T. (ed.) 2003. Jahiraamat. Eesti Entsüklopeediakirjastus, 296 pp.

Randveer, T. 2001. Estonians and the wolf. Human dimensions of large carnivores in Baltic countries. Proceedings of BLCIE symposium. Siauliai, Lithuania: 28–35.

Ratkiewicz, M., Matosiuk, M., Kowalcyk, R., Konopiński, M. K., Okarma, H., Ozolins, J., Männil, P., Ornicans, A. & Schmidt, K. 2012. High levels of population differentation in Eurasian lynx at the edge of the species` western range in Europe revealed by mitochondrial DNA analyses. Animal Conservation, 15: 603–612.

Ritchie, E. G. & Johnson, C. N. 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecology Letters, 12: 982–998.

Rootsi, I. 2011. Hunt ja inimene: suhted Eestis XVIII sajandi keskpaigast XIX sajandi lõpuni. Dissertationes Historiae Universitatis Tartuensis, 24, 282 pp.

Rootsi, I. 2005. Tuli susi soovikusta. Tartu, 480 pp.

Rootsi, I. 2003. Rabid wolves and the man in Estonia of the 18^{th}–19^{th} centuries. Acta Zooloogica Lituanica, 13: 72–77.

Rootsi, 2001. Man-eater wolves in 19-th century Estonia. Human dimensions of large carnivores in Baltic countries. Proceedings of BLCIE symposium. Siauliai, Lithuania: 77–91.

Räikkönen, J., Bignert, A., Mortensen, P. & Fernholm, B. 2006. Congenital defects in a highly inbred wild wolf population (Canis lupus). Mammalian Biology, 71: 65–73.

Ryser-Degiorgis, M.-P., Ryser, A., Bacciarini, L. N., Angst, C., Gottstein, B., Janovsky, M. & Breitenmoser, U. 2002. Notoedric and sarcoptic mange in free-ranging lynx from Switzerland. Journal of Wildlife Diseases, 38 (1): 228–232.

Ryser-Degiorgis, M.-P., Hoffmann-Lehmann, R., Leutenegger, C. M., Hård af Segerstad, C., Möner, T., Mattson, R. & Lutz, H. 2005. Epizootiologic investigations of selected infectious disease agents in free-ranging Eurasian lynx from Sweden. Journal of Wildlife Diseases, 41 (1): 58–66.

Sagør, J.T., Swenson, J.E., & Røskaft, E. 1997. Compatibility of brown bear *Ursus arctos* and free-ranging sheep in Norway. Biological Conservation, 81: 91–95.

Salo, P. 2007. Biology of the lynx. In: Management plan for the lynx population in Finland. Ministry of Agriculture and Forestry, 1b/2007: 9–19.

Salvatori, V. & Linnell, J. 2005. Report of the conservation status and threats for wolf (*Canis lupus*) in Europe. Council of Europe, T-PVS/Inf 16, 24 pp.

Sand, H., Wabakken, P., Zimmermann, B., Johansson, Ö., Pedersen, H. C. & Liberg, O. 2008. Summer kill rates and predation pattern in a wolf–moose system: can we rely on winter estimates? Oecologia, 156: 53–64.

Santos, N., Almendra, C. & Tavares, L. 2009. Serologic Survey for Canine Distemper Virus and Canine Parvovirus in Free-ranging Wild Carnivores from Portugal. Journal of Wildlife Diseases, 45 (1): 221–226.

Sastre, N., Vila, C., Salinas, M., Bologov, V. V., Urios, V., Sanchez, A., Francino, O. & Ramirez, O. 2011. Signatures of demographic bottlenecks in European wolf populations. Conservation Genetics, 12:701–712.

Sæther, B-E., Engen, S., Odden, J., Linnell, J.D.C., Grutan, V. & Andren, H. 2010. Sustainable harvest strategies for age-structured Eurasian lynx populations: The use of reproductive value. Biological Conservation, 143: 1970–1979.

Sæther, B-E., Swenson, J. E., Engen, S., Bakke, O. & Sandegren, F., 1998. Assessing the

viability of Scandinavian brown bear, Ursus arctos, populations: the effects of uncertain parameter estimates. Oikos, 83: 403–416.

