Adopted by the Minister
of Environmental Protection and Regional Development
Order No. _____
_____

Action Plan for Eurasian lynx *Lynx lynx* Conservation and Management

Plan is elaborated for the period from 2018 to 2028

Developed by the Latvian State Forest Research Institute "Silava"
Authors: Jānis Ozoliņš, Guna Bagrade, Aivars Ornicāns, Agrita Žunna, Gundega Done,
Alda Stepanova, Digna Pilāte, Jurģis Šuba, Mārtiņš Lūkins, Samantha Jane Howlett

Photo authors: Velga Vītola, Vilnis Skuja, Jānis Ozoliņš
Photo composition: Ginta Šuba
Translation: Jurģis Šuba, Samantha Jane Howlett
Suggested citation: Ozoliņš et al., 2017. Action Plan for Eurasian lynx *Lynx lynx* Conservation and Management. LSFRI Silava, Salaspils: 1-78.

Latvijas vides aizsardzības fonds

Salaspils
2017 (2002; 2007)

SILAVA

Contents

List of used abbreviations and glossary

The Baltic population of the Eurasian lynx – the population of lynx living in the territories of Latvia, Estonia, Lithuania, Belarus, the north of Poland, the north-western part of Ukraine and the Russian Federation regions adjacent to the Baltic States.

Biological (ecological) carrying capacity – the maximum sustainable population size of a given species that can be supported in a habitat without causing significant changes to the ecosystem concerned.

Coexistence – the ways and means to reduce and find solutions to the conflict of interests of people with the presence of large carnivores in their commonly inhabited environment.

Methods of non-invasive research – wildlife research techniques without the need to kill, capture or even observe animals directly (e.g. observation of animal tracks and other records of activity/evidence of presence, use of automatic cameras, etc.).

Non-consumptive use – activities related primarily to outdoor recreation, nature tourism (such as observation and photography of wild animals, nature trails), excluding the direct use of wildlife or other natural resources.

Social carrying capacity – the maximum number of individuals affecting the society (in terms of both wild and domesticated animals, in the context of this plan – lynx or livestock, as well as people, such as tourists or immigrants) in a specific area that does not cause significant dissatisfaction or conflict to local inhabitants, or degradation of quality of life, including psychological stress. See also *Wildlife acceptance capacity*.

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

CLC – CORINE Land Cover

IUCN – International Union for Conservation of Nature

LCIE – Large Carnivore Initiative for Europe

NCA – Nature Conservation Agency

SFS – State Forest Service

SPNA (NR, NP, RA) – Specially protected nature area (nature reserve, national park, restricted area)

Summary

Today, under favourable legislation and improved ecological conditions, large carnivores have begun to return to many European territories after centuries of persecution. However, some small populations are still critically endangered. Currently there are 11 Eurasian lynx populations in Europe. Lynx in Latvia are part of the so-called Baltic population.

Lynx is a threatened species at the European level, and its conservation in Latvia is regulated by Annex IV of the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. In Latvia, lynx is listed among the specially protected species whose use is limited. The species conservation plan, which was first developed and approved in Latvia in 2002 by the order of the Minister of the Environment, confirmed that the exception to the species exploitation complies with the conditions of Article 16 of the Council Directive 92/43/EEC – whereby that lynx are obtained without affecting the favourable condition of the population under strict surveillance, selectively and in a limited amount. In accordance with the report of Article 17 of Directive 92/43/EEC in 2013, the species status (population size, distribution, amount of suitable habitats and future prospects) after the current evaluation is deemed favourable in Latvia. Available information on species history shows that lynx in Latvia currently have the best population status over the last 100 years.

The purpose of the renewed Action Plan for Eurasian lynx (*Lynx lynx*) Conservation and Management in Latvia (referred to hereafter as the Action Plan) is to maintain a favourable status for the lynx population in Latvia for an unlimited period of time and to promote the maintenance of a favourable status of the Baltic lynx population without specifying the maximum number of individuals and habitats, while ensuring the presence of lynx as a united and functional component of the wildlife environment in a man-made and managed landscape, respecting and promoting the quality of life and well-being of a diverse society.

The Action Plan describes actions and measures required to ensure the conservation and management of the species by legislation, species research and data collection, information, education and training, as well as organizational and planning actions.

The Action Plan was developed at the Latvian State Forest Research Institute “Silava” within the project “Renewal of the Eurasian lynx *Lynx lynx* conservation plan” (No. 1-20/115) supported by the Latvian Environmental Protection Fund.

Introduction

Lynx is the largest representative of the cat family Felidae in the European fauna (Sunquist and Sunquist 2009) and the only wild cat species in Latvia (Tauriņš 1982). It is the third largest carnivore in Europe after the brown bear and wolf (Tauriņš 1982, Breitenmoser et al. 2000). In the past it was widespread throughout Europe, but in the first decades of the 20th century the prevalence of lynx, in comparison with its historical distribution, declined very rapidly (von Arx et al. 2004). Today, under favourable legislation and improved ecological conditions, large carnivores have begun to return to many European territories after centuries of persecution. However, some small populations are still critically endangered (von Arx et al. 2004, Kaczensky et al. 2013, Chapron et al. 2014, Boitani et al. 2015).

In reports on the Eastern Baltic and Latvian fauna the lynx is always referred to as a relatively rare and unevenly distributed animal (Grevé 1909, Tauriņš 1982). It entered the territory of Latvia with the development of boreal forests. In excavations at Iron Age settlements, as well as in medieval castles, lynx bones are poorly represented – about 1%. Already in the early centuries, lynx was hunted less than other carnivores, and lynx hunting was associated with a system of fees and penalties for unlawful killing (Mugurēvičs un Mugurēvičs 1999). However, among hunters, lynx along with other carnivores is considered as an undesirable competitor and even harmful to game management. During the Soviet period, the official policy was to reduce the number of lynx to a minimum, keeping them only as a "biological species" (Tauriņš 1982). The first formal management principles of game fauna, including the lynx population, were introduced in Latvia in 1968 via the so-called game management planning. In the 1970s and 1980s, theories on optimal population density and measures to ensure this dominated game management and the regulation of animal numbers (Ziediņš 1985).

In Latvia, systematic data collection began at the end of the 1990s, and studies have shown that the species status has not deteriorated (Ozoliņš et al. 2008, Bagrade et al. 2016) and lynx has become one of the most studied mammals in Latvia (see Chapter 1.5.). The knowledge gained in the research, along with the information from other countries, became a basis for scientifically based conservation measures. The first draft of the Action Plan for the conservation of Eurasian lynx (*Lynx lynx*) in Latvia was developed in 2000 during the project "Inventories of Species and Habitats, Development of Management Plans and Capacity Building in relation to Approximation of EU Birds and Habitats Directives". In accordance with the updated version of this document (Ozoliņš 2002), the introduction of species conservation measures was started. The Latvian position in joining the negotiations on the adoption of European Union requirements for wildlife conservation and management was to preserve as many previous rights as possible

(V.Bernards, J.Ozoliņš, pers. com.). A favourable lynx population status and detailed conservation strategy for the species allowed limited use of this protected species to continue in accordance with Article 16 of the EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. The implementation of a relatively successful Action Plan and the functioning of the conservation system allowed the document to remain unchanged for a longer period of time. Updating of the first Action Plan was foreseen in 2005, but it took place in 2007, which, in turn, provided for the renewal of the Action Plan in 2012. Also, the last updated Action Plan (Ozoliņš et al. 2007) did not radically change the current lynx population management system, but the region-wide perspective and species conservation measures were strongly emphasized.

A major challenge in the renewed Action Plan has been to find a balance between the needs of carnivores and humans in the territory of Latvia, without deterioration of the overall species status within the Baltic population. It is also necessary to comply with international legislation, initiatives and guidelines on issues of species conservation and management. It is important to recognise that the conservation of carnivores does not necessarily imply a strong protection regime and a sustainable use of wild species in hunting does not contradict their conservation (Sutherland 2000, Linnell et al. 2008). Currently, the document summarizing the activities, management methods and measures planned to monitor the species conservation status is called the Species Conservation Plan, but, according to the principles mentioned in the EC Directive 92/43/EEC, it would be more appropriate to refer to it as the Action Plan for Species Conservation and Management.

The aim of the renewed Action Plan for Eurasian lynx *Lynx lynx* Conservation and Management is to maintain a favourable status for the lynx population in Latvia for an unlimited period of time and to promote the maintenance of a favourable status of the Baltic lynx population without specifying the maximum number of individuals and habitats, while ensuring the presence of lynx as a united and functional component of the wildlife environment in a man-made and managed landscape, respecting and promoting the quality of life and well-being of a diverse society.

1. Species characteristics

1.1. Taxonomy and morphology

The Eurasian lynx *Lynx lynx* (order: Carnivora, family: Felidae, genus: *Lynx*) found in Latvia is one of the four lynx species in the world (Соколов 1979, Sunquist and Sunquist 2009), and it is the largest species of the genus. Latvian lynx belong to the nominate subspecies *L. l. lynx* (Sunquist and Sunquist 2009). According to the population distribution in Europe, Latvian lynx belong to the so-called Baltic population (von Arx et al. 2004, Katczensky et al. 2013, Chapron et al. 2014). The lynx is the third largest carnivore in Latvia and Europe, after the brown bear and the wolf (Tauriņš 1982, Breitenmoser et al. 2000). Body size varies, individuals from the northern and eastern parts of the distribution range are bigger than those from the southern and western parts. For example, the body length of lynx in Russia ranges from 82 to 105 cm (Новиков 1956), whereas in Europe it ranges from 71 to 130 cm (Breitenmoser et al. 2000, von Arx et al. 2004). Lynx also display sexual dimorphism as males are bigger and heavier than females (Sunde and Kvam 1997, Breitenmoser et al. 2000). In Europe, the weight of an adult individual ranges from 12 to 35 kg (Breitenmoser et al. 2000). In Estonia the average weight for an adult male is 22 kg, whereas for females it is 17 kg (Männil and Kont 2012). In Latvia it ranges mainly between 10 to 18 kg, rarely exceeding 30 kg. Reported data on the weight of lynx hunted in Latvia during the period from 1998 to 2016 suggest that the heaviest lynx males weighed 29 kg (adult individual, Liezēre parish, 2005), 27 kg (adult individual, Pāle parish, 2010) and 26 kg (8 year-old individual, Vaive parish 2006; adult individual, Jaunkalsnava parish 2013). There are two reports of lynx weighing over 30 kg: 31.5 kg (adult individual, Litene parish, 2012) and 32 kg (8 year-old individual, Zvārde parish, 2010). Whereas the heaviest hunted female recorded weighed 23 kg (3 year-old individual, Kuldīga forest district, 2007).

Typical characteristics of the genus *Lynx* are a short, black-tipped tail and triangular-shaped ears with hair tufts at the ends, which are especially prominent in winter. For other mammals of similar size, the lynx is distinguished by a relatively short and laterally flattened body and relatively long and massive legs. The hind legs are longer than the forelegs. The face is round with denser fur at the sides. Lynx fur may vary from ash-blue to reddish, with varying degrees of patterning, with regard to spot shape and size. Some body parts have a unvarying colouration – the abdomen, chest, neck, chin, the lower parts of the sides and the arm-pits are almost always white. Sexual dimorphism in pelt colour is not proven (Гептнер и Слудский 1972, Гвоздев 1982, Tauriņš 1982, Breitenmoser et al. 2000, Sunquist and Sunquist 2009). Moulting occurs twice a year – in spring and autumn. The pelt is thicker from November to March. Due to shorter hair in

the summer months, the spots tend to be more pronounced during this time. Spring moulting starts in April and lasts until July. Males and non-breeding females finish moulting sooner than juveniles and females with kittens (Данилов и др. 1979).

Lynx fur colour and body sizes are so variable that it was previously thought that there were several subspecies of the lynx even within Latvia (Grevé 1909). Later it was considered that lynx age, sex and locality of origin affects fur colour variations in Latvia (Kalniņš 1943). In a study conducted in Latvia from 2004 to 2014 (A. Ornicāns, unpublished data), it has been observed that mainly brown-gray shades occur among the hunted lynx. Lighter (paler) shades are typical of Vidzeme and Latgale region, whereas brighter, darker shades are typical of Kurzeme, West Zemgale, East Zemgale and Sēlija region, as well as in Central Latvia around the Daugava river. In terms of patterning (according to Шевченко и Песков 2007), fuzzy or indistinct spots, mainly on the hips and limbs are most commonly encountered in Latvian lynx.

Live observations of lynx are rare in nature, as individuals are very cautious and active mostly at night and dusk (Schmidt 1999), so presence of the species is mainly determined by indirect evidence. The most common signs of lynx presence are tracks, which are best seen in snow. Each footprint shows four toes and unlike dog and wolf prints of similar size, lynx prints are rounder and lack claw marks (Fig. 1). The diameter of the footprint is 8–13 cm. The front paw print is bigger than that of a hind paw. As lynx walk they put the hind paws into the footsteps of the front paws, therefore usually lynx tracks are distinguished by footprints of the hind paws. If there are several lynx, they can walk in each other's footprints. The track forms a zigzag line since prints of the left and right paws do not go in a straight line. The length of the step is 30–80 cm. Lynx do not follow a straight line in the forest but often make circles and stops. They often use quiet forest roads, paths, ditch systems, dry riverbeds and frozen ditches (Гептнер и Слудский 1972, Tauriņš 1982, Кучерепко 1988, Матюшкин 2000, Sunquist and Sunquist 2002).

Figure 1. Lynx footprint on the left, wolf – on the right. Photo by J. Ozoliņš.

1.2. Species ecology

Habitat, behaviour and individual territories

The lynx is considered as a species of woodland habitats and is a typical inhabitant of boreal forests, therefore Latvia (forests cover 3.07 million ha of the territory, State Forest Service data) and other Baltic states (Tauriņš 1982, Männil and Kont 2012) provide suitable habitats. It is known that in the northern, mountainous, and Asian regions, lynx are found in less forested areas (Breitenmoser et al. 2000, Sunquist and Sunquist 2009). Lynx climb in trees and often use the cover of fallen trees for ambush, but the perception that lynx spend the majority of their time in trees is usually exaggerated, especially regarding attacks on prey by jumping from trees. It is true that in lynx habitats various elevations, including sloping tree trunks or high stumps, play an important role as recreational or hunting spots, from which a wide area can be observed. It has been reported that lynx in Latvia prefer forest stands with dense spruce canopy layers (Tauriņš 1982). A preference for wind damaged forest stands has also been found. The main environmental requirements for lynx are the availability of sufficient food, safe places for resting and establishment of dens for reproduction, and the proximity of water (von Arx et al. 2004). It is believed that the conditions for lynx in Latvia have been greatly improved by beavers through the formation of additional water bodies, especially at sites inaccessible for people, as well as attracting ungulates and hares. Marshlands are not permanently inhabited by lynx, but they often utilise the edges of bogs, use patches of mineral soils as resting areas, and often cross bogs along roads and trails (Anderson et al. 2003). Lynx avoid agricultural lands and cross less forested areas along scrublands and river valleys. Lynx are also good swimmers (Кучеренко 1988).

Lynx have the potential to live in a landscape with a relatively high level of human presence/activity, if humans accept the presence of the animal. A study in Norway identified parameters which may indicate when lynx start to avoid a territory – 20 inhabitants per km^2, 1.1 km of forest roads and 0.54 km of public roads per km^2 and less than 1.4 roe deer excrement piles per km^2 (Bouyer et al. 2014). Roe deer, which are the main lynx prey, are more common in human modified landscapes (Bunnefeld et al. 2006, Bouyer et al. 2015). Such territories are more attractive to lynx, although they are also related to a higher mortality risk. It has been found that selection of such areas is associated with different behavioural strategies of males and females in relation to reproduction. Females with kittens avoid areas of human activity more than males, but as kittens grow and a need for food increases, they use more risky territories, which are richer in prey (Bunnefeld et al. 2006).

In Latvia, individual lynx territories and habitats have been studied by radio telemetry and satellite telemetry, tracking animals marked with transmitters. The obtained data from the radio telemetry study showed that various resources were available to the tracked lynx (one female, two males) – up to 15 habitats according to the CORINE Land Cover (CLC) data and 54 habitats, types of forests and land cover according to the State Forest Service (SFS) and CLC data where SFS data did not provide coverage for the area (Figs. 2, 3). Lynx most often choose woodland habitats, mainly dry and drained forest areas with lesser amounts of wet woodlands and forests on peatlands. They avoid staying in agricultural and urban areas, and marshlands. Data on habitat selection by male lynx indicate that they significantly utilise habitats related to human activities, such as glades for supplementary game feeding, possibly due to facilitated food acquisition (Bērziņa 2016). The territory inhabited by a male lynx tracked in Vidzeme had a more mosaic landscape, with a lower proportion of forests than in Kurzeme, and the animal was often also found in open landscapes (meadows, fields, arable lands, Ornicāns et al. 2007).

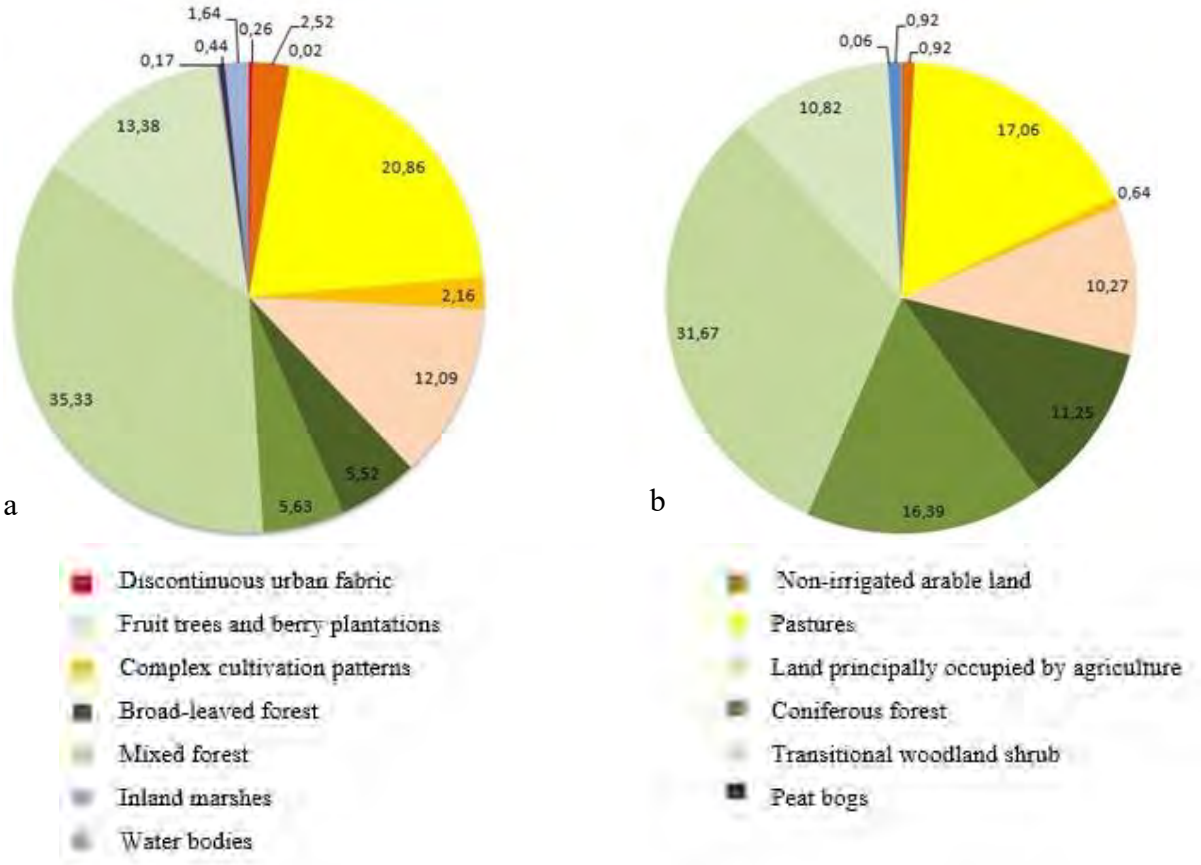


Figure 2. Habitat availability (a) and use (b) in a male lynx territory in Vidzeme (CLC data; Bērziņa 2016).

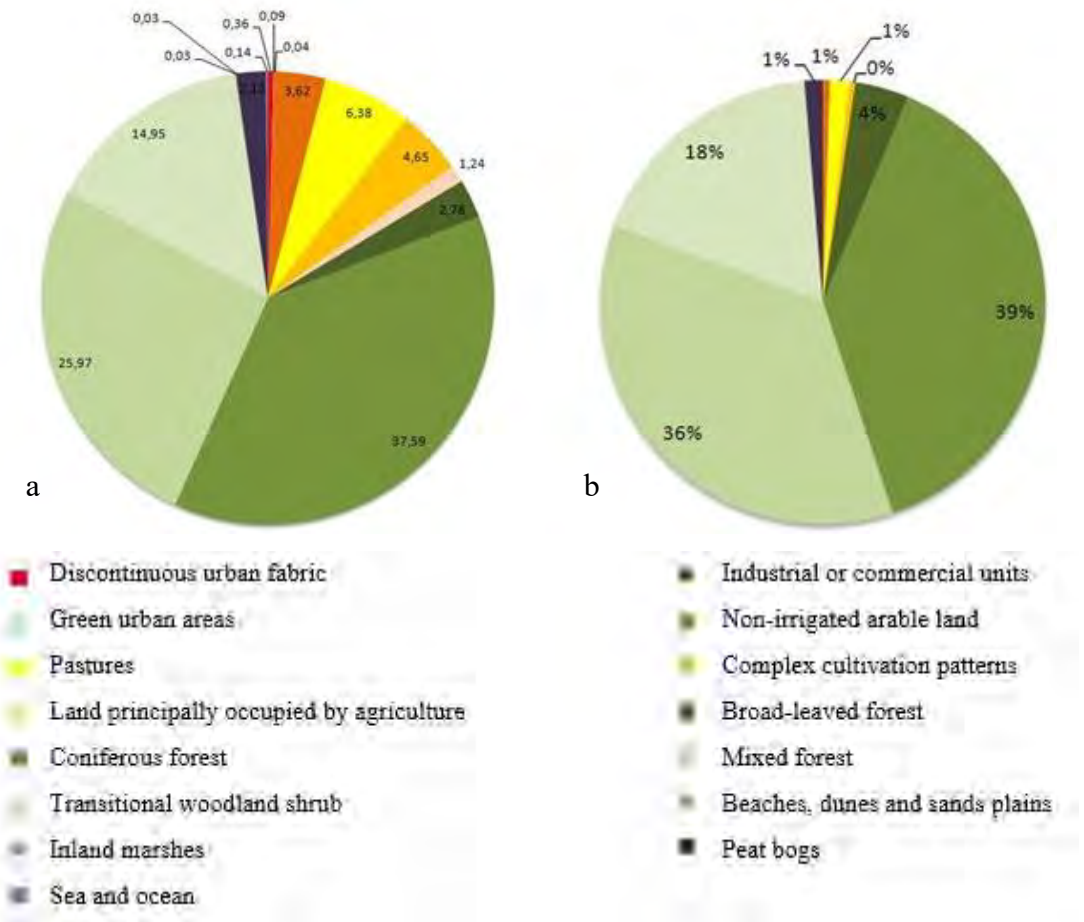
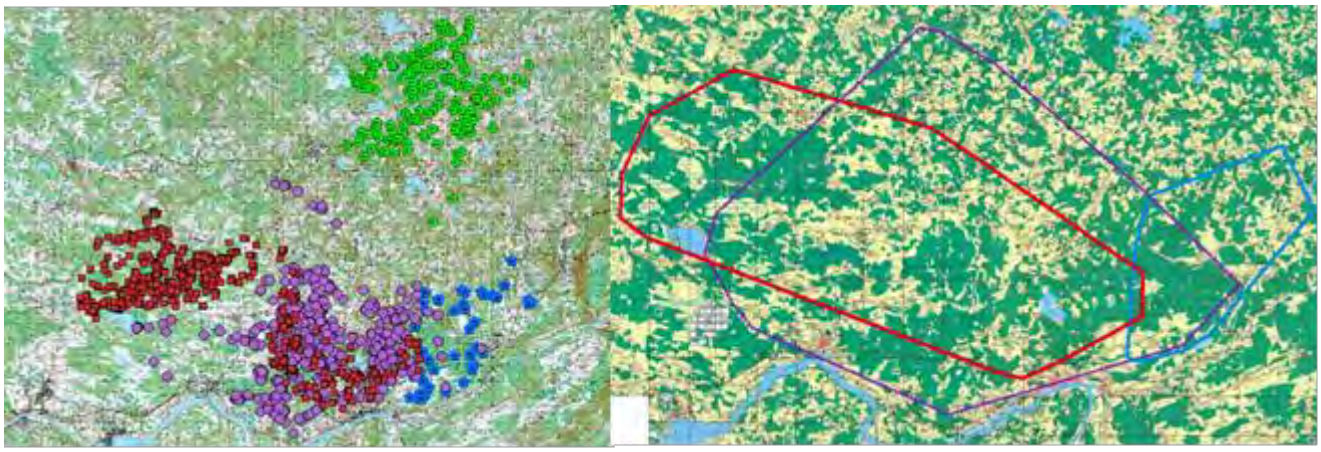


Figure 3. Habitat availability (a) and use (b) in a female lynx territory in Kurzeme (CLC data; Bērziņa 2016).

Lynx are territorial (Breitenmoser et al. 2000). The size of each individual's territory varies and depends on several factors, such as sex, age, presence of kittens to a female, nutritional conditions and season. The territories of female lynx do not overlap at all or minimally with another female's territory, whereas male territories may overlap; the territories of individuals of the opposite sex may overlap almost completely (Tauriņš 1982, Schmidt et al. 1997, Breitenmoser et al. 2000). This fact was also confirmed by the data obtained in Latvia – in Kurzeme, most of the home range of male and female lynx tracked by radio telemetry overlapped (Fig. 4; Ornicāns et al 2005, Ornicāns 2006, Ornicāns et al. 2008), in Vidzeme, the territories of tracked male lynx overlapped partly and only in spring (Fig. 5; Ornicāns and Ozoliņš 2010).

Figure 4. Individually inhabited territories and territorial overlap of male and female lynx tracked by radio telemetry in Kurzeme from 2004 to 2006 (Ornicāns 2006).



a b

Figure 5. Inhabited territories (a) for four male lynx and territorial overlap (b) for three (out of four) male lynx during spring tracked by radio- and satellite telemetry in Vidzeme (Ornicāns un Ozoliņš 2010).

Lynx live solitarily, except females with kittens. On a daily basis animal movements are within the limits of the animal's territory, the size of which depends on conditions for availability of food and suitable habitats. The area of individual territories range from 25 up to more than 4,000 km^2. Females occupy territories which are 2–3 times smaller, on average, than those of males. Territory sizes also vary seasonally. The smallest territories are occupied by females with newborn kittens. As winter approaches, female territories increase in size (Schmidt et al. 1997, Breitenmoser et al. 2000, Linnell et al. 2001, Jędrzejewski et al. 2002, Schmidt 2004, Herfindal et al. 2005, Breitenmoser-Würsten et al. 2007, Molinari – Jobin et al. 2007, Bouyer et al. 2014). According to studies in Poland, during autumn and winter male lynx occupied a territory of

approximately 165 km^2, while in summer and spring the area decreased to 140 km^2. Similar changes were observed in female territories. Female territories were approximately 94 km^2 in autumn and winter, but only 55 km^2 in spring and summer. Despite these seasonal changes the total area which the lynx inhabited did not change over the years (Schmidt et al. 1997). In Norway, 49 lynx (25 females and 24 males) were radio-tracked from 1995 to 2012. The area of female territories varied between 428 to 1978 km^2, but for males it varied from 429 to 4130 km^2 (Bouyer et al. 2014). Meanwhile, in Estonia, the territories for lynx females with kittens varied from 64 to 161.8 km^2 in winter (Männil 2007 quoted by Männil and Kont 2012), while for adult males it was from 124 to 160 km^2 from late spring to early summer (Kont et al. 2009 quoted by Männil and Kont 2012).

In Latvia, radio- and satellite-tracking data on inhabited territories have been obtained from six individual lynx – five males and one adult female (Ornicāns et al 2004, Vaiders 2007, Ornicāns et al. 2008, Ornicāns and Ozoliņš 2010). The radio-tracking results showed that the total area inhabited by the lynx female was 172 km^2, but the area of male territories varied between 136 to 308 km^2 (523–703 km^2, data obtained by satellite tracking). In Latvia, the largest area for male lynx is in spring and autumn with the smallest in summer and winter. In comparison, for females the smallest territory is in summer and the largest is in winter (Tab. 1, Figs. 6, 7).

Table 1

Changes in average area of lynx territories (km^2) depending on the season (according to Vaiders 2007, Ornicāns et al. 2008, Ornicāns un Ozoliņš 2010).

Season	Lynx					
	female Kurzeme, 2004-2006*	male Kurzeme, 2004-2006*	male Vidzeme, 2004-2006*	male Vidzeme, 2007-2008 */**	male Vidzeme, 2008**	male Vidzeme, 2009*
Winter	79	58	94	65/ 262	-	
Spring	54	107	147	74/ 372	397	
Summer	9	68	51	9/ 253	163	136
Autumn	58	74	112	70/ 200	122	
Total inhabited area	172	205	308	187/ 703	523	136

* - radio telemetry, ** - satellite telemetry

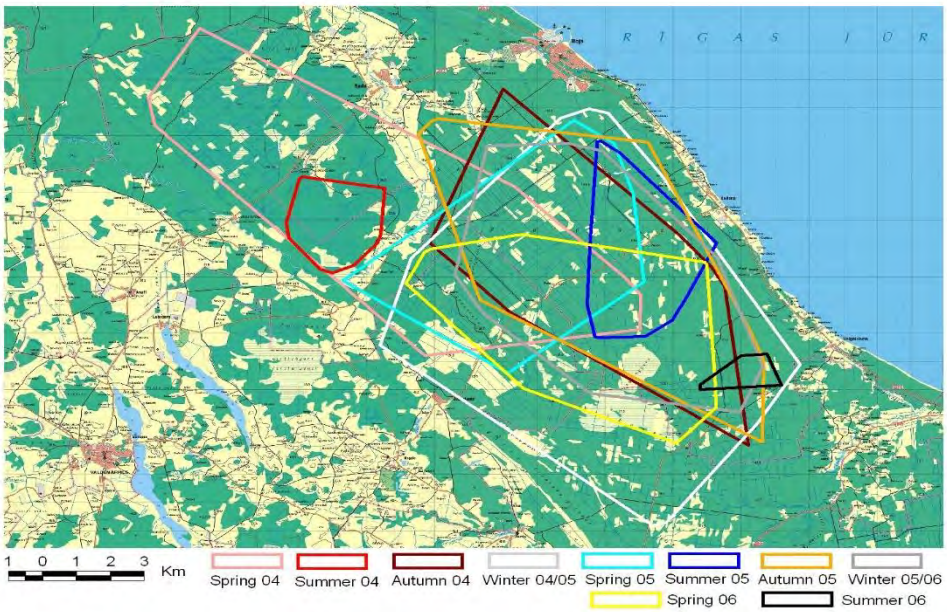


Figure 6. Seasonal changes in the territories of radio-tracked female lynx in Kurzeme during 2004 to 2006 (Ornicāns 2006).

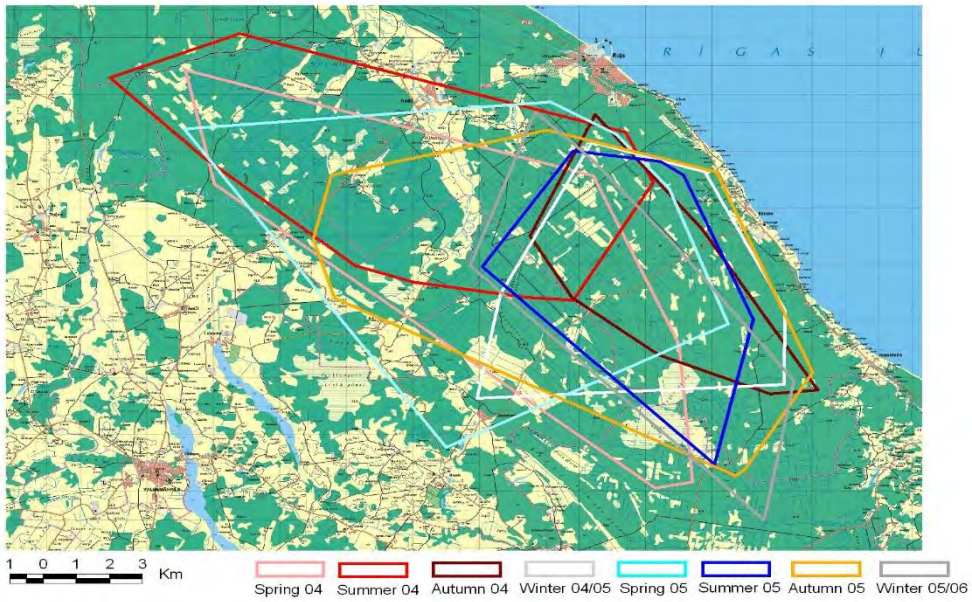


Figure 7. Seasonal changes in the territories of radio-tracked male lynx in Kurzeme during 2004 to 2006 (Ornicāns 2006).

In Latvia, lynx show two peaks in daily activity – the first late in the evening and the second early in the morning (spring and summer data). Observations on changes in lynx activity and movements throughout the year indicated that the animals show two periods of increased activity – at the end of winter and in the beginning of spring and in autumn. The activity at the end of winter and early spring is most likely associated with mating. One of the reasons for the autumn activity may be associated with hunting disturbance (driven hunts start in October), which could

cause lynx to increase movement frequency and distance. Lynx activity is also significantly affected by a variety of abiotic factors. It was found that low activity in summer was determined mainly by unfavourable abiotic factors – higher ambient temperature, amount of precipitation, and reduced atmospheric pressure. Variations in lynx activity were also determined by lunar phases – during the full moon movement activity and distance increased significantly. However, during the new moon the movement activity was two times lower than during the full moon, while variations during the waxing and waning moon phases were not particularly significant and the movement activity was moderate (Vaiders 2007).

Reproduction and demographic parameters of the population

Detailed information on changes in demographic parameters is very important for understanding the development of evolutionary strategies of living organisms and population dynamics. Qualitative demographic data provide very important information for planning species conservation and management measures, especially in hunted populations (Linnell et al. 2010, Sæther et al. 2010, Nilsen et al. 2012). In Europe, information on lynx reproduction in the wild is available from the reintroduced lynx population in the Jura Mountains (Breitenmoser-Würsten et al. 2007), lynx populations in Norway and Sweden (Kvam 1991, Nilsen et al. 2012b), Białowieża Forest (Poland and Byelorussia; Jędrzejewski et al. 1996), Estonia (Männil and Kont 2012) and Latvia (Ozoliņš et al. 2008, Bagrade et al. 2016).

The sex ratio between males and females in the lynx population is close to 1:1. A slight female predominance is usually found in hunted lynx kittens (Danilov et al. 2003, Kozlovskiy 2003). Similarly in Latvia, from 1998 to 2006, an average of 56.7% of tested lynx kittens in hunting bags were females (Ozoliņš et al. 2008), while in Estonia it was 50% (Männil and Kont 2012). The sex ratio in the population is more equal among older lynx. Latvian data also confirmed this – in the sample of individuals with a precisely defined age there was no significant difference between the sexes (Bagrade et al. 2016). In Poland, it was found that the proportion of adult males in the population was 29%, while reproductive females accounted for 23%. Kittens (offspring of the current year) comprised 35%, while subadults accounted for 12% of the population (Jędrzejewski et al. 1996). In Estonia, kittens accounted for on average 30%, subadults – 21% and adults – 49% of the animals harvested from 2006 to 2010. The proportion of females in the group of kittens and adults did not accurately reflect the population, as it is prohibited to hunt females with kittens in Estonia. Consequently, solitary lynx were predominantly hunted (Männil and Kont 2012). For lynx hunted in Latvia between 1998 and 2006, the population structure was found to be similar to that of the Polish lynx population – 33.7% for kittens, 12.4% for one-year-old lynx and 53.9% for adults (Fig. 8, Ozoliņš et al. 2008). However, differences appeared in a later study. Between 2006

and 2015 (Bagrade et al. 2016), a low proportion of one-year-old lynx were found among hunted animals (only 3.2%), while kittens accounted for 29.8% and adults 57.2% (Fig. 9). One explanation for this small number of one-year-old individuals amongst harvested lynx is that during the first year when young carnivores become independent, they are more likely to occupy inferior habitats while avoiding older individuals. These inferior habitats are associated with lower hunting intensity. In addition, subadult lynx tend to live solitarily, but hunters are more likely to detect presence of a carnivore if they are in a group. Hence young individuals are better capable of avoiding hunting. A significant difference in the proportions of sex and age classes also appears when comparing the western and eastern parts of the country, with more older males hunted in the western region.

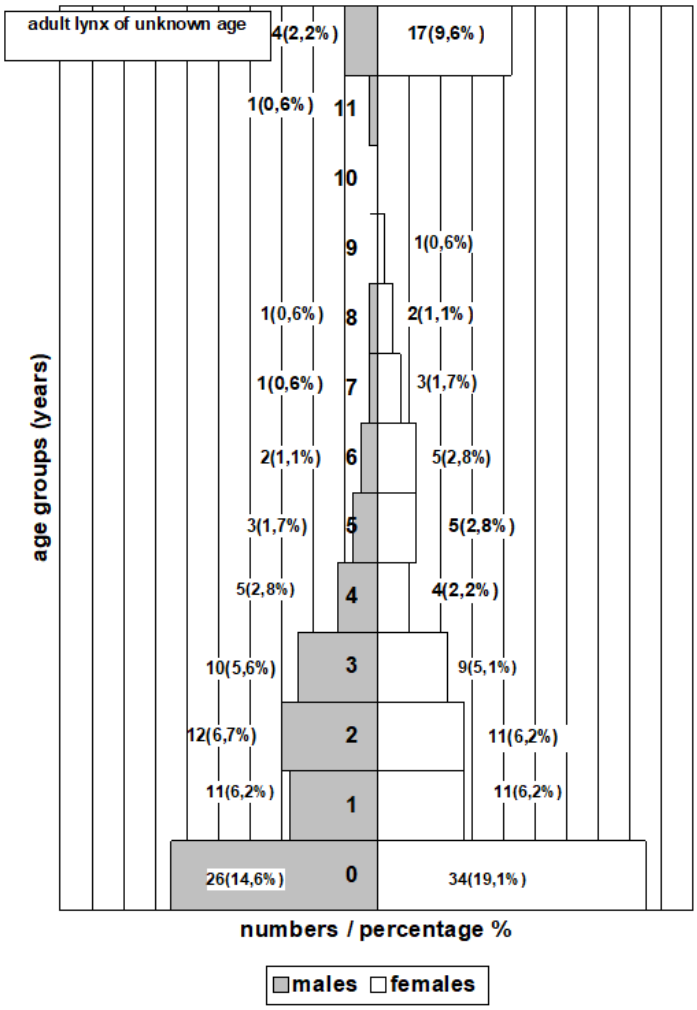


Figure 8. Sex and age structure of lynx hunted in Latvia from 1998 to 2006 (altogether 553 lynx were hunted, 178 collected for research, Ozoliņš et al. 2008).