Sidorovich, V. E. 2006. Relationship between prey availability and population dynamics of the Eurasian lynx and its diet in northern Belarus. Acta Theriologica, 51 (3): 265–274.

Sidorovich, V. E., Tikhomirova, L. L. & Jedrzejewska, B. 2003. Wolf *Canis lupus* numbers, diet and damage to livestock in relation to hunting and ungulate abundance in northeastern Belarus during 1990–2000. Wildlife Biology, 9 (2): 103–111.

Singer, A., Kauhala, K., Holmala, K. & Smith, G. C. 2009. Rabies in northeastern Europe – the threat from invasive racoon dogs. Journal of Wildlife Diseases, 45 (4): 1121–1137.

Schmidt, K., Ratkiewicz, M. & Konopinski, M. 2011. The importance of genetic variability and population differentiation in the Eurasian lynx *Lynx lynx* for conservation, in the context of habitat and climate change. Mammal Review, 41: 112–124.

Schmidt, K., Kowalczyk, R., Ozolins, J., Männil, P. & Fickel, J. 2009. Genetic structure of the Eurasian lynx population in north-eastern Poland and the Baltic states. Conservation Genetics, 10: 497–501.

Schmidt, K. 2008(a). Behavioural and spatial adaptation of the Eurasian lynx to a decline in prey availability. Acta Theriologica, 53 (1): 1–16.

Schmidt, K. 2008(b). Factors shaping the Eurasian lynx (Lynx lynx) population in the north-eastern Poland. Nature Conservation, 65: 3–15.

Schmidt, K. 1999. Variation in daily activity of the free-living Eurasian lynx (*Lynx lynx*) in Bialowieza Primeval Forest, Poland. J. Zool. Lond., 249: 417–425.

Schmidt, K. 1998. Maternal behaviour and juvenile dispersal in the Eurasian lynx. Acta Theriologica, 43 (4): 391–408.

Schmidt, K., Jedrzejewski, W. & Okarma, H. 1997. Spatial organization and social relations in the Eurasian lynx population in Bialowieza Primeval Forest, Poland. Acta Theriologica, 42 (3): 289–312.

Schmidt-Posthaus, H., Breitenmoser-Wursten, C., Bacciarini, L. & Breitenmoser, U. 2002. Causes of mortality in reintroduced Eurasian lynx in Switzerland. Journal of Wildlife Diseases, 38 (1); 84–92.

Schwartz, C.C.,Swenson, J.E. & Miller, S.D. 2003. Large carnivores, moose and humans: a changing paradigm of predator management in the 21st century. Alces, 39: 41–63.

Smith, M. E., Linnell, J. D. C, Odden, J., & Swenson, J. E. 2000. Review of Methods to Reduce Livestock Depredation: I. Guardian Animals. Acta Agric. Scand., Sect. A, Animal Sci., 50: 279–290.

Sobrino, R., Arnal, M. C., Luco, D. F. & Gortázar, C. 2008. Prevalence of antibodies against canine distempter virus and canine parvovirus among foxes and wolves from Spain. Veterinary Microbiology, 126 (1–3): 251–256.

Solberg, K. H., Bellemain, E., Drageset, O-M., Taberlet, P. & Swenson, J. E. 2006. An evaluation of field and non-invasive genetic methods to estimate brown bear *(Ursus arctos)* population size. Biol. Conservation, 128: 158–168.

Soulé, M. E., Estes, J. A., Berger, J. & Martinez del Rios, C. 2003. Ecological effectiveness: conservation goals for interactive species. Conservation Biology, 17 (5): 1238–1250.

Stahl, P., Vandel, J. M., Ruette, S., Coat, L., Coat, Y. & Balestra, L. 2002. Factors affecting lynx predation on sheep in the French Jura. Journal of Applied Ecology, 39: 204–216.

Stahl, P., Vandel., Herrenschmidt, V. & Migot, P. 2001. Predation on livestock by an expanding reintroduced lynx population: long term trend and spatial variability. Journal of Applied Ecology, 38: 674–687.

Støen, O-G., Zedrosser, A., Sæbø, S. & Swenson, J. E. 2006. Inversely density-dependent natal dispersal in brown bears *Ursus arctos*. Oecologia, 148 (2): 356–364.