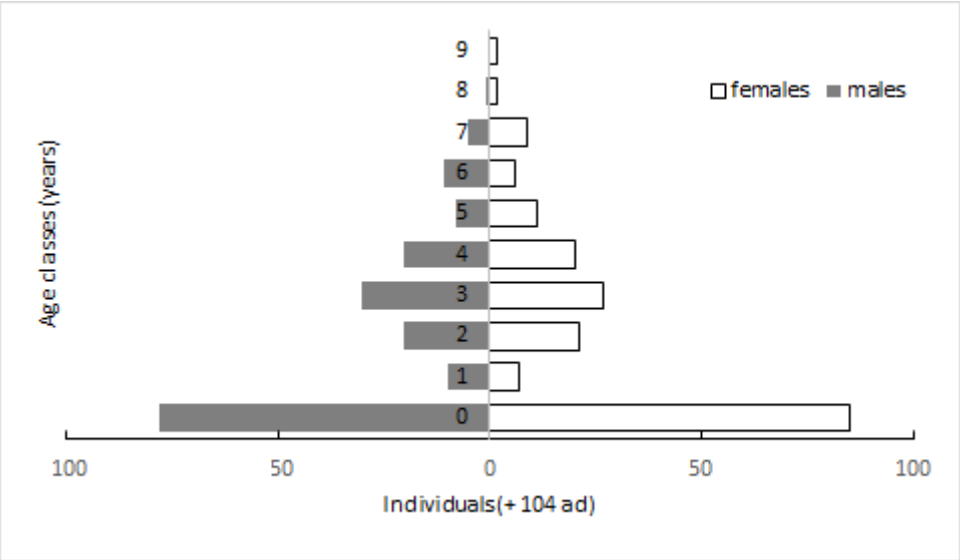


Figure 9. Sex and age structure of lynx hunted in Latvia from 2006 to 2015 (altogether 1188 lynx were hunted, 530 collected for research, brackets contain number of adult animals of unknown age, Bagrade et al. 2016).

Lynx reproduction is relatively well studied both in the wild and in captivity (von Arx et al. 2004). Mating starts at the end of February and lasts until April. During this time adult males become more active – they travel long distances without hunting and actively mark their territory with urine. In contrast to the usual solitarily habits of lynx, during the mating period, lynx behaviour changes completely and where they are abundant there are several males surrounding a female. Males fight each other. The female mates with one male only while the male, especially if it is a high-ranking animal, can mate with several females during one breeding season. If a female is not fertilised, she comes into heat again after seven days. There are known cases when females do not breed every year. Sometimes females are accompanied by subadults older than one year. Usually there are certain factors such as unfavourable environmental conditions or low population density that leaves some females unfertilised. Under normal conditions, females mate every year (Breitenmoser et al. 2000). Studies in Latvia confirm that on average 87% (Bagrade et al. 2016) to 91% (Ozoliņš et al. 2008) of adult females reproduce annually.

Pregnancy lasts 67–74 days, and kittens are usually born in May. In Latvia, there are three precisely known cases when kittens in the wild were born at the end of May (A. Ornicāns et al. unpublished data). In the wild, there may be 1–5 kittens in a litter, usually 2–3 (Breitenmoser et al. 2000, von Arx et al. 2004). In Latvia, data on the average pre-natal litter size during the two research periods was 2.3 (1998–2006; Ozoliņš et al. 2008) and 3.2 kittens (2006–2015; Bagrade et al. 2016), respectively, while the average number of kittens born to three captive females in the Riga Zoo was 1.9 (data from the Riga Zoo). There is extensive information on species breeding in

captivity as well as in other regions of the area, but in order to properly evaluate lynx fecundity it is important to take into account the method used to obtain the data (Tab. 2). It is believed that in studies of many other authors the size of the litter is determined when some of the kittens born have already died.

Table 2.

Fecundity of the Eurasian lynx according to information provided by various authors

Country of geographic region	Pre-natal fecundity (number of placental scars of embryos per female)	Post-natal fecundity* or litter size averaged during one year	Litter size in winter	Source
Estonia	-	-	1.7-2.1	Männil and Kont 2012
Latvia in wild	2.33 (1-4)	-	-	Ozoliņš et al. 2008
	3.2	-	-	Bagrade et al. 2016
in captivity	-	1.9 (1-3)	-	data from the Riga Zoo
Norway	2.5	-	-	Kvam 1991
	-	2.08-2.12	-	Nilsen et al. 2012b
Norway, Finland, Sweden, Switzerland, Czech Republic, in captivity	-	1.95 (1-4)	-	Henriksen et al. 2005
Poland	-	3.3*	1.6	Jędrzejewski et al. 1996
Switzerland (Jura Mountains)	-	2	-	Breitenmoser-Würsten et al. 2007
Caucasus	-	1.47 (1-4)	-	Kudaktin 2003
Kazakhstan	-	1.8-2.75 (1-4)	-	Zhiraykov and Baydavletov 2003
Byelorussia	-	-	1.82 (1-3)	Kozlo 2003
NW Russia in wild	-	1.73 (1-3)	1.4 (1-3)	Danilov et al. 2003, Danilov 2005
in captivity	-	2.08 (1-3)	-	
Baikal	-	1.56 (1-4)	-	Smirnov and Noskov 2003
Far East in wild	-	-	1.9-2.36 (1-3)	Darman 1990, Kutsherenko 1996 in Matyushkin et al. 2003
in captivity	-	3.2 (1-6)	-	Yudina and Yudin 1990 in Matyushkin et al. 2003
Sayan region	-	-	1.3 (1-3)	Zyryanov and Smirnov 2003
Western Siberia	-	1.5-1.9 (1-3)	-	Azarov and Shubin 2003
Yakutia	3 (2-4)	-	-	Mordosov 2003

In Latvia, the litter size was also found to be dependent on the female's age (precisely determined). Middle-aged females gave birth to a larger number of kittens than younger ones (Ozoliņš et al. 2008). In a later study for the period from 2006 to 2015, however, such a relationship

could not be established, but it was recorded that the youngest (2 and 3 years old) and the oldest (8 and 9 years old) female lynx had a higher number of placental scars than females from other age classes (Bagrade et al. 2016). A study on the reproductive performance of captive lynx confirms that the fecundity of lynx held in captivity is not higher than for lynx living in the wild (Henriksen et al. 2005). Data from the Riga Zoo indicate that a female born in 2000 has bred for 11 seasons since 2003 and had 18 kittens in total (1 to 3 kittens in a litter). Currently (2017) the animal lives in the zoo, but no longer breeds.

Kittens are born helpless, blind and weigh about 300 g. In 3–4 weeks they start venturing from the den. At the age of 3 months they already eat meat. At this point the females stop lactation. Natural mortality among young lynx is very high, almost a half of them do not reach adulthood (Jędrzejewski et al. 1996, von Arx at al. 2004, Breitenmoser-Würsten et al. 2007). In the harvested population of Latvia kitten mortality is even higher – only 18.3 – 20.2% of all kittens survive one year (Ozoliņš et al. 2008, Bagrade et al. 2016).

The female lives with the young until the next breeding season. Males become sexually mature at the age of 3 years, with 2 years for females. In the Riga Zoo, females started breeding at the age of 2–3 years (data from the Riga Zoo). Lynx can live up to 25 years in captivity (Breitenmoser et al. 2000). A 17-year-old female (born in 2000) and an 18-year-old male (born in 1999; data from the Riga Zoo) currently reside in Riga Zoo. In the wild, they do not live beyond 17 years (Breitenmoser et al. 2000, von Arx et al. 2004). The oldest lynx examined in Latvia was 11 years old (Ozoliņš et al. 2008).

Diet

Compared to other carnivores, lynx is relatively heavily dependent on the availability of suitable prey. Lynx only feeds on prey it catches itself and rarely scavenges, and its food niche is quite narrow (Breitenmoser et al. 2000). Lynx can eat any animal that it is able to catch and kill, therefore, bigger animals such as adult ungulates rarely fall prey to lynx, mainly under the conditions of deep snow or snow crust. During snow-free periods, rodents and birds play an important role in the lynx diet (Гептпер и Слудский 1972, Данилов и Русаков 1979, Jędrzejewski et al. 1993, Breitenmoser et al. 1998). V. Gaross (1994) emphasises that mountain hares used to be the main prey of lynx in the previous centuries while in the 20th century roe deer and wild boar piglets started to prevail. He also mentions some observations that indicate feeding opportunism, claiming that lynx were observed to take poultry from farms, to eat heron and black stork chicks. More unusual prey are utilised by subadult lynx, recently abandoned by their mother or whose mother died. In Latvia, the stomach of a 6-month old kitten killed by hunters was full of

the remains of a raccoon dog *Nyctereutes procyonoides*, while two other hunted lynx kittens had stomachs full of waste from a poultry farm's slaughterhouse (Fig. 10).

Figure 10. Remains of slaughtered poultry in the stomach of a lynx kitten hunted in December 2006 near Smiltene (photo by J. Ozoliņš).

Lynx in Latvia are specialized in feeding on roe deer, and they continue to feed on roe deer even when this prey is at low densities (Kawata et al. 2008). It is known that there is a long-term relationship between roe deer and lynx number/density in Latvia (Baumanis et al. 2012). In studies on lynx feeding, it has been found that 73% of the diet components contain roe deer (Valdmann et al. 2005, Žunna et al. 2011). In a 10-year study on lynx diet it has been found that in 90% of cases the diet composition contained cervids and the rest is made of other species – small rodents, beaver, hares, poultry, wild boar, raccoon dog, earthworms (Žunna et al. 2011) and weasel (Valdmann et al. 2005). One third (31%) of the examined stomachs were empty (Žunna et al. 2011). A study on diet conducted in Estonia, also involving radiotracking and track census in winter, also concluded that roe deer are the main object of lynx feeding (Valdman et al. 2005, Männil 2007, Kont et al. 2009, Kont 2010b cited by Männil and Kont 2012).

There is a large discrepancy in the information on the amount of food eaten by lynx per day. Despite their large body size, lynx consume rather little (Гептнер и Слудский 1972). In Latvian studies on lynx diet, the average weight of stomach contents was 440.5 g (max. 1370 g) (Valdmann et al. 2005; study period from 1997 to 2000) and 333.5 g (max. 1165 g) (Žunna et al. 2011; study period from 2000 to 2010). Data from the literature report that lynx consume between 1 to 1.5 kg of food per day (Данилов и Русаков 1979). According to other reports, an adult male (18–20 kg) eats 2.5–3 kg food per 24 hours in winter and, if it is very hungry, it can consume twice as much (Кучеренко 1988). Thus, on average, wild lynx consume about 2 kg meat per 24 hours (Haglund 1966 cited from Jedrzejewski et al. 1993, Okarma et al. 1997).

Like most carnivores, lynx can kill more animals than they can eat, but such cases are not typical. A more common occasion is the situation where the killed animal is only partially eaten, mainly just some blood licked or specific internal organs eaten. There are attempts to find a rational

explanation for such situations. One explanation for the bloodthirstiness of lynx is believed to be a vitamin deficiency; vitamins are synthesized in the digestive tract of herbivores, which results in the blood and liver of these animals being saturated with vitamins. The abandonment of prey may also be caused by the lynx's caution when the carnivore, having sensed the presence of a human, does not return to continue feeding (Гептнер и Слудский 1972, Леснов 1976, Гвоздев 1982).

1.3. Species distribution and population size

The lynx is considered to be a representative of the Palearctic Taiga fauna (Tauriņš 1982). Historically, lynx was found throughout the European territory (Fig. 11), but in the first decades of the 20th century lynx distribution rapidly shrank in comparison with its historical range (Fig. 12; von Arx et al. 2004). Today, due to favourable legislation and improvement of ecological conditions, large carnivores are beginning to return to many parts of Europe after centuries of persecution, although some small populations are still critically endangered (von Arx et al. 2004, Chapron et al. 2014, Boitani et al. 2015). Lynx are common in Northern and Eastern Europe and are found in 23 countries. Based on several criteria, including distribution and other geographical, ecological, political and social factors, 11 lynx populations have been recognized (Fig. 13). The Latvian lynx belong to the so-called Baltic population. For European lynx in general, the status and distribution of the species in the northern part of Europe is considerably better than in the south, with a similar situation within the Baltic population (Fig. 14).

Information and interpretations on species and population occurrence rates and range are regularly updated by collaboration of lynx specialists at the international level. After the last update (Kaczensky et al. 2013), the Baltic population comprises of about 1,600 individuals distributed throughout Estonia (49% of the Baltic population), Latvia (37%), Lithuania (3%), part of Ukraine (5%) and Poland (6%); the assessment excludes the territory of Belarus and the Russian Federation. The worst conditions for the Baltic lynx population are in the territories of Lithuania, Poland and Ukraine, where the population is fragmented. In the northern part of the region there is a connection with the Karelian population of about 1,500 individuals, with the eastern part of the Baltic population having a connection with the continuous lynx range in Russia. The Baltic population is one of the largest and most numerous in Europe.

Figure 11. Historical distribution of lynx in Europe (Breitenmoser et al. 1998).

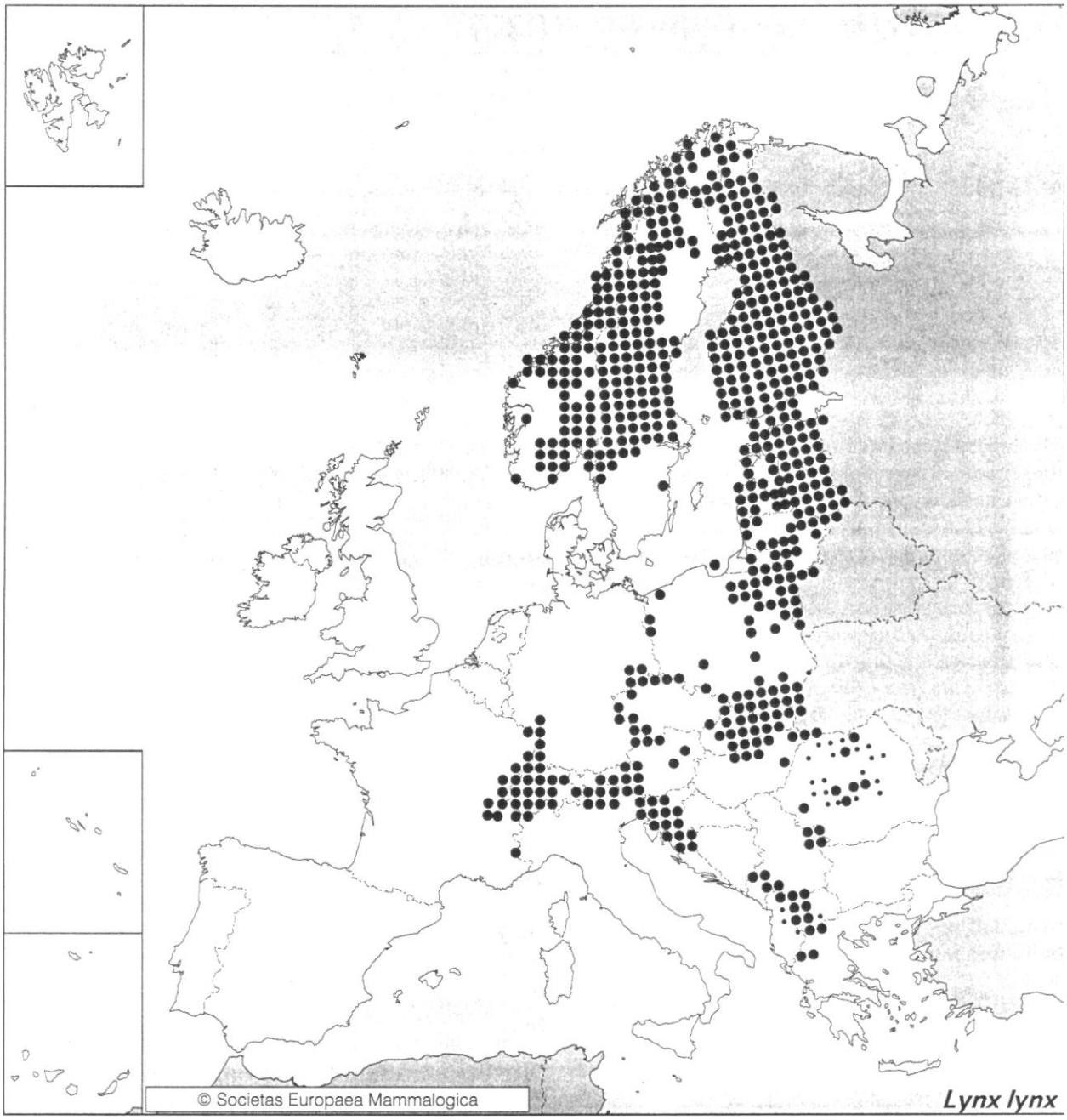


Figure 12. Lynx distribution in Europe according to 50x50 km UTM squares in the Atlas of European Mammals, excluding the CIS countries (Mitchell-Jones et al. 1999).

Figure 13. The 11 populations of lynx in Europe (Boitani et al. 2015).

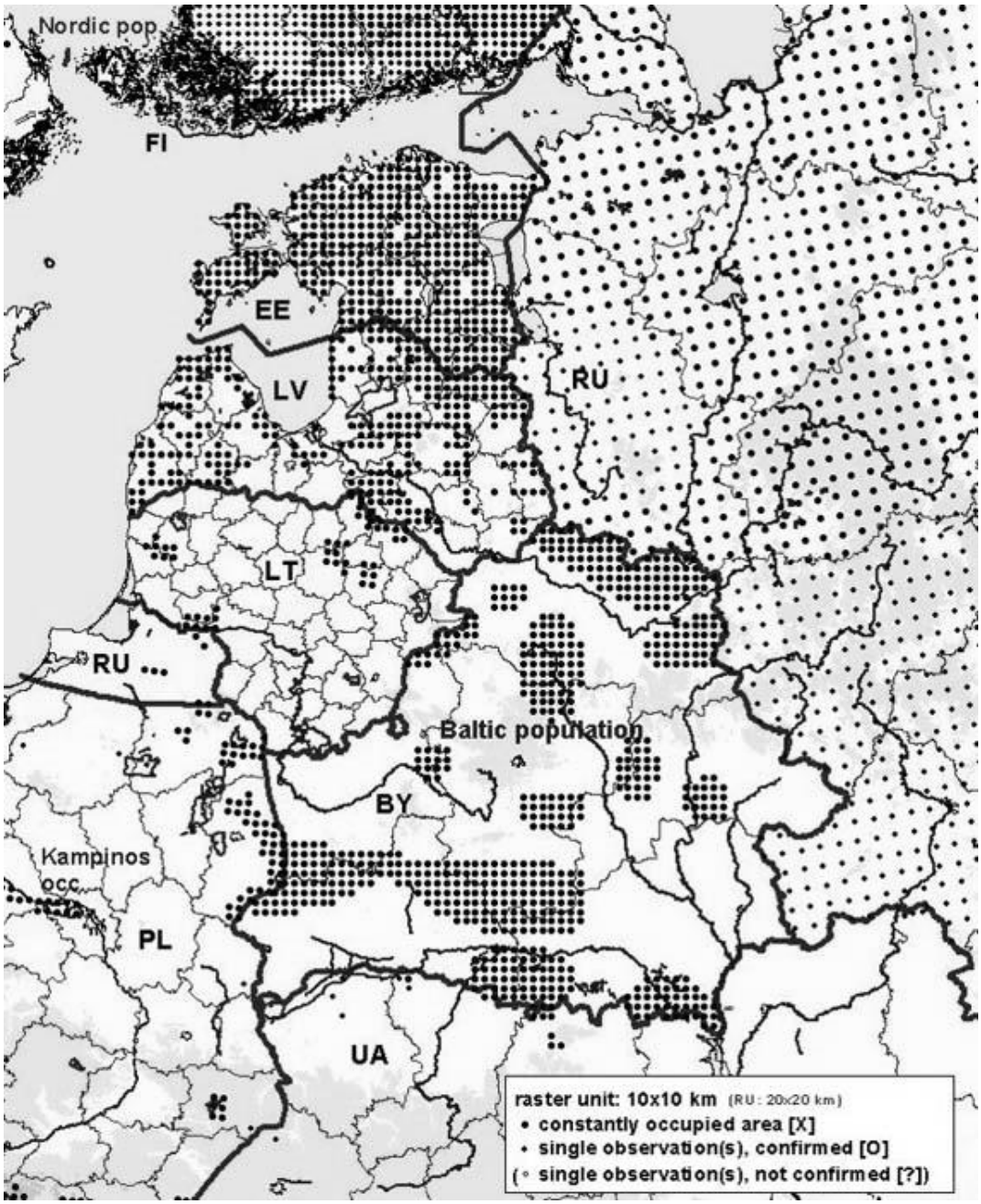


Figure 14. Lynx distribution within the Baltic population in 2001 (according to von Arx et al. 2004): the occurrence is indicated by a 10x10 km grid, the largest points signify regular occurrence, the smallest points correspond to separate observations.

In reports on Baltic and Latvian fauna, lynx have always been mentioned as a relatively rare and unevenly distributed species (Grevé 1909, Tauriņš 1982). Lynx entered the current territory of Latvia with the development of boreal forests (Mugurēvičs un Mugurēvičs 1999) and its distribution has not been uniform, however, it has constantly improved over time (Figs. 15–19).

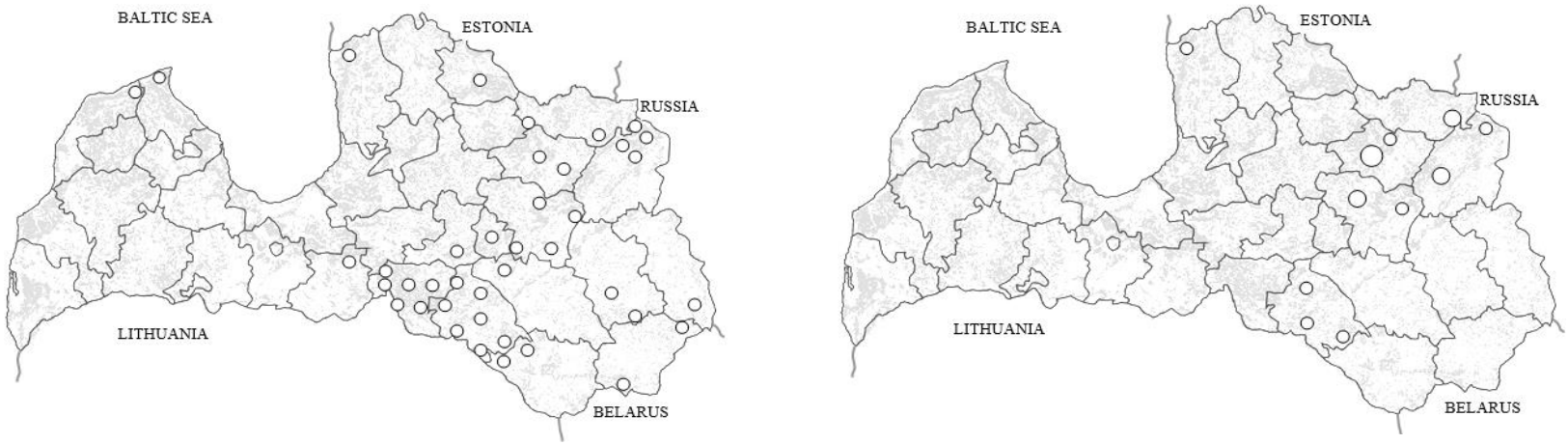


Figure 15. Lynx occurrence in Latvia in 1940 (left) and 1970 (right).

○ <10 individuals; ◯ 10–20 individuals; ◯ 20–30 individuals.

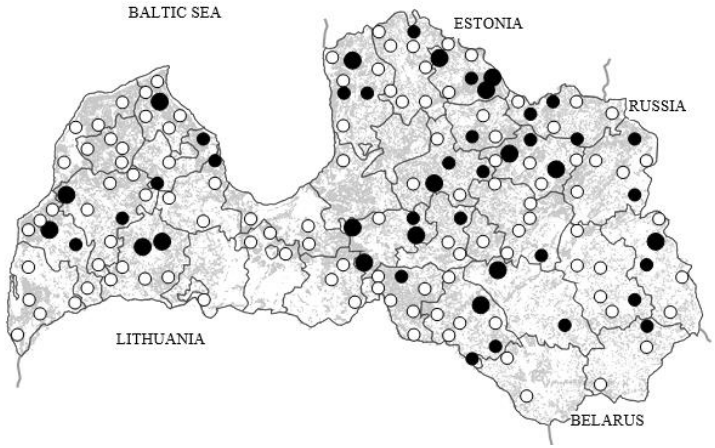


Figure 16. Lynx occurrence in Latvia in 2000: the largest black circles indicate the place where, in the season of the year 1999/2000, more than 1 lynx was hunted, the smallest black circles – 1 lynx, white circles – the lynx was registered in the forest census but not hunted (altogether 72 lynx hunted in the season 1999/2000).

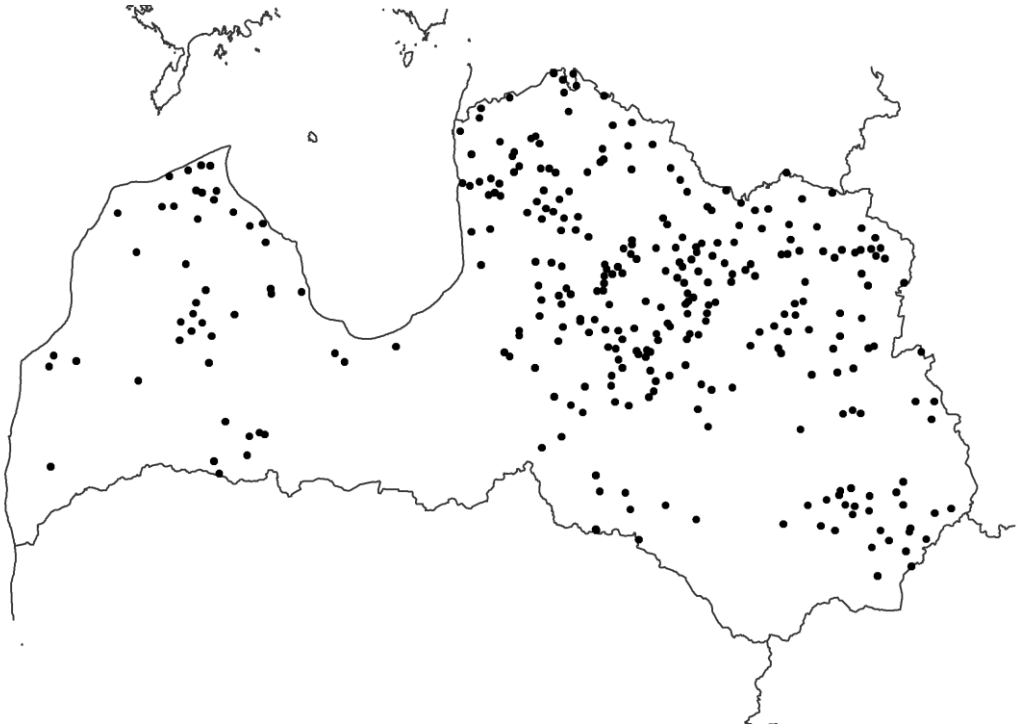


Figure 17. Distribution of fresh lynx tracks, registered during a simultaneous census throughout Latvia in March 2008, after 86 lynx were hunted in the hunting season of 2007/2008.

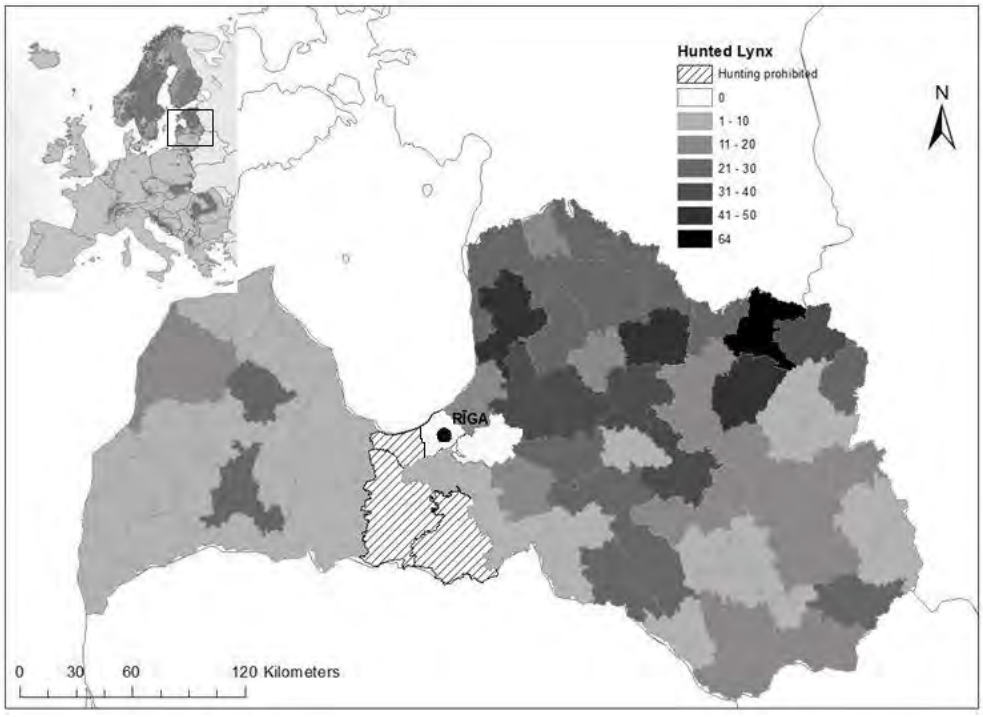


Figure 18. Number of hunted lynx from 2006 to 2015 (Bagrade et al. 2016; distribution map of lynx from LCIE 2015).

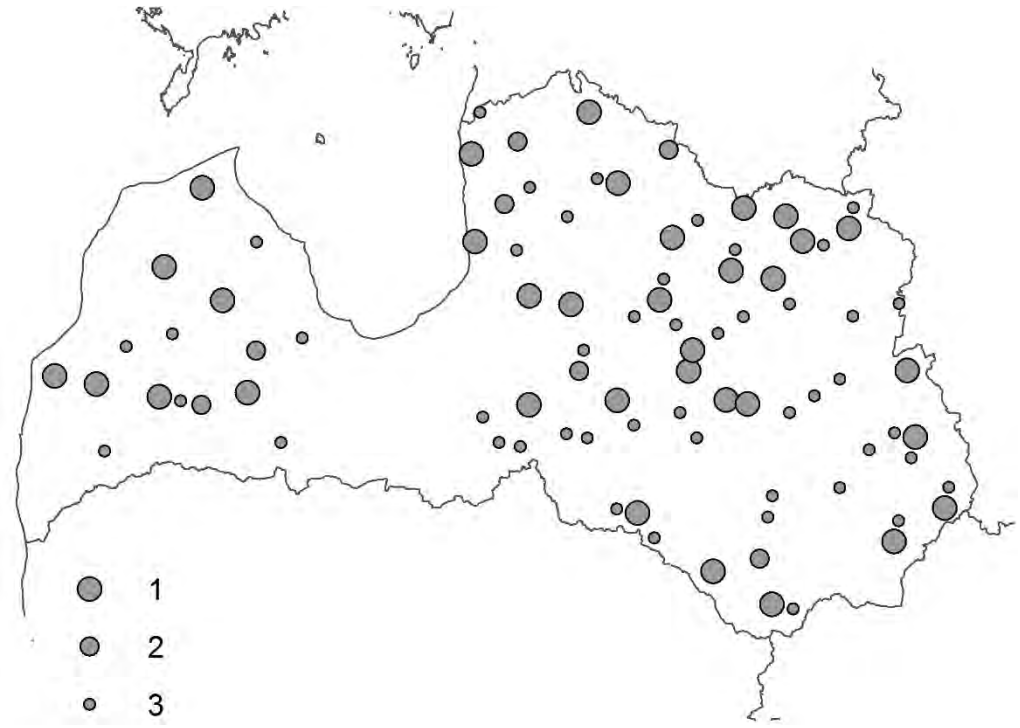


Figure 19. Distribution map of lynx after hunting results in 2012–2016.

1 – sites where hunted lynx confirm reproduction in a nearby vicinity of 100 km^2 during the last three years. 2 – sites where lynx have been hunted in at least 3 out of 5 recent years within a nearby vicinity of 100km^2, but reproduction has not been confirmed during the last three years. 3 – sites where at least one lynx has been hunted in the last 5 years, but no evidence of reproduction has been found.

The population size has increased since the beginning of the 2000s (Fig. 20). The official censuses are based on regular observations by SFS employees, giving an estimate on the number of lynx for each year by the 1st of April. Taking into account that SFS staff do not always co-ordinate the evaluation of lynx numbers, the same animals can be registered several times. Hence the total number of lynx in the country is likely to be an overestimation. However, there is no doubt that the current lynx population in Latvia is the biggest since the beginning of the 20th century.

Indirect information on lynx in the 19th century suggests that at that time there were two isolated regions of lynx distribution in Latvia – the western population in Kurzeme and the eastern population in north-eastern Vidzeme (Grevé 1909). At the beginning of the 20th century, both populations declined significantly, and in Kurzeme lynx survived only in the northern part of the region within the territory which is currently the Slītere National Park. Before the 2nd World War, lynx were only found in the north-eastern part of Latvia (Lange 1970). After the war, lynx number and distribution increased. During the 20th century, the size of the population has changed several times. Fluctuations in lynx numbers have not been as huge in comparison to changes in wolf

numbers (Andersone-Lilley and Ozoliņš 2005), but there has been a steady increase since the end of the 1960's or early 1970's (Fig. 20). The post-war period was characterised by a rapid increase in numbers of wolves and several other species, but the lynx population dynamics do not follow this trend. The decline in the number of lynx in the second half of the 1980s could be due to a high purchase price for pelts, which was doubled in 1983 by the government of the former USSR. This was subsequently followed by an increase in the proportion of hunted individuals. In recent years the population is slowly growing, although expert estimates based on the analysis of data on hunted animals and subsequent changes in population structure, are different from the official census. Although the population has increased, according to experts, no more than 600–800 lynx are found in Latvia before the start of the hunting season (Fig. 21). However, in general, the population status of lynx in Latvia currently is the most favourable that it has been in the previous 100 years (Ozoliņš et al. 2008, Bagrade et al. 2016).

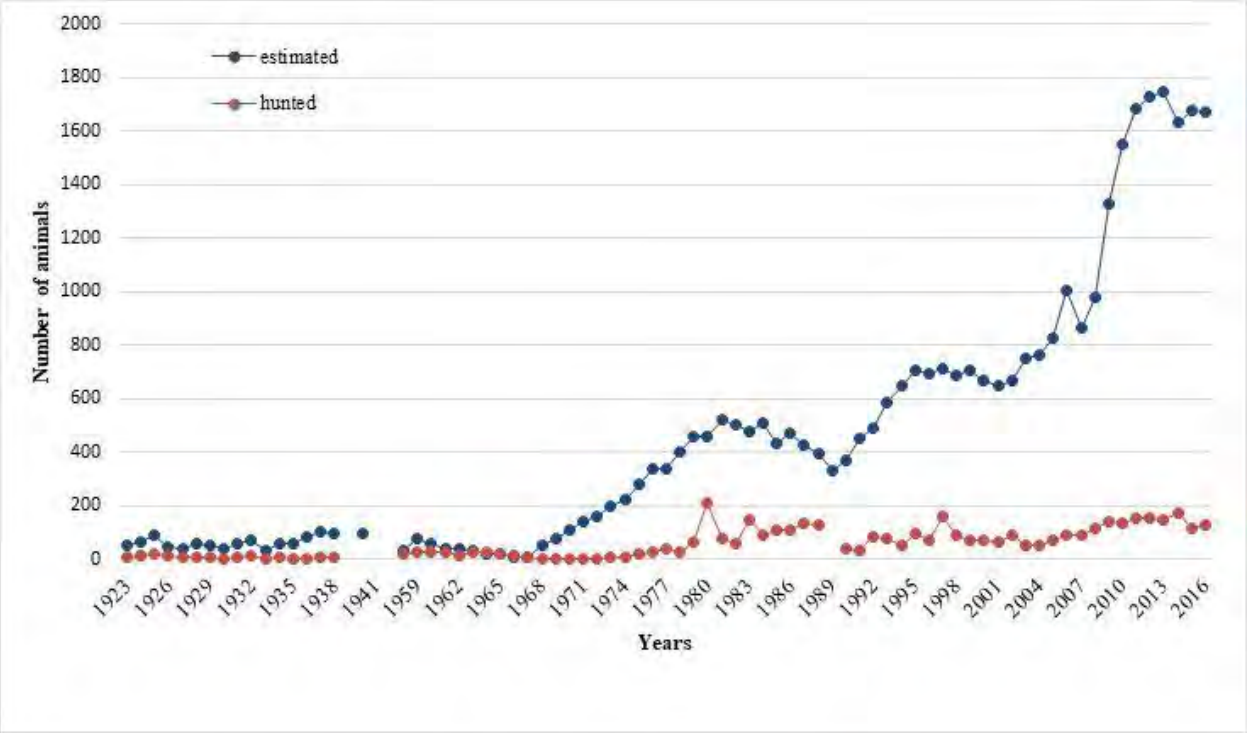


Figure 20. Population dynamics of lynx number in Latvia. No data are available for the period of the 2nd World War and following years, as well as for 1989 (SFS statistics).

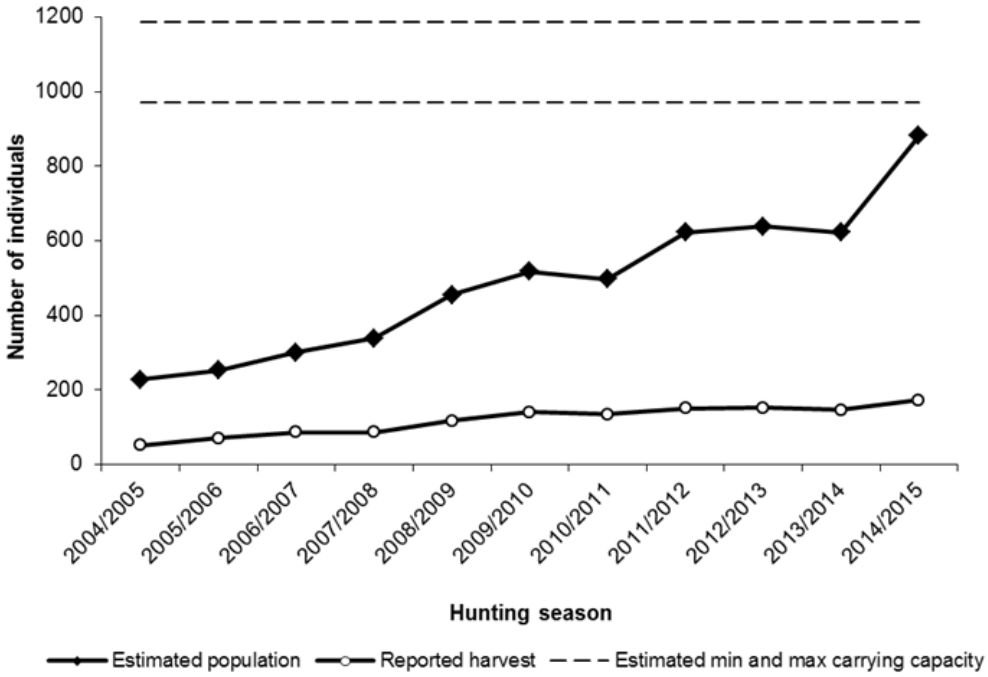


Figure 21. Estimates of lynx number according to a population reconstruction model from the age structure of hunted individuals (Fry 1949, 1957 cited from Skalski et al. 2005) in comparison to the estimated minimum and maximum carrying capacity of lynx in Latvia by Kawata 2008 (Bagrade et al. 2016).