Støen, O-G., Bellemain, E., Sæbø, S. & Swenson, J.E. 2005. Kin-related spatial structure in brown bears *Ursus arctos*. Behav Ecol Sociobiol, 59: 191–197.

Sunde, P., Kvam, T., Bolstad, J.P. & Bronndal, M. 2000. Foraging of lynxes in a managed boreal-alpine environment. Ecography, 23: 291–298.

Sunde, P., Overskaug, K. & Kvam, S. 1999. Intraguild predation of lynxes on foxes: evidence of interference competition? Ecography, 22: 521–523.

Swenson, J. E., Taberlet, P. & Bellemain, E. 2011. Genetics and conservation of European brown bears *Ursus arctos*. Mammal Review, 41 (2): 87–98.

Swenson, J. E., Dahle, B., Busk, H., Opseth, O., Johansen, T., Söderberg, A., Wallin, K. & Cederlund, G. 2007. Predation on Moose Calves by European Brown Bears. Journal of Wildlife Management, 71 (6): 1993–1997.

Swenson, J. E.,Sandegren, F., Brunberg, S. & Segerström, P. 2001(a). Factors associated with loss of brown bear cubs in Sweden. Ursus, 12: 69–80.

Swenson, J. E., Dahle, B. & Sandegren, F. 2001(b). Intraspecific predation in Scandinavian brown bears older than cubs-of-the-year. Ursus, 12: 81–92.

Swenson, J. E., Gerstl, N., Dahle, B. & Zedrosser, A. 2000. Action plan for the conservation of the brown bear in Europe (*Ursus arctos*). Nature and environment, No 114, Council of Europe Publishing, 69 pp.

Swenson, J. E., Sandegren, F., Söderberg, A., Heim, M., Sørensen, O.J., Bjärvall, A., Franzen, R., Wikan, S. & Webakken, P. 1999(a). Interactions between brown bears and humans in Scandinavia. Biosphere Conservation, 2 (1): 1–9.

Swenson, J. E., Jansson, A., Riig, R. & Sandegren, F. 1999(b). Bears and ants: myrmecophagy by brown bears in central Scandinavia. Can. J. Zool., 77: 551–561.

Swenson, J. E., Sandegren, F. & Söderberg, A. 1998. Geographic expansion of an increasing brown bear population: evidence for presaturation dispersal. Journal of Animal Ecology, 67: 819–826.

Swenson, J. E., Sandegren,F., Brunberg, S. & Wabakken, P. 1997. Winter den abondoment by brown bears Ursus arctos: Causes and consequences. Wildl. Biol., 3 (1): 35–38.

Swenson, J. E., Sandegren, F., Bjärvall, A., Söderberg, A., Wabakken, P. & Franzén, R. 1994.

Size, trend, distribution and conservation of the brown bear *Ursus arctos* population in

Sweden. Biol. Conserv., 70: 9–17.

Taberlet, P., Swenson, J. E., Sandegren, F. & Bjärvall, A. 1995. Localization of a contact zone between two highly divergent mitochondrial DNA lineages of the brown bear Ursus arctos in Scandinavia. Conservation Biology, 9 (5): 1255–1261.

Tallmon, D. A., Bellemain, E., Swenson, J. E. & Taberlet, P. 2004. Genetic monitoring of Scandianvian brown bear: effective population size and immigration. Journal of Wildlife Management, 68: 960–965.

Tammeleht, E., Veske, L., Keis, M., Leht, M., Martin, A-J., Lind, A., Männil, P., Kilk, A., Valdmann, H. & Saarma, U. 2011. Pruunkaru ja inimene: kuidas vältida konflikte. Eesti Loodus, 12: 8–14.

Tammeleht, E., Remm, J., Korsten, M., Davidson, J., Tumanov, I., Saveljev, A., Männil, P., Kojola, I. & Saarma U. 2010(a). Genetic structure in large, continuous mammal populations: the example of brown bears in northwestern Europe. Molecular Ecology, 19: 5359–5370.

Tammeleht, E., Korsten, M., Leht, M., Martin, A.-J., Lind, A., Männil, P., Valdmann, H. & Saarma, U. 2010(b). Mida sööb pruunkaru Eestis ja Euroopas? Karu kõhust leiti Eestile uus sipelgaliik. Eesti Loodus, 12: 6–13.