Genetic diversity of species is one of the global priorities for species conservation (McNeely et al. 1990). Decline in genetic diversity affects the existence of populations, evolutionary potential and individual adaptability (Garner et al. 2004). Although large carnivores, including lynx, are well-studied by traditional methods, it is only recently that molecular techniques are being used to supplement biological, ecological and palaeontological knowledge. In Europe, techniques of molecular genetics have been used to study genetic diversity and differentiation of lynx populations (Hellborg et al. 2002, Breitenmoser-Würsten and Obexer-Ruff 2003, Rueness et al. 2003, Sindičić et al. 2013a, Rueness et al. 2014). Such data may reveal not only fragmentation of the population area, caused by anthropogenic factors, but also phylogenies and genetic differentiation of the species within the population (Rueness et al. 2003, 2014). Relatedness of individuals, ascertained by molecular methods, provides valuable information about population structure of the species, and the data are also valuable for analyzing species/individual breeding success, inbreeding, selection and gene flow (Sindičić et al. 2013b). Currently data on basic genetic evaluation of the Baltic lynx population are available. The first study on lynx in Latvia and Estonia (material collected at the end of the 20th century, when in both countries lynx hunting was conducted without any restrictions) showed small genetic differentiation (Hellborg et al. 2002). The highest values of genetic diversity indices (the number

of haplotypes, haplotype and nucleotide diversity) among the seven investigated populations from the north-western periphery of the species distribution range in Scandinavia to the Carpathian region were found in Latvia (and also in Estonia) (Ratkiewicz et al. 2012). Genetic investigation of the material from 2009–2014 indicated that the diversity index of the population remained high, and there are no significant differences in the genetic parameters between the western and eastern parts of the area. The data were also tested to detect a genetic bottleneck. There was no deviation in the distribution of alleles, and the occurrence (frequency) of rare alleles had not decreased. Phylogeny analysis identified 13 mother-offspring groups consisting of 59 individuals (Fig. 22) and 30 groups consisting of full or half siblings. Both groups were equally represented in the western and eastern regions of Latvia, and representatives of some groups were found in both regions. By analysing data on the geographic distance between related individuals, it is possible to evaluate the distribution of genetic material in the area. The average distance (in a straight line) between a mother and female offspring and male offspring did not differ significantly – 108±74 km and 118±69 km, respectively. There were also no significant differences in the distances travelled between the western and eastern regions. Consequently, based on the genetic parameters and kinship data, it can be concluded that currently there are no restrictions to gene flow in the area (Bagrade et al. 2016).

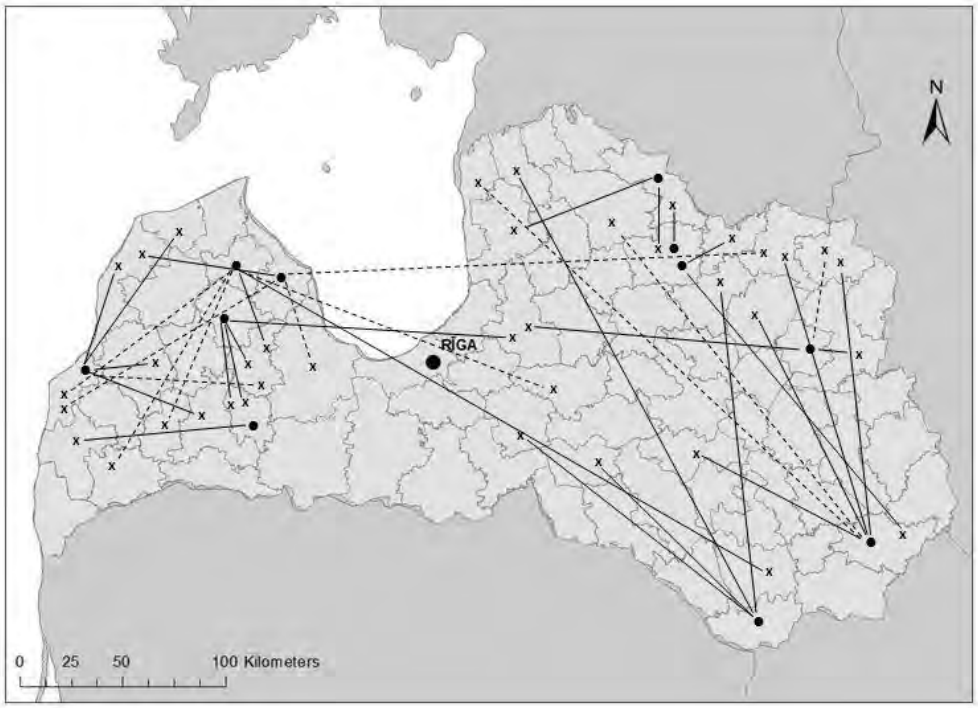


Figure 22. The location of the kinship group (mother–offspring) of lynx in Latvia. Black circle – mother, cross – offspring, continuous line – distance between mother and offspring, broken line – distance between mother and offspring, but not excluding the possibility of full or half sibling relationship (Bagrade et al. 2016).

1.4. Threats and conservation status

At the global scale, according to the International Union for Conservation of Nature (IUCN; www.iucnredlist.org) criteria, lynx have been classified as of 'Least Concern' since 2008, which means that the Eurasian lynx are not endangered in the wild. The inclusion of lynx in this category is based on its wide distribution and stable population assessment of the northern part of Europe, although some small populations are still considered to be 'Critically Endangered' or 'Endangered' in Europe (Kaczensky et al. 2013) and within most of its distribution range in Asia (Breitenmoser et al. 2015).

The species is considered threatened at the European level and is included in Annex III to the Bern Convention as well as in Annexes II and IV to the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. Upon joining the European Union, Latvia had an exception for Annex II. In accordance with the last report of Article 17 of the Directive (for 2007 to 2012), the species status (population size, distribution, suitable habitat, future prospects) is considered 'favourable' in Latvia.

In the Baltic region, the degree of species endangerment varies greatly, but in the Red Book of the Baltic region (Ingelőg et al. 1993) the lynx was recognized as rare only in the territories of Finland, Poland and the Kaliningrad Oblast. In the Baltic population, lynx is a strictly protected species except for in Estonia (included in Annex V to Council Directive 92/43/EEC) and Latvia. In general, the status and trend of the Baltic population are recognized as stable (rising in the north, stable/decreasing in the south). Species distribution patterns in the Baltic population are acknowledged to be stable, even growing in Lithuania. The Baltic lynx population is connected to the western population of the Russian Federation at the east and the Karelian population at the north, but it is fragmented in the southern and western parts of its area and most likely is no longer linked to the Carpathian population (Kaczensky et al. 2013). Action Plans for species conservation have been developed in Latvia and Estonia.

1.5. Previous research

Even though research on lynx in Latvia began only at the end of the 1990s, the species has become one of the most studied mammal species in the last few years. Prior to this, only a few cases were recorded where lynx, according to the opinion of hunting ground users, caused significant damage to game species (Gaross 1994, 1997). In 1999, the first BSc thesis on lynx was completed at the Faculty of Biology of the University of Latvia. In total, two BSc theses (Bagrade 1999, Jaunbirze 2004) and five MSc theses (Bagrade 2001, Jaunbirze 2006, Vaiders 2007,

Mihailova 2013, Bērziņa 2016) have been completed. In 2009, one PhD thesis (Bagrade 2009) was defended and another PhD thesis is currently in preparation (A. Ornicāns). More studies were conducted within a framework of projects funded by the Danish Environmental Protection Agency (1999–2000), a grant from the Latvian Council of Science (2004–2012), Fund for Hunting Development of the Ministry of Agriculture (since 2005), the Norwegian Council of Science (2003–2007) and the European Social Fund (2014–2015).

Currently in Latvia, lynx monitoring involves the collection of a portion of the annual harvest (Fig. 23) for research purposes, in order to determine sex, age, female fecundity, as well as assessing dietary components, parasitological status and relatedness structures in the lynx population (by DNA analysis). Further background monitoring is performed by the SFS. During the previous period of the Action Plan, special in-depth monitoring of the species was ensured within the framework of projects by the LSFRI "Silava" and Fund for Hunting Development of the Ministry of Agriculture. The methods used for monitoring lynx, including the methods used in Latvia (http://biodiv.daba.gov.lv/fol302307/fol634754), were summarized and published by Linnell et al. (1998).

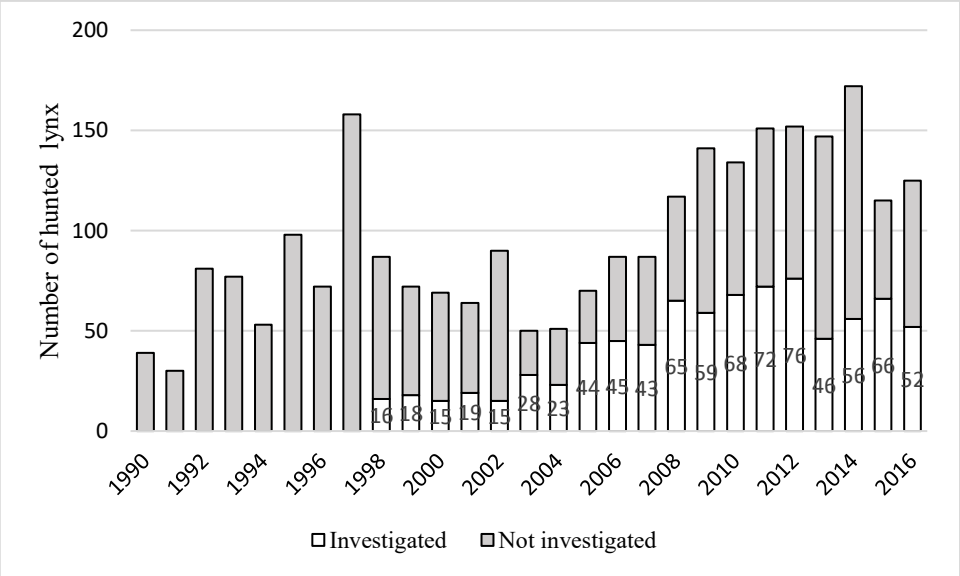


Figure 23. Number of lynx hunted and collected for examination.

In 1999, a joint project between the Estonian and Latvian Funds for Nature "Conservation planning of wolves in Estonian-Latvian cross-border region" was started in co-operation with Latvian and Estonian border guards. During two winter seasons the movements of large carnivores, including lynx, were registered on the Estonian-Latvian and Latvian-Russian borders. The study indicated that there was no intensive emigration/immigration of lynx between these

countries. Studies and data collection on lynx along the northern border of Latvia also occurred in 2003–2005 within the PIN-Matra funded project "Integrated Wetland and Forest Management in the Transborder Area of North Livonia" (Ozoliņš et al. 2005).

From 2003 to 2007, research projects on the territorial behaviour of lynx by using radio telemetry (Ornicāns et al. 2004) were initiated within the framework of a project funded by the Norwegian Council of Science in cooperation with the Norwegian Institute for Nature Research (NINA) and scientists from Estonia, Lithuania and Poland. By March 2007, radio transmitters were placed on three lynx in Latvia. Afterwards, with the support of the Fund for Hunting Development, the research was continued by using satellite telemetry, with transmitters once again being placed on three lynx (Ornicāns and Ozoliņš 2010).

Since the beginning of the 2000s, in collaboration with researchers from other countries, a study on lynx genetics was initiated in Latvia (Helborg et al. 2002, Breitenmoser-Würsten and Obexer-Ruff 2003, Schmidt et al. 2009, Ratkiewicz et al. 2012, 2014). In 2014–2015, with the project of the Human Resource Excellence for Research of the European Social Fund, establishment of a genetic monitoring system of wild species for large carnivores was launched. The first results on lynx genetic relationships were published in 2016 (Bagrade et al. 2016).

Research on lynx diet has been conducted since the end of the 1990s (Valdmann et al. 2005, Žunna et al. 2011). Studies are continuing within the framework of the species monitoring programs. Research on the parasite fauna of lynx is based primarily on parasitic worms (Bagrade et al. 2003, Deksne et al. 2016). The effect of lynx on species that constitute their dietary basis is primarily based on the relationship between the numbers of carnivores and roe deer (Kawata et al. 2008, Baumanis et al. 2012). Species dynamics, distribution and reproductive success have been published in several scientific papers (Anderson et al. 2003, Ozoliņš et al. 2008, Bagrade et al. 2016). Wider attention is paid to the evaluation of species conservation and management issues (Ozoliņš 2001, Andersone-Lilley and Ozoliņš 2005, Ozoliņš 2006, Kawata 2008, Bischof et al. 2012, Chapron et al. 2014, Ozoliņš et al. 2016).

Public opinion on lynx has been studied twice; once in 2001 (Andersone and Ozoliņš 2004) and then again in 2004 within the project "Large Carnivores in the Landscapes of Northern Europe: an Interdisciplinary Approach for Regional Species Conservation" funded by the Norwegian Council of Science (Jaunbirze 2004, 2006, Linnell et al. 2006). At the time of the Action Plan renewal, a new inquiry of public opinion was conducted (A. Žunna et al., unpublished data).

The Large Carnivore Initiative for Europe (LCIE) of the IUCN co-ordinates lynx experts from all European countries and regions. Information about projects, international co-operation and results can be obtained from the website: www.lcie.org.

The Action Plan for lynx conservation and management in Latvia has been developed and updated since 2002.

Gaps in knowledge and approach to species research

In order to assess the impact of hunting on the lynx population in Latvia and within the Baltic region more accurately, it is important to gain regular information on the annual hunting effort, i.e. how many hunters and how many days per year are devoted to hunting of lynx and other mammals, during which lynx may be hunted. There is no information about a) lynx migration between neighbouring countries, in order to assess the structure and genetic characteristics of the Baltic population; and b) interaction with other carnivores (wolves, golden jackals). It is necessary to supplement species monitoring with non-invasive methods and to ensure the comparability of species research data throughout the Baltic region. Although impact of forest fragmentation on lynx is not well understood, recommendations to manage forests conservatively and prioritize research on understanding the relationship between forests and lynx numbers should be considered (for reference see Dr. A. Bath review, comment No 5).

2. Key factors affecting species status

2.1. Factors affecting species survival

The main threats to lynx populations in Europe are:

a) a low level of tolerance of large carnivores by humans, mainly due to conflicts with hunters and livestock farmers (in northern Europe);

b) hunting;

c) reduction of available habitats due to development of infrastructure;

d) an incomplete conservation and management system and accidental death through traffic collisions (Kaczensky et al. 2013).

In the Jura Mountains in Switzerland, 70% of lynx deaths were of anthropogenic origin – traffic accidents, illegal hunting (Breitenmoser-Würsten et al. 2007). A study in Scandinavia also concluded that deaths of adult lynx mostly occur due to anthropogenic factors (Andrén et al. 2006). Low genetic diversity and small numbers of individuals may also raise concerns about some lynx

populations in Europe (Breitenmoser-Würsten and Obexer-Ruff 2003, Schmidt et al. 2011, Kaczensky et al. 2013, Sindičić et al. 2013a, b).

Hunting is the main factor limiting the lynx population in Latvia over the previous centuries. The main incentive for intensive lynx hunting in Latvia is a deep belief among hunters that lynx is their competitor for ungulates, mainly roe deer. The role of lynx in roe deer mortality, especially during deep snow conditions, is supported by scientific research (Okarma et al. 1995, 1997, Reig and Jędrzejewski 1998); however, it is not entirely proven that carnivores are the main factor shaping roe deer population density (Fig. 24). Baumanis et al. (2012) concludes that under favourable climatic conditions roe deer populations do not particularly suffer from increasing lynx numbers. Moreover, a larger number of roe deer was typically associated with a higher number of lynx, although the assertion that a greater amount of roe deer contributes to lynx breeding success was not confirmed in this analysis.

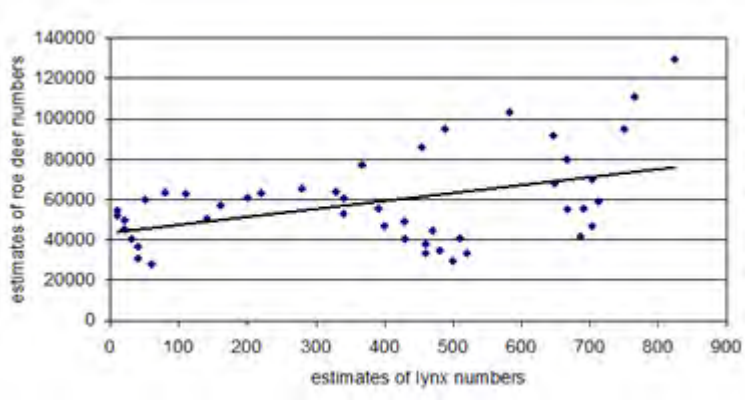


Figure 24. Positive correlation between roe deer and lynx population sizes in Latvia from 1960 to 2005 (r = 0.441, n = 46, P = 0.01; Ozoliņš et al. 2008).

There are also other arguments promoting lynx hunting (Ozoliņš et al. 2008), which are unlikely to directly influence the current number of hunted lynx:

- until 1991, trophy owners received a significant amount of money for pelts from the state;
- lynx pelts and skulls are assessed at hunting trophy exhibitions according to international standards (International Council for Game and Wildlife Conservation (CIC));
- lynx has always been a relatively rare game animal and killing one increases the status of that hunter within the hunting club;
- taxidermied lynx are sought after as decorative elements, especially in the last few years;
- lynx meat is sometimes consumed by hunters;

- foreign hunters from countries where lynx hunting is banned want to hunt lynx.

All this indicates that lynx hunting is not only a management procedure to limit carnivore populations but also a tradition in itself. To change or replace hunting traditions is much more difficult than to regulate the extent of hunting. In such a situation it is essential to choose the right arguments for restricting lynx hunting without conveying the impression that hunting traditions are endangered. Quite the opposite, hunting traditions (i.e., a wish to hunt the species in a sustainable way) can be used as a regulating instrument in lynx conservation that would reduce disagreements regarding the upper limit for the lynx population and its influence on prey populations.

Lynx hunting quotas as well as a shorter hunting season were introduced in 2003. In 2003, the hunting season commenced on the 1st of November instead of the 1st of October, while in 2004, the starting date was set on the 1st of December. In order to set the quota correctly, all available information from Latvia and other countries and regions was analysed. However, since there was a high variation of lynx harvest quotas among countries and years, not all of the examples and experience in quota setting from other countries were applicable to the situation in Latvia.

In Latvia, after more than 150 lynx were harvested in 1997 (21% of an estimated population of 700), the population increase both in the official estimates and the hunting bag suddenly came to a halt (Figs. 20, 23). Although the harvest constituted about the same proportion as the population increment in the following years, such a high hunting pressure was obviously too much for the population's renewal capacity. Monitoring shows that 1-year olds typically comprise approximately 12% of the population. 1-year old animalss act as a population reserve that can ensure rapid recovery of the population after hunting, due to the fact that in subsequent year they become a part of the reproductive nucleus of the population (especially females). When planning the first lynx quota for the 2003/2004 hunting season, the maximum acceptable limit was less than 10% of the official population estimate and exactly 10% of the expert estimate – 50 out of 500. In Estonia, it was also suggested to harvest no more than 10% of the estimated lynx population (Lõhmus 2002). A similar maximum allowable quota was also kept for the following season. This quota was reached within a very short time after the lynx hunting season was opened (Fig. 25). Comparing the situation in Latvia, Estonia and Norway, it was concluded that in Latvia lynx hunting limits are met first (Bischop et al. 2012).