Tear, T. H., Kareiva, P., Angermeier, P. L., Comer, P., Czech, B., Kautz, R., Landon, L.,

Mehlman, D., Murphy, K., Ruckelshaus, M., Scott, J. M. & Wilhere, G. 2005. How much is enough? The recurrent problem of setting measurable objectives in conservation. BioScience, 55 (10): 835–849.

Trouwborst, A. 2010. Managing the Carnivore Comeback: International and EU Species Protection Law and the Return of Lynx, Wolf and Bear to Western Europe. Journal of Environmental Law, 22 (3): 347–372.

Zager, P., & Beecham, J. 2006. The role of American Black Bears and Brown Bears as Predators on Ungulates in North America. Ursus, 17: 95–108.

Zedrosser, A., Støen, O-G., Sæbø, S. & Swenson, J. E. 2007. Should I stay or should I go? Natal dispersal in the brown bear. Animal Behaviour, 74: 369–376.

Zedrosser, A. & Swenson, J.E. 2005. Do brown bear litter sizes reported by the public reflect litter sizes obtained by scientific methods? Wildlife Society Bulletin, 33 (4): 1352–1356.

Žunna, A., Ozolinš, J. & Pupila, A. 2009. Food habits of the wolf Canis lupus in Latvia based on stomach analysis. Estonian Journal of Ecology, 58 (2): 141–152.

Vaisfeld, M.A. & Chestin, I.E. (eds.) 1993. Bears: brown bear, polar bear, Asian black bear; distribution, ecology, use and protection. Moscow, Nauka, 519 pp.

Valdmann, H., Andersone-Lilley, Z., Koppa, O., Ozolins, J. & Bagrade, G. 2005. Winter diet of wolf *Canis lupus* and lynx *Lynx lynx* in Estonia and Latvia. Acta Theriologica, 50: 521–527.

Valdmann, H., Moks, E. & Talvik, H. 2004. Helminth fauna of Eurasian lynx (*Lynx lynx*) in Estonia. Journal of Wildlife Diseases, 40 (2): 356–360.

Valdmann, H., Koppa, O. & Looga, A. 1998. Diet and prey selectivity of wolf *Canis lupus* in middle- and south-eastern Estonia. Baltic Forestry, 4 (1): 42–46.

van Dijk, J. J. 2005. Considerations for the Rehabilitation and Release of Bears into the Wild. Rehabilitation and Release of Bears. Zooloogishe Garten Köln: 7–16.

Viiburg, T. 2007. Jahimeeste suhtumine hunti. Eesti Jahimees, 7: 22–24.

von Arx, M., Breitenmoser-Würsten Ch., Zimmermann F. & Breitenmoser U. (eds.) 2004. Status and conservation of the Eurasian lynx (*Lynx lynx*) in Europe in 2001. KORA Bericht 19.

von Holdt, B. M., Stahler, D. R., Bangs, E. E., Smith, D. W., Jimenez, M. D., Mack, C. M., Niemeyer, C., Pollinger, J. P. & Wayne, R.K. 2010. A novel assessment of population structure and gene flow in grey wolf populations of the Northern Rocky Mountains of the United States. Molecular Ecology, 19: 4412–4427.

von Holdt, B. M., Stahler, D. R., Smith, D. W., Earl, D. A., Pollinger, J. P. & Wayne, R. K. 2008. The genealogy and genetic viability of reintroduced Yellowstone grey wolves. Molecular Ecology, 17: 252–274.

Vulla, E., Hobson, K.A., Korsten, M., Leht, M., Martin, A.-J., Lind, A., Männil, P., Valdmann, H. & Saarma U. 2009. Carnivory is positively correlated with latitude among omnivorous mammals: evidence from brown bears, badgers and pine martens. Annales Zoologici Fennici, 46: 395–415.

Waits, L.P., Taberlet, P., Swenson, J.E., Sandegren, F. & Franzén R. 2000. Nuclear DNA microsatellite analysis of genetic diversity and gene flow in the Scandinavian brown bear (Ursus arctos). Molecular Ecology, 9: 421–431.

White, P. J. & Garrott, R. A. 2005. Yellowstone's ungulates after wolves – expectations, realizations, and predictions. Biological Conservation, 125 (2): 141–152.