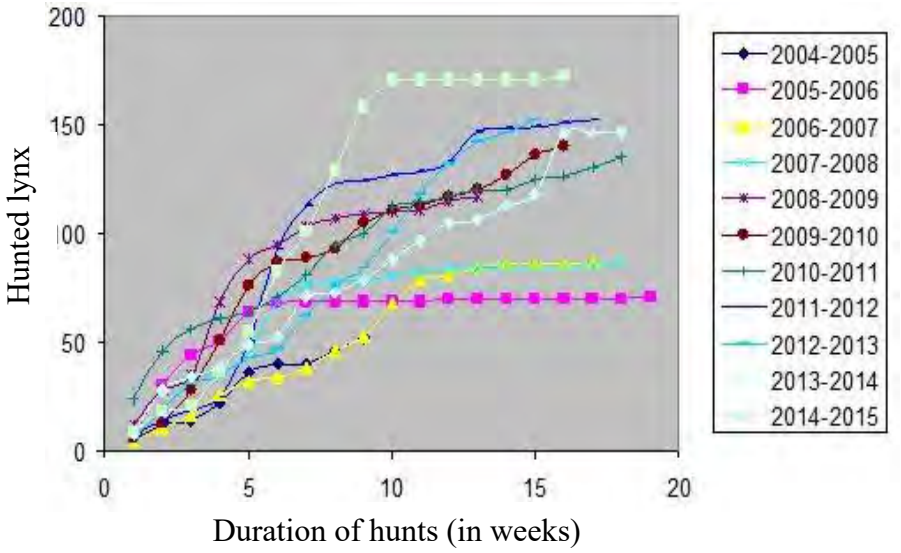


Figure 25. Lynx hunting progress from the 1st of December until the 31st of March.

The hunting season of 2006/2007 was different because a considerably higher quota was set, which, up to the 1st of February, was distributed among districts (head forestry units). In the last part of the season, lynx hunting was allowed in all districts, except for districts with low population density (i.e. in Zemgale (S Latvia) and around Riga), until the quota was reached. Moreover, in 2006/2007, it was not allowed to hunt more than 70 lynx in the eastern part of Latvia. These restrictions ensured that the lynx hunting quota was filled until February, but no hunting was reported in March. In 2010, due to critically unfavourable snow conditions for ungulates, driven hunts were banned from December until weather conditions improved.

Statistics indicate that lynx hunting is most intensive when hunting seasons for other species are open as well. Hunting for moose, red deer hinds and calves is open until the 31st of December, for red deer stags – until the 31st of January, and driven hunts are allowed until the 31st of January. During this time, lynx tracks or the animals themselves are discovered almost by chance while pursuing and hunting for ungulates.

There is a negative aspect to hunting lynx intensely early in the season. If a female is killed, then her kittens will almost certainly die as a result. Until 2003, the lynx hunting season began on the 1st of October and there was no quota set. However, at that time, the proportion of females hunted early in the season was most likely low, as lynx were mainly hunted during winter in order to obtain high quality pelts (Ozoliņš 2002). The lynx samples collected for examination also contained a very small proportion of old animals (Ozoliņš et al. 2008, Bagrade et al. 2016), which is a clear indication of high hunting pressure considering the maximum potential longevity of lynx is 17 years (Breitenmoser et al. 2000, von Arx et al. 2004).

In Estonia, hunting is also considered to be the main cause of lynx mortality. Other causes of lynx mortality not associated with hunting (traffic accidents, diseases, intraspecific competition) are detected in Estonia every year, comprising 13% on average (Männil and Kont 2012). In Finland, Norway and Switzerland, poaching is the main cause of death for adult lynx (Schmidt-Posthaus et al. 2002, Andrén et al. 2006). There are no such data in Estonia (Männil and Kont 2012) and Latvia, although in Latvia in recent decades several cases of illegal lynx killings have been discovered and their perpetrators have been prosecuted (information from SFS).

In Latvia, conflict situations between lynx and farmers are not frequent. In the period from 2004 to 2016, from 349 officially registered attacks on livestock, lynx attacks were detected in eight cases (data from SFS). A survey on large carnivores in Latvia conducted in 2017 suggests that among hunters lynx is still considered as a threat to other forest animals, in particular causing a negative impact on roe deer, hare and capercaillie populations (A. Žunna et al. unpublished data).

Theoretically in Latvia, the natural enemy of the lynx is the wolf, although bears are also mentioned (Tauriņš 1982). There are no real data on the impact of natural enemies in Latvia. Instances of infanticide, whereby a lynx male kills a sub-adult lynx could also be a factor. Such situations have been confirmed by observations in Estonia, when radio tracking revealed that the cause of death of a sub-adult lynx was an attack by another lynx (Männil and Kont 2012).

A similar situation is associated with lynx competitors. Many predators could theoretically be considered as competitors for food, including predatory birds (e.g., the goshawk), attacking mountain hares and grouse. Small carnivores (e.g., the pine marten) can be considered as lynx commensals, although feeding by other animals on lynx prey is insignificant, and lynx tend to cover excess food with snow, making it difficult for other animals to access it. Lynx and foxes are considered as antagonists by several authors. Foxes not only prey on similar species as lynx, but also often eat the remains of lynx prey, while lynx follow and kill foxes themselves (Данилов и Русаков 1970). In Estonia, fox remains are found in 7.1% of lynx stomach contents and excrements (Valdmann et al. 2005). Competition between wolf and lynx is primarily associated with feeding of wolf pups, while they are not able to participate in collective hunting, when wolves prey primarily on small and medium animals. At other times, the main prey of wolves are large ungulates, which are usually less accessible to lynx. One exception may be competition for roe deer (Данилов и Русаков 1970, Гептнер и Слудскй 1972).

Lynx diseases are poorly investigated. Lynx are reported to be able to be infected with rabies and other viral diseases and are often infected with helminths (Данилов и Русаков 1979, Breitenmoser et al. 1998), but detailed research has only been conducted in some countries. In Estonia, there are data on eight lynx rabies cases, detected from 2002 to 2006, – the last case was

registered in 2006 (Männil and Kont 2012). In Latvia, from 1984 to 2016 (data not available for 2002 –2003), six rabies cases were detected (one case in 1984, 1986, 1994, 1997, two cases in 1992; data from Food and Veterinary Service). The recorded incidence of rabies among lynx does not reflect the actual situation for the entire population, since only lynx in contact with humans are tested. Since 2010, the scabies mite *Sarcoptes scabiei* has been detected in the lynx population (Männil and Kont 2012). It was detected in Latvia in 2011 (J. Ozoliņš, unpublished data). In other parts of Europe, scabies mites were found in Switzerland, Finland, Sweden and Norway (quoted by Männil and Kont 2012).

In Latvia, systematic investigations of the helminthofauna of carnivorous animals were started in 1999. There are 12 parasite species in the Latvian lynx population, one of which is a trematode, five tapeworms, five nematodes and one unidentified nematode species (Bagrade et al. 2003, Bagrade 2009). Comparing the data from Latvia to the data of other research conducted in the Baltic States, it can be concluded that the lynx helminthofauna in the region is similar (Казлаускас и Прусайте 1976, Okarma 2000, Valdman et al. 2004, Valdman 2006).

The parasite and its host organism are in close interaction with each other. At the individual and population level, this relationship can have a very different degree of mutual influence and "benefit". The presence of parasites in wildlife is inevitable and in natural circumstances with little or no human influence, parasite-host relationships maintain the stability of parasite and their host populations. A study in Spain points to the existence of a negative correlation between the intensity of parasites and the physical condition of animals (Rodriguer and Carbonell 1998). There is evidence that, for example, the invasion of the nematode *Toxocara cati* can endanger the viability of lynx kittens (up to one year of age) in the absence of favourable living conditions (Breitenmoser et al. 1998, Schmidt-Posthaus et al. 2002). In Switzerland, the cause of death for seven out of 72 lynx casualties was related to parasitic worms (Schmidt-Posthaus et al. 2002). Data from studies in Estonia suggest that distribution and intensity of lynx helminths do not pose a threat to the population (Valdmann et al. 2004, Valdmann 2006). It can be assumed that under current management conditions of game fauna in Latvia the helminthofauna of carnivorous animals is not a limiting factor for their populations.

Many wild predators facilitate expansion of helminthoses that are dangerous to humans, livestock and other wildlife animals. One of the most dangerous parasites that occur in the lynx and is pathogenic to humans is a nematode of genus *Trichinella*. In Latvia, *T. britovi* and *T. nativa* have been found in lynx (Bagrade 2008, Deksne et al. 2016).

2.2. Factors affecting species habitat

One of the major constraints of large predators is the amount and quality of suitable habitats, with fragmentation of landscapes being one of the primary risks to large carnivores in Europe. The main barriers that restrict the movement of animals are main roads, urban and sub-urban areas and large cultivated areas. Ecological corridors can provide connections between local populations, thus ensuring gene flow and viable meta-populations (Huck et al. 2010, Kaczensky et al. 2013). In the framework of the railway infrastructure line *Rail Baltica* construction project in Latvia, an assessment has been made of the potential impact of *Rail Baltica* on the movement corridors and habitats of wild mammals. Providing wildlife (including lynx) with the opportunity to cross the *Rail Baltica* corridor will be an important mitigation measure to prevent fragmentation of populations and the possibility of a gradual disappearance in some places (more information: http://edzl.lv/, section Environmental Impact Assessment).

In Latvia, forest cover is the main factor influencing lynx numbers and distribution. Forest cover increased from the middle of the 20th century (Matīss 1987, Priedītis 1999, Tab. 3), although in the last few years the intensity of forest exploitation has increased, however there are no data suggesting that this factor would reduce habitat suitability for lynx. In general, all major woodlands are suitable for lynx in Latvia, and the distribution of animals is unlikely currently restricted by a shortage of habitats and biotopes.

Table 3.

Changes to the forested area and number of lynx in Latvia

Year	Total forest cover (ha)	Estimated number of lynx
1924	1780400	54
1929	1659200	50
1935	1747100	61
1961	2439500	40
1973	2578900	200
1983	2782300	480
2006	2950267	1006
2014	3260000	1633

(References: Kalniņš 1943, Kronītis 1987, Matīss 1987, Priedītis 1999, Strods et al. 1999, SFS data).

There is a clear correlation between the size of forested area in Latvian administrative districts and the estimated lynx number by official census, as well as between the percentage of forest cover in districts and lynx number (Ozoliņš et al. 2007). In addition, radio telemetry data

from two male lynx show that an adult male from a region with higher forest fragmentation had a bigger home range than a male from a region with a relatively continuous forest (Vaiders 2007, Ornicāns et al. 2007). There are three main areas in Latvia with a higher density of lynx – Northern Kurzeme, Northern Vidzeme and Sēlija. Maintaining the connections among these three areas is extremely important as this enables animal movement throughout the entire Baltic population, the center of which is located in Latvia. Within the territory of the Baltic population, lynx is rare and not hunted in Lithuania, Belarus, Poland, and Ukraine (National strategy 1998, Bluzma 1999, von Arx et al. 2004, Kaczensky et al. 2013). Although in most of Latvia the number of lynx is sufficient to replenish uninhabited areas, the plains of Latgale and Zemgale, which characteristically have a small proportion of forests, potentially impede the migration of animals in Latvia between the east and the west, and for the entire Baltic population between the north and the south. In turn, a Baltic-scale lynx distribution corridor serves a practically evenly populated zone from the north-east county of Alūksne to the southern part of Aizkraukle, Aknīste and Viesīte counties at the Lithuanian border area. Lynx also inhabit the forested area in northern Lithuania across the border (Fig. 14). A study in Poland suggests that there are less suitable habitats in the area for lynx than for wolves, and concluded that habitats suitable for lynx are also suitable for wolf, but that the reverse scenario is less applicable (Huck et al. 2010).

3. The present conservation of the species, the effectiveness of the actions

3.1. Legislation

International obligations:

Convention on Biological Diversity (Rio, 1992). Latvia took part in signing the document and ratified it in 1995. Rather than containing any species lists or annexes, it provides general guidelines on the conservation of biological diversity, research and public awareness, which the parties within the agreement follow according to their capabilities and needs. The Eurasian lynx is listed under Article 8 *In-situ Conservation*. Its enforcement in Latvia is implemented by the Law *On the Convention on Biological Diversity (Rio, 5 June 1992)* (adopted on the 31st of August 1995, enforced since the 8th of September 1995).

Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979). Lynx is listed under Annex III *Protected fauna species*. This means that governments that have signed this convention should organise management of the species with certain limitations (closed season, types of hunting) as well as regulating trade of animals and their body parts. Its enforcement in Latvia is implemented by the Law *On the Convention on the Conservation of*

European Wildlife and Natural Habitats (Bern, 1979) (adopted on the 17th of December 1996, enforced since the 3rd of January 1997).

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Washington, 1973, in force since the 1st of July 1975). Lynx is listed under Appendix II as potentially threatened. This means that international trade with lynx is limited and may only occur under strict control. Its enforcement in Latvia is implemented by the Law *On the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973)*, adopted on the 17th of December 1996, enforced since the 3rd of January 1997, and by European Council regulations, which are directly enforced in Latvia.

The lynx is included in Annex A of the Council's Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein, and its actual redaction, while updating the Action Plan for this species in Latvia, is determined by the Commission Regulation (EU) No 2016/2029 amending Council Regulation (EC) No 338/97 on the protection of species of wild fauna and flora by regulating trade therein. This regulation decrees a strict process, implemented by a system of special permits and certificates, on how individual lynx or their products can be imported or exported to or from the European Community and used within the borders of the European Community. It also regulates species' exploitation in local trade.

The European Council's Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. Lynx is listed under Annex II (lynx habitats have to be designated as strictly protected areas) and Annex IV (need of strict protection). Upon joining the European Union on the 1st of May 2004, Latvia got an exemption from Annex II – there is no need to designate specially protected areas for lynx conservation in Latvia. The Directive's claims are implemented by all national legislation (laws, regulations issued by the Cabinet of Ministers, decisions of responsible institutions, decrees) concerning conservation and exploitation of wild species and natural habitats. Limited exploitation of lynx in Latvia occurs in accordance with Article 16, which allows exemptions, which in turn are included in the Action Plan.

The role of international obligations in securing legislation:

International obligations, which the state has undertaken during the previous 20 years, play a substantial role in maintaining a species' favourable conservation status. There are additional recent requirements not covered by legal acts. These requirements are related to population recovery, preservation of current status or sustainable exploitation in situations where one biological population extends over the borders of two or more countries. The Baltic population of Eurasian lynx meets such conditions. Scientists and species conservation experts have

developed conceptual guidelines, which meet the requirements of international obligations as well as enhance collaboration between countries in practical population level conservation and management of large carnivores (Linnell et al. 2008, Boitani et al. 2015). They serve as explanatory and recommendatory documents for the achievement and conservation of a favourable lynx population status. Compliance with the guidelines will depend on the future ability of the Member States to cooperate at the international level and the desire to reconcile their national interests with the requirements of species conservation. The documents will also serve as a basis for assessing good practices in the management of large carnivores, including lynx.

National legislation:

In Latvia, according to the Law on the Conservation of Species and Biotopes (16/03/2000, latest amendments 08/10/2015) and Annex 2 of the Regulation No. 396 *List of the Specially Protected Species and the Specially Protected Species Whose Use is Limited* (Cabinet of Ministers, 14/11/2000), the lynx is classified as a specially protected species whose use is limited.

The Law on Animal Conservation (09/12/1999, latest amendments 15/06/2017) permits the killing of lynx as a game animal in cases specified by law, but forbids cruel treatment of animals of all species as well as purchase, keeping in captivity, confiscation, offering for trade, keeping for sale or exchange, of carnivores, except for zoos and registered wildlife breeding sites.

Exploitation of lynx occurs in accordance with the Hunting Law (08/07/2003, latest amendments 26/11/2015) and according to Regulation No 421 *Hunting Regulations* (Cabinet of Ministers, 22/07/2014, latest amendments 08/09/2016), lynx is listed among game animals. Lynx hunting is allowed from the 1st of December until the 31st of March in accordance with the quota set by the SFS. These regulations also determine the procedures for handling dead lynx, if the cause of death is not hunting.

The fines for illegal killing of lynx are 5 minimum wages if the killing occured during the hunting season or 10 minimum wages if it occured during the closed season according to Regulation No. 1482 *Compensation of Losses Incurred via Breaking Hunting Jurisdiction as well as Compensation for the Illegal Game Products* (Cabinet of Ministers, 17/12/2013).

In turn, if the lynx has caused damage to agriculture (damage to livestock), the amount of damages is determined by the Hunting Coordination Committee, which is organized by the municipality of the relevant territory. The procedures of this process are laid down by Regulation No. 269 *Regulations on Hunting Coordination Committees and Determination of Damages Caused by Game Animals* (Cabinet of Ministers, 26/05/2014). Compensation, if protective

measures have been enacted, is the responsibility of the user of the hunting rights in accordance with the Hunting Law.

In accordance with Regulation No. 1055 *Regulations for the list of animal and plant species of importance in the European Community requiring protection and the list of individuals of animals and plants that may be subject to conditions of restricted exploitation in the wild* (Cabinet of Ministers, 15/09/2009), issued according to the Paragraphs 15 and 16 of Article 4 of the Law on the Conservation of Species and Biotopes, lynx is listed among animal and plant species of importance to the European Community which require protection.

The procedure for international trade, storage, registration, capture, marking, marketing and certificate issuance of lynx is determined by Regulation No. 1139 *Procedure for the storage, registration, keeping in captivity, marking, trade and certificate issuance for international trade of endangered species* (Cabinet of Ministers, 06/10/2009).

Application of Latvian legislation in species protection and management

The legal protection of lynx in national legislation provides for practically all aspects related to maintaining a favourable species conservation status:

- Population status assessment;
- Exploitation in limited amounts and strictly defined circumstances;
- Procedures concerning individuals that have been accidentally killed or found dead;
- Keeping and breeding conditions in captivity;
- Trade, import/export, storage and transportation of individuals and products;
- Penalties for unlawful killing;
- Liability for damage to agriculture, and procedures for determining the extent thereof.

The hunting regulations, indicating that lynx is a game animal, provide for actions that are compatible with the status of a species of importance in the European Community that requires protection. However, in deciding on lynx protection and management, the responsible authorities must follow a large number of legal documents with a complex delegation structure and a reciprocal hierarchy. As a result, there is a risk that, when making amendments and additions to legislation, as well as in individual cases and non-standard situations there are increasing difficulties in complying with legal protection requirements in the administrative process. Past practices indicate a number of risks.

In one case, an enquiry was made about the possibility of keeping lynx in in a restricted area in circumstances similar to the wild (SFS, pers. com.), and the SFS is entitled to issue an authorization for the keeping of game animals in registered fenced areas without coming into

conflict with the Law on Animal Conservation. However, in this situation, the regulation on the CITES species is binding, which is monitored by the Nature Conservation Agency (NCA).

The SFS, pursuant to the requirements of Section 2 of Article 20 of the Hunting Law, and using the methodology specified in Section 3 of Article 20 of this Law, is not able to conduct an assessment of the lynx population status and apply this assessment appropriately to determine the maximum allowable hunting quota, while, in accordance with the methodology for the assessment of the condition of game animals and the determination of the permissible hunting quota, approved by the Ministry of Agriculture (02/27/2014) in accordance with Section 3 of Article 20 of the Hunting Law, there is a lack of guidelines for setting a quota for lynx hunting.

In the case of damage to agriculture (livestock) by game animals, the owner of the land or the user of the hunting rights if they have been transferred to another person by agreement is liable for damage. Evaluation of the damage amount is conducted by the Hunting Coordination Committees, which are coordinated by the relevant municipality. For damage prevention, the SFS is entitled to issue permits for hunting of limited game animals outside of the specified hunting period and the maximum allowable hunting quota. Such a regulation in the case of damage to livestock leads to contradictions arising from the concurrent status of lynx as a game animal and a specially protected species. According to the Hunting Law, users of hunting rights are responsible for damage. If the sufferer of the loss himself is a user of hunting rights, compensation is not even theoretically possible, moreover, in the case of other game species (not specially protected species), users of hunting rights have greater opportunity to engage in the determination of the maximum allowable hunting quota through the municipal Hunting Coordination Committees and to regulate population density in such a way that damages are not incurred. The individual territory of a single lynx, which varies from 100 to 500 km² depending on the sex of the individual and season, includes many land properties, where in turn hunting rights may belong to many physical or legal persons. If the lynx causes damage to one property, the determination of the responsible user of hunting rights is not possible, because the lynx inhabits a much wider area. Moreover, the lynx is protected by the state, which restricts the ability to control their number compared to other game mammals that cause damage, such as red deer or wild boar. In the case of lynx, the priority is to maintain a favourable species conservation status, which influences the scale of hunting, the hunting season and techniques. The loss is assessed only if adequate protective measures are taken in the site of damage. An effective but not absolute protection measure against large carnivores is an electric fence, rather than separate electric wires, which are sometimes used by livestock farmers in Latvia. Lynx attacks on livestock are extremely rare and, if there are no other carnivores in the area, fence costs compared to the risk of damage are disproportionate. Such a regulation can

lead to farmers' dissatisfaction with the requirements of species conservation, when their implementation impedes their business and places different stakeholder groups in unequal situations. Not implementing livestock protection measures can also adversely affect the carnivore species, since access to uncharacteristic food sources changes the behaviour of animals and their role in ecological processes.

As a result, it should be acknowledged that in the area of legal protection, specific guidelines for the management of lynx and other carnivores would be useful, which would facilitate the adoption of administrative decisions and the application of future legislative initiatives.

3.2. The role of specially protected nature areas and micro-reserves in species conservation

Lynx are found in many specially protected nature areas (SPNAs), but specific conservation measures are not implemented. In some cases only prohibitions or restrictions on hunting or supplementary animal feeding intended to reduce the overall disturbance of the site are enacted. Nevertheless, the SPNAs have a major role in protecting habitats for large carnivores, including lynx. In addition to other natural values, these territories contain a higher proportion of environmental structures suitable for hiding places and dens – landslides, steep slopes, wetland shorelines etc. Hunting is allowed in most SPNAs that have developed nature conservation plans and individual conservation and exploitation regulations. Hunting of large carnivores, including lynx, is prohibited in Krustkalni Nature Reserve (NR) and Teiči NR. Hunting is prohibited in the nature reserve areas of Gauja National Park (NP) and nature reserve areas and hunting restriction grounds of Ķemeri NP, but in the rest of areas of both NPs, lynx hunting is permitted only in the case of an outbreak or spread of epizootic diseases or if lynx cause significant damage to livestock and wildlife. In such circumstances lynx may be hunted in the landscape protection area of Slītere NP, but not in the nature reserve area. In the severe regime zone of Restricted Area (RA) "Jaunanna", the hunting of wild carnivores with beaters (driven hunt) is forbidden from the 1st of March to the 31st of August. In the controlled regime zone of RA "Ovīši", hunting is prohibited from the 1st of February to the 1st of August. In the nature reserve area of RA "Vecumu meži", hunting is prohibited from the 1st of May to the 15th of August.

Hunting prohibitions and restrictions usually do not apply to the entire specially protected area, but to one of the functional zones. In general, most of the lynx population in Latvia lives outside the SPNAs and micro-reserves, and their individual territories are much wider. Therefore, there is no reason to believe that additional protection of lynx habitats would be necessary in order to maintain a favourable conservation status of the population.

3.3. Previous species conservation actions and measures

The Action Plan for lynx, which was first developed and approved in Latvia in 2002 by the order of the Minister of the Environment, confirmed that exceptions to the species exploitation complies with the provisions of Article 16 of the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora – lynx are obtained without affecting the favourable condition of the population under strict surveillance, selectively and in limited quantities (Guidance document on the strict protection of animal species under the Habitats Directive 92/43/EEC). According to this Action Plan, the conservation of lynx in Latvia also includes strictly limited hunting, because they have always been hunted and currently their distribution is the most extensive, compared to the previous 100 years. Moreover, the population range and lynx habitats substantially exceed the total area of Natura 2000 sites. A complete hunting ban in such a situation would create unpredictable consequences in public attitude towards the protection of lynx and wildlife, which could in turn also lead to an unpredictable impact on the species status. Representatives of stakeholders and the authorities responsible for lynx conservation and management, who were invited to a joint meeting on the renewal of the Action Plan for the Eurasian lynx on the 17th of January 2017, were involved in the evaluation of the actions and measures recommended by the previous Action Plan. The evaluation was carried out by 35 persons who were asked to evaluate each of the previous planned activities of Action Plan in a 10-point scale, taking into account their current utility and accomplishments, and the need to maintain them in the renewed Action Plan. It was also possible to use a negative score (-1) if the evaluator did not support the activity at all. The results were summarised and an average rating was calculated for each activity (Fig. 26). Monitoring of the population status as well as promoting research results and rising awareness received the highest evaluation of the accomplishments and the greatest support for continuation. The planning of amendments regarding large carnivores to the Regulations of the Cabinet of Ministers on the calculation of losses for agriculture caused by game animals received the lowest rating. This activity has not been initiated and is an important component of the Action Plan. In general, it can be concluded that all activities receive a high level of support as their average score exceeds 5 points. Activities that have not been fully implemented so far were also positively rated, which can be explained as the view that these measures should be implemented as soon as sufficient funding and capability for their implementation is available.

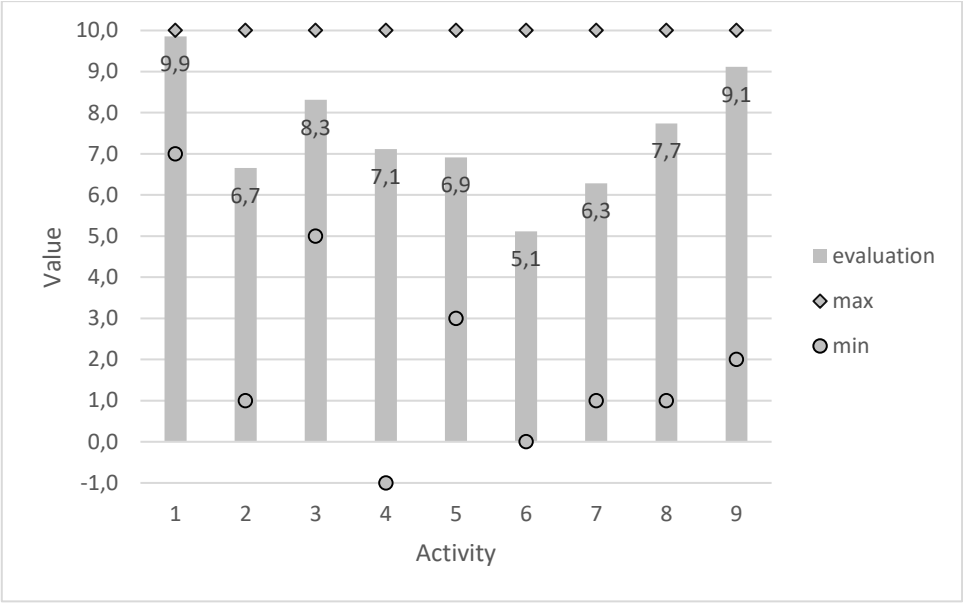


Figure 26. Evaluation of lynx conservation and management activities by the 35 representatives of the responsible institutions and stakeholders. List of activities as numbered in the graph:

1. Monitoring of population status
2. Inspections of taxidermy and pelt workshops
3. Diet studies and assessment of lynx impact on prey populations
4. Continuation of the telemetry project and data analysis with the aim to find out about lynx habitat use
5. Anonymous hunters' survey about lynx number, non-registered lynx deaths and attitude towards the control system of lynx hunting
6. Amendments in the Regulations of the Cabinet of Ministers on calculating losses caused by game species to agriculture
7. Introduction of a more user-friendly and fault-resistant system for reporting hunted and dead lynx
8. Workshops (for experts) on lynx (large carnivore) conservation status in the country
9. Promoting research results and raising awareness

Among other Action Plans for species conservation and management developed in Latvia, the Action Plan for the lynx is closely linked to the Action Plan for the grey wolf (*Canis lupus*) (Ozoliņš et al. 2008) in terms of the content and implementation of the necessary measures. In the Action Plans for other species and habitats in Latvia, measures for lynx conservation and population management are not included.

4. Assessment of the requirements and capabilities for species conservation

Lynx require large individual territories, and sometimes they move long distances in a short period of time. The territory of a single state and the NATURA 2000 network created within the EU, which consists mainly of relatively small protected areas, is not ample enough that

countries could maintain a sufficiently large part of the population independently of each other. Therefore measures for population monitoring, conservation and exploitation should also be coordinated at the regional cross-border level. Failure to do so and deterioration of population status in one country will endanger the species throughout the region.

Within the Baltics there is a lack of a unified system which would allow for comparable data on the situation of the Baltic populations at a regional scale, especially in light of recent events whereby hunting intensity increased in Latvia more than in Estonia, but there are no data on killed lynx in Lithuania.

The Institute of Applied Ecology in Rome, with the involvement of experts from the LCIE, has developed an action plan and submitted a technical report to the European Commission (Boitani et al. 2015), which lists and prioritises the activities required to ensure the conservation of carnivores at the European scale and at the level of populations. The report is based on the latest available information, collegially involving experts from all the European countries and regions. In this document, 11 crucial tasks up to 2020 have been set for the protection of large carnivores, including lynx. It is expected that most of these tasks will not lose their relevance in Latvia after this period.

Cross cutting actions – across species and populations:

1. Preventing habitat fragmentation and reducing disturbance associated with infrastructure development.
2. Reducing large carnivore depredation on livestock.
3. Integrating large carnivore management needs into wildlife and forest management structures.
4. Evaluating social and economic impacts of large carnivores.
5. Improved transboundary coordination of large carnivore management.
6. Standardisation of monitoring procedures.
7. Managing free-ranging and feral dogs to reduce hybridisation with wolves and other conflicts (this also affects lynxes, especially kittens and young animals [authors'coment]).
8. Law enforcement with respect to illegal killing of large carnivores.
9. Genetic reinforcement of small populations of lynx and bears.
10. Institutional capacity-building in wildlife management agencies.
11. Developing best practice for large carnivore based ecotourism.

This report mentions six specific actions for all lynx populations in Europe – to elaborate and implement:

1. Population-level and national management plans.
2. Intra- and inter-population connectivity and fragmentation.

3. Standardised, robust quantitative monitoring of lynx populations.
4. Health monitoring and genetic reinforcement of small, inbred populations.
5. Habitat conservation and environmental impact assessments.

As well as to

6. Integrate lynx predation impact into wildlife management practise.

In addition, specific actions are defined for each of the lynx populations, taking into account the status of the particular population and the factors influencing it. For the Baltic lynx population, two measures are essential:

1. Establishment of an international working group for large carnivore management in the Baltic region.

The need for such action is determined by the sharp differences in the political, economic and legal systems within the countries of the region, because the formal cooperation agreements among the countries currently do not provide for sufficiently rapid responses to changes at the population level and for flexible adaptations of management measures at the national scale. At least one researcher and one specialist from a decision making authority from each country, should be included in the working group.

2. Increased surveillance of trade with lynx trophies.

The need for this action is associated with different regulations on species exploitation and conservation within the area of a single population with free movement of citizens within the EU and the economic zone of the European Community.

The most predictable factor hindering the implementation of both tasks is the constant problems of maintaining contacts with the responsible officials of Belarus and the Russian Federation.

Support for conservation measures within Latvian society has been evaluated by a survey. The survey was conducted within the framework of this project of the Action Plan renewal, distributing 1,000 questionnaires among families of Latvian residents in accordance with repeatedly used methods (Andersone and Ozoliņš 2004). The questionnaire was also electronically distributed among hunters, involving hunting organizations (Latvian Hunters Society, Latvian Hunters Association), and the editorial personnel of the magazine “Hunting, Fishing, Nature” in selection of recipients. The electronic questionnaire was also sent to 13 farmer organizations and associations. As a result, responses were obtained from 595 respondents that represent the domestic part of society, as well as from 510 hunters and 17 cattle-breeders. Of the respondents that represented families, 60.4% stated that they live in cities. Among the surveyed hunters this proportion was 54.9%.

In the survey it was found that 13.9% of the Latvian population living in families participate in hunting, although only 5.1% of them did so frequently or very frequently. The responses of these respondents were analyzed together with the views of the families, but responses from the hunters obtained through hunter organizations were treated separately as opinions of this specific stakeholder group. Due to a low level of responsiveness, the opinion of farmers was represented by a very small number of respondents. However, surveys received from families and hunters indicate that some of these respondents are engaged in livestock farming. Therefore, some specific issues related to livestock and lynx conservation were examined by selecting relevant questionnaires from the all the respondents, bringing together 127 responses from farmers, i.e. 67 from the group of hunter organizations, 43 from the families and 17 from the farmer organizations.

In 2001, the first study on public perception of large carnivores was conducted in Latvia, which was funded by the World Wildlife Fund. It included 3 local carnivore species – brown bear, lynx and wolf (Andersone and Ozoliņš 2004). The majority of respondents admitted that the number of lynx in Latvia is sufficient. At the same time, more than half of the respondents believed that the number of lynx should be limited (56.1%), while lynx protection was supported by only 33.2%. In 2004, the survey was repeated (Jaunbirze 2004, 2006). During that time, hunting restrictions, which are currently in force, were introduced, while retaining the possibility of lynx hunting. The results showed that species conservation measures have not increased dissatisfaction in local people, but have actually led to improvements in attitude. More than half of the respondents felt satisfied with the number of lynx in Latvia and 20–30% wanted to have more lynx (Fig. 27). In the survey of 2017 (A. Žunna et al., unpublished data), 44.7% of the respondents from the family group were satisfied with the current number of lynx, but for members of hunter organizations this proportion was greater – 54.2% (Figure 28). In turn, 26.1% of families would like to see slightly more lynx in Latvia, but only 6.0% of the hunters would prefer so, and are more likely to support the view that lynx numbers are slightly too high – 29.2% of respondents. It was concluded that the attitude towards lynx has not significantly changed in the past 12 years and that species conservation and management measures are satisfactory to both hunters and randomly selected respondents from families. A large proportion of the respondents believe that the existing species management system should be maintained (Fig. 29). There is a clear majority among hunters supporting this opinion, despite the difference in opinion about lynx hunting quotas and hunting season by the respondents from the family groups. The most influential tool for informing the public on large carnivores is TV and radio (Figure 30). Also articles in newspapers and magazines are of great importance, especially among hunters' circles. Many respondents favoured the internet as a source of information.

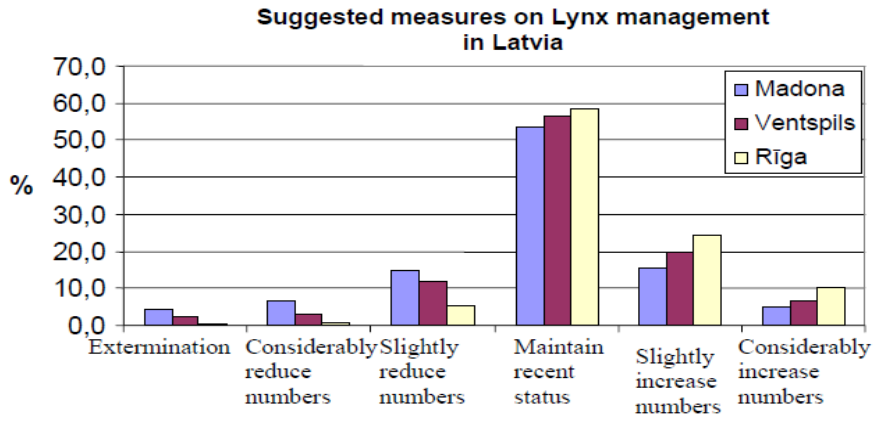


Figure 27. Results of the family survey on attitude towards lynx in 2005.

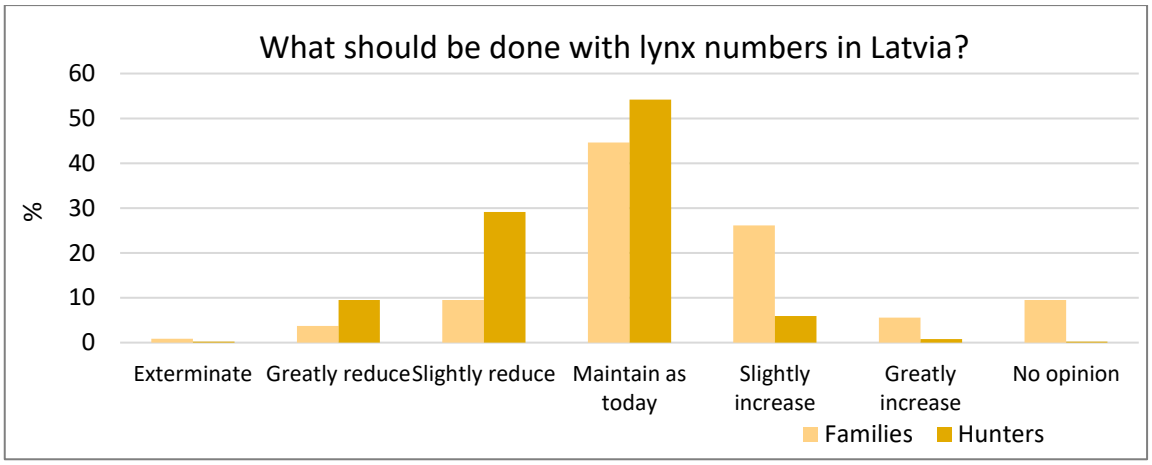


Figure 28. Results of the family and hunter survey on attitude towards lynx in 2017.

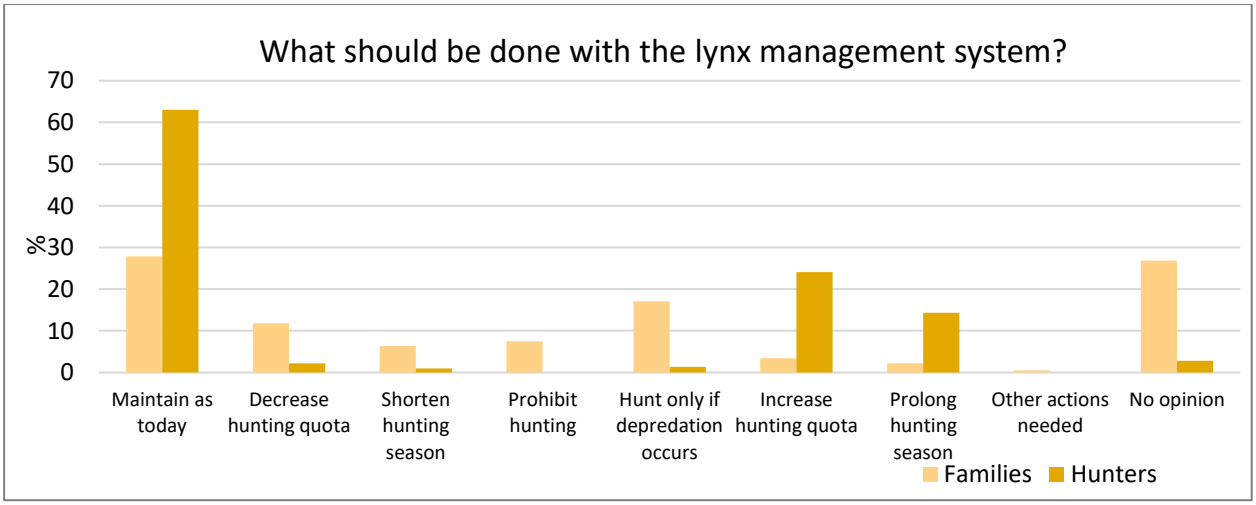


Figure 29. The opinion on current lynx population management, expressed by the families and hunter organization in a survey in 2017.

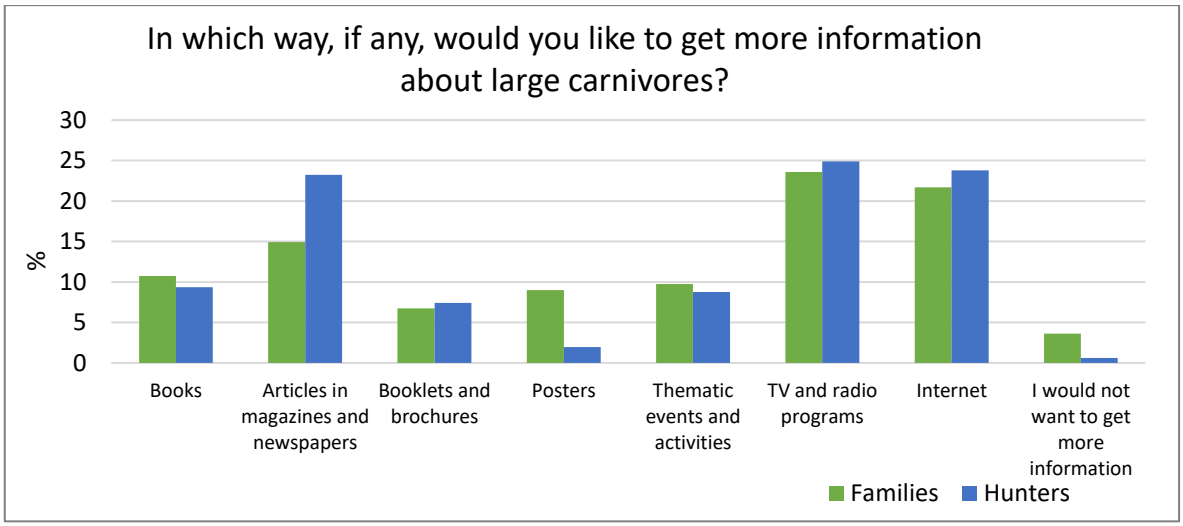


Figure 30. The preferred source of information on large carnivores, expressed by the families and hunter organizations in a survey in 2017.

Livestock farmers face some of the biggest challenges in finding opportunities to coexist with lynx. On the one hand, the total economic losses caused by large carnivores are negligible, with lynx being involved in very rare cases. On the other hand, the risk of losses caused by lynx still exist at the level of individual farms, and strict mitigation activities lead to more general negative opinion of livestock farmers about predator conservation. At the same time, among farmers there is a lack of co-ordinating authorities or organizations unifying opinions, perhaps as a result of their economic competition. There is also a widespread lack of consensus in popular opinion on large carnivore management issues. The common feature is that livestock farmers generally do not choose to take preventive measures against damage caused by carnivores until they have been personally affected. This attitude could be improved through informative, financial and organizational support, as this desire was expressed in responses to the questions already formulated in the questionnaire, as well as in additional comments. The majority of livestock farmers believe that hunting is a necessary tool to prevent carnivores from causing damage.

In general, it can be concluded that the current lynx management system is perceived favourably in Latvian society. This is supported by both the implementation success of the current Action Plan and by the conducted survey. There are no contrasting opinions among the majority of stakeholders. The majority of respondents do not express a desire to change the current species management system significantly. Differences in opinions can be minimised by information campaigns. When a need for more strict protective measures emerges, attention should be paid as to how they will be justified and explained.

5. The aim and tasks of the species conservation plan

The purpose of the Action Plan is to maintain a favourable status for the lynx population in Latvia for an unlimited period of time and to promote the maintenance of a favourable status in the Baltic lynx population without specifying the maximum number of individuals and habitats, while ensuring the presence of lynx as a united and functional component of the wildlife environment in a man-made and managed landscape, respecting and promoting the quality of life and well-being of a diverse society. For defining this objective, the previously described situation analysis for the scale of the Latvian and Baltic region (Sections 3 and 4) was used as well as the concept of coexistence of large carnivores and humans, described extensively in the IUCN Manifesto for large carnivore conservation in Europe (2013, *https://www.rewildingeurope.com/wp-content/uploads/.../Manifesto.pdf)*.

To achieve this goal, general long-term tasks that have been defined in the previous Action Plan should be continued or initiated and continued throughout the future conservation process (I), and short-term tasks must be implemented in the nearest future, which, once implemented or completed, will ensure long-term conservation measures (II).

I. Long-term tasks that constitute the system of protection and management of the species.

- Planning infrastructure for economic and recreational purposes in the landscape, establishment of movement corridors for large carnivores and other wild mammals that would maintain dispersal and prevent severe fragmentation of the area.
- Promotion of a positive public attitude towards the presence of lynx at the landscape level and within a context of wildlife diversity, including outside of the SPNAs, to reduce the attitude to this species as an unwanted competitor or an unacceptable obstacle to economic activity. This should increase the possibility of sighting lynx in the wild, evidence of their presence being positively perceived and making information on the lynx population status more widely available.
- Conflicts involving attacks of large carnivores on livestock are reduced by providing advisory and financial support to livestock owners, as well as by a convenient system and procedures for detecting and recording damages.
- Restricted lynx hunting as an optional activity for maintaining carnivore and human coexistence is applied only if the population is managed in a way that is not detrimental towards a favourable conservation status and the hunting process complies with conditions that make it relevant to the generally recognized ethical values of society.

- Management of other wildlife species and forests is conducted so that lynx functional activities in the ecosystem (foraging, breeding and habitat selection, dispersal) are kept as close to natural as possible.
- Management of the lynx population in Latvia is conducted in a way that the actions taken in Latvia would not be an obstacle to improvement of the population status in other parts of the Baltic population, especially in Belarus and Lithuania, which share their borders with Latvia.
- Lynx conservation requirements are to be considered as further changes and additions to legislation regarding hunting, forestry and environmental conservation are introduced.
- Population status is assessed by applying a monitoring system based on unified methods for collection of mutually comparable data, as well as by implementing and maintaining a common database that is accessible to all interested users in the three Baltic States within the limits of information security requirements. The monitoring system should provide data on species distribution, population dynamics and proportion of reproductive females obtained by non-invasive methods.
- Within the monitoring framework, changes in sex, age and kinship structure of the lynx population are to be followed and utilised to predict changes in the population status.
- A convenient damage registration and support and advisory system is to be maintained for owners who have suffered from large carnivore attacks on their livestock. Advisory and financial support is to be focussed on reducing the risk of damage rather than compensating for losses.
- Implementation and application of the latest available technologies (e.g. DNA tests) for investigation of large carnivore attacks and protection of livestock against potential large carnivore attacks.
- Consumptive and non-consumptive exploitation of the species should be organized according to the population status in accordance with the principles of adaptive management, taking into account the needs for environmental, economic and social culture of the local inhabitants (at the county scale). See Dr. A. Bath review, comment No 12.
- Hunting quotas for lynx are to be immediately reduced as soon as the first apparent signs of deterioration in the population status appear.

- Scientific research on lynx is to be continued, with particular emphasis on diet, reproduction, habitat and site selection, genetic diversity and health status of the population (including parasites, diseases, body condition).
- Public education and raising awareness on lynx conservation issues is to be continued. The target audience consists of professionals from state administration authorities, environmental NGOs, education and tourism sectors, as well as hunters and farmers.
- Changes in public attitude are to be monitored, e.g. by surveys on tolerance to large carnivores after the implementation of the planned measures and before the next renewal of the Action Plan.

II. Short-term tasks that serve to support the conservation and management system of the species.

- To develop recommendatory guidelines for administrative decision makers that facilitate navigation of the legislation and ensure lynx conservation and management in accordance with the dynamic situations, the need for a regulatory framework and a place in the overall legislative hierarchy.
- To supplement monitoring methods with the collection of information on the wild population and the proportion of reproductive females in it, as well as the total number of hunters and the duration of hunting per year in which lynx are hunted, planned to be hunted or there is a legitimate opportunity to hunt lynx.
- To participate in the establishment of a working group and the associated rules of procedure for the management of Baltic large carnivores in order to maintain a regular exchange of information and decide on actions for lynx conservation at the population level;
- To improve and upgrade the cooperation framework among institutions that supervise the fulfilment of CITES requirements, control hunting and conduct scientific research.
- To introduce a system for marking of lynx hunting trophies.
- To develop simple procedures for damage prevention and compensation in cases when a lynx has attacked livestock.

6. Recommendations for species conservation

All recommended actions are evaluated by a three-step scale of importance/priorities, where:

I – indicates crucial actions: their non-fulfilment could lead to species extinction from current range and habitats or jeopardize international obligations;

II – indicates important actions: their fulfilment helps to achieve conservation goals within the current reference period of the Action Plan, however omitting these does not endanger species survival within current range or habitats;

III – indicates significant actions that are recommended, yet do not crucially impact population survival at national level.

6.1. Changes in legislation

Priority I

Documentation of lynx hunting efforts (number of hunters and duration of hunts) within the scope of existing Hunting Regulations is possible by several amendments proposed below.

a) Paragraph 25 of the Hunting Regulations is to be supplemented with a sub-paragraph 25.4 in the following wording:

"if wolf and lynx hunting is permitted during the hunting season".

b) Annex 2 of the Hunting Regulations "Register of hunted game animals" is to be supplemented, providing for recording the number of participants and duration of the hunt (this change would allow for obtaining the most comprehensive information on the hunting effort for each season).

c) Annex 4 of the Hunting Regulations "Act concerning wolf/lynx hunting" is to be supplemented, providing for recording the number of participants and duration of the hunt.

d) Exchange of information between authorities managing hunting activities and hunters is to be provided electronically, replacing paper forms with data transmission by mobile networks.

Priority I

In order to ensure the monitoring and sufficient amount of data for planning the maximum allowable hunting quota, Paragraph 51.10 of the Hunting Regulations is to be expressed in the following wording:

„The initial processing of harvested animals after hunting is to be organised and samples of mammalian species, which are important in the European Community and require their population monitoring, are to be prepared, in addition to samples for veterinary examination regardless of species, if necessary".

Priority II

In order to avoid the risk that the holder of hunting rights in localities where livestock predation has occured would be more likely to demand lynx hunting permits, exceeding the

permissible seasonal hunting quota or the prescribed hunting period, than to assume other responsibilities related to the damage caused, Paragraph 1 of the Article 29 of the Hunting Law should be expressed in the following wording:

„The owner or legal possessor of the land is responsible for the damage and losses caused by the game animals in the land owned by him/her if the hunting rights have not been transferred to another user, except in cases when damages are caused by carnivorous mammals of restricted exploitation and special protection in the European Community.

6.2. Establishment of specially protected nature areas and/or micro-reserves

Not required.

6.3. Measures for population renewal

Not required.

6.4. Measures for species habitat management

Maintaining the current trend in the dynamics of the total forest area (see Chapter 2.2., Table 3), special measures for the restoration or conservation of habitats by limiting forestry are not necessary.

Priority III *

It is essential to take into account the opportunity for movement of lynx and other mammal species when planning and building linear infrastructures in the landscape – not creating fences without interruption for more than 5 kilometers, building green bridges or tunnels where animals can cross motorways, etc. Particular attention should be paid to the progress of the *Rail Baltica* project and impact assessments. *See Dr. A. Bath review, comment No 11.

6.5. Research and data collection

6.5.1. (*Priority I*) Information for the species conservation is to be obtained from hunted, accidently killed or found dead individuals, as well as by recording, collecting and analyzing lynx tracks and evidences of their presence in the wild (non-invasive monitoring). Procedures for collecting and analysing information about the lynx population status in Latvia is included in the monitoring programs for monitoring biodiversity, background monitoring within the framework of game mammal monitoring (http://biodiv.daba.gov.lv/fol302307/fol634754/fona-monitoringa-metodikas/ziditajdzivnieki/mon_met_fona_2013_ziditaji_medijamie.doc) and also special monitoring of large carnivores, including methods for inspecting individuals that have been hunted or found dead “Methodology for Special Monitoring of Large Carnivore Population Demographics, namely wolf (*Canis lupus*) and lynx (*Lynx Lynx*)” (http: //biodiv.daba.gov.lv/

fol302307/fol634754/speciala-monitoringa-metodikas/mon_met_spec_2013_lielie_pleseji.doc).

Current methods need to be complemented so that the obtained information could be used for local requirements and at the trans-border level. Data on the amount of reproductive females and dynamics should be used for the estimation of population size and regenerative capacity. Users of hunting rights, the SFS, scientific institutions and volunteers are to be involved in the collection of data. The results of the monitoring should include: reports on observed footprint tracks with precise location and date at least annually regardless of hunting season, for each census unit (within 10x10 km square of the grid); collection and analysis of data from automatic camera traps and eye-witnesses photographs; DNA samples from fur/hair found in nature or acquired by non-invasive methods; DNA samples from bite wounds/scars (in cases of livestock predation), should be introduced in monitoring methodologies. Samples from all hunted and accidentally found dead lynx are to be collected, including at least a cuspid root for age determination of individuals older than one year, reproductive organs of adult females and a small (ca. 1 cm^3) muscle sample for DNA analysis. In agreement with the research institute, which performs lynx monitoring, a whole skinned body is to be collected from several lynx, hunted and accidentally found dead, for parasitological examination and diet studies. Updating of monitoring methods and procedures for compiling the results and publishing them in accordance with the National Monitoring Program is determined by the NCA.

6.5.2. (*Priority I*) Analysis of the fulfilment of the hunting quota and shortening of the lynx hunting season, is to be conducted by linking the collected monitoring data on the demographic status of hunted lynx with information on the seasonal distribution of hunting intensity. The analysis should include 3 situation models: (1) shortening the length of the hunting season, by excluding December (justifiable by a greater possibility to avoid hunting of immature individuals); (2) shortening the hunting season by suspending lynx hunting at the end of February (justifiable by avoiding the killing of already fertilized females); (3) shortening the hunting season, starting the hunting in January and ending at the end of February (justifiable by a reduced impact on population demographics by a shorter hunting period). The purpose of this study is to evaluate the possibility of hunting in a significantly shorter period, which is more favourable for species conservation, allowing for the same lynx hunting quotas as in the current hunting period of 4 months.

6.5.3. (*Priority II)* Ecological research of the species should be continued, with particular attention being paid to the dependence on the dynamics of prey species numbers, interaction with other predators (wolves, golden jackals) and indicators of population vitality (genetics, parasitology, factors influencing natural mortality).

6.5.4. (*Priority III*) Important information for species conservation is gained by the analysis of societal needs and attitudes. This should be conducted on two levels: involving a comprehensive situation survey at the end of the planned period and prior to the renewal of the next Action Plan; the results of which are at least partially comparable to the results of the 3 previous surveys; and the assessment of particular conservation measures and performance of their implementation (e.g., evaluation of the system for informing farmers of methods to protect livestock against damage and evaluation of the support system for conservation measures). The questionnaires should be as user-friendly as possible and should be conducted with the most appropriate technical means for the target audience.

6.6. Information and education, improvement of professional qualifications

6.6.1. (*Priority II*) A joint training exercise for the identification of carnivore species in the case of damage to livestock should be organized among the responsible specialists, including both identification in the field and sampling for DNA analysis.

6.6.2.* (*Priority I*) Involvement of hunters in the monitoring of large carnivores should continue, including data collection on hunted animals and acquisition and implementation of non-invasive monitoring methods. *See Dr. A. Bath review, comment No 4.

6.6.3. (*Priority I*) Species identification skills from lynx body parts (for monitoring of CITES requirements) and tracks in the wild (for monitoring, nature tourism) should be improved and propagated among the staff of the institutions involved and other associated organizations.

6.6.4. (*Priority II*) A Code of Hunting Ethics, based on the moral values of society and scientific arguments, should be developed, made public and signed by the leading hunting organizations of the country.

6.6.5. (*Priority III*) The public is to be regularly informed about species status, management strategiesand scientific research. The most influential forms of information should be chosen, that are appropriate to the target audience and follow trends information technologies.

6.6.6. (*Priority III*) In the process of developing Action Plans for SPNAs, which are designed to preserve other endangered species and habitats, lynx conservation measures should be carefully assessed, if necessary, so that they would be in line with the aims and tasks contained in this lynx Action Plan.

6.6.7. (*Priority III*) The training for volunteers in the use of non-invasive monitoring methods should be organized.

6.6.8.* (Priority II) Public relations and conflict resolution skills training workshops for interest groups involved in lynx conservation and management (hunters, livestock farmers,

wildlife managers, decision making authorities, NGOs, etc.) should be organized. *See Dr. A. Bath review, comment No 14 and 16.

6.7. Organizational, planning and other activities

For further conservation and management of the lynx population, the following organizational actions must be taken.

6.7.1. (*Priority I*) Establishment of a working group for determining the maximum allowable harvest quota for lynx.

Group coordination is undertaken by the SFS. The group includes specialists and responsible officials from the SFS, the NCA, institutions conducting the species monitoring, organizations of the users of hunting rights, Joint Stock Company "Latvia's State Forests", the Latvian Forest Owners' Association, the Cooperation Council for Farmers' Organizations and the Environmental Advisory Council. Not later than two weeks before the opening of the lynx hunting season, the working group meets and, by examining the best available information on the population status, including results of the appropriate background and special monitoring, decides on the maximum allowable hunting quota, duration of the hunting period and areas where lynx hunting is prohibited. The decision should be based on:

- the planned hunting quotas and their fulfilment in the previous years;
- hunting effort (number of hunt participants and time spent in hunting) of the season;
- changes in species distribution and abundance;
- population demographics and kinship structure;
- amount of reproductive females and litter size;
- status of genetic diversity;
- status of roe deer population;
- lynx conservation status in neighbouring countries and border area within the Latvian territory.

If all of these indicators indicate a favourable status of the lynx population, the hunting quota should be planned within the range of 10-20% of the estimated population size before hunting, but not exceeding more than 150 lynx per year, which historically has been confirmed as a limit to which the Latvian lynx population has been able to recover without subsequent deterioration. The duration of the hunting season is to be determined in an annual administrative order by the SFS, taking into account current meteorological and phenological conditions, but not

exceeding the current deadlines specified in the Hunting Regulations, i.e. from the 1st of December to the 31st of March. If signs of deterioration in the population are detected or predicted, in addition to the reduction of the hunting quota or as an alternative to it, the following options for reducing the hunting effort should be used:

- shortening of the hunting season, preferably with a later start to the hunting season when juvenile lynx which were born in spring are more likely to survive the loss of a mother;
- discontinuation of lynx hunts if during hunting, a female has been found with juvenile lynx born in the previous spring;
- to divide the total hunting quota of the country among the territorial units (game management units) without the possibility of redistribution;
- to expand areas where lynx hunting is not conducted (around the central part of the country, in national parks, in areas bordering Lithuania and Belarus);
- to issue fixed-term hunting permits in specific hunting areas;
- to postpone harvesting for the entire season.

Regardless of population status, lynx hunting with beaters in snowless conditions during hunting of other game animals is to be limited to prevent animals from not being found after injury or failure to notice juveniles born in the previous spring. The decision is made public in the form of an SFS administrative order. If difficult situations arise, an outside facilitator may be required (for reference see Dr. A. Bath review, comment No 17).

6.7.2. (*Priority II*) Engaging in the establishment of an international working group and work on the protection and management of lynx at the Baltic population level. Group establishment is undertaken by representatives of the Baltic States at the IUCN LCIE.

6.7.3.* (*Priority II*) Coordination of the parties involved in species monitoring and expansion of public participation (in relation to actions referred to in sections 6.6.2 and 6.6.7). Organize training for SFS staff and NCA environmental inspectors in the search and identification of lynx, wolf and brown bear tracks, marks and signs in nature. Develop a volunteer network involving owners of automatic camera traps within the hunting community and broader society. *See Dr. A. Bath review, comment No 4.

6.7.4. (*Priority II*) Labelling of lynx game trophies (including those previously legally acquired) according to CITES certificates issued by NCA. With the help of a unique marking (skull mark or electronically readable code on the skin), lynx game trophies are to be linked with their corresponding CITES certificate numbers and registration data base. The possibility of legalizing previously legally acquired trophies is to be organised in accordance with CITES requirements.

For requesting and issuing of permits, a user-friendly electronic system must be created, which simultaneously also allows for rapid confirmation for inspection purposes.

6.7.5. (*Priority III*) Developing and supporting non-consumptive initiatives for the species. The Department of Tourism of the Investment and Development Agency of Latvia, in co-operation with the competent authorities, specialists and the tourism association “Lauku ceļotājs” [Country Voyager], creates tour offers for the identification of large carnivores and their habitats in Latvia without causing unacceptable impact for the species.

6.7.6.* (*Priority II*) Developing a convenient system and procedures for recording damages, inspecting and evaluating damages caused by large carnivores and examining applications for support for protection measures and compensation of losses. Advisory and financial support is to be focused on reducing the risk of damage rather than compensating for losses. Damages caused by lynx are very rare, however, in order to avoid negative impacts on the species conservation initiated by such cases, the system should provide for a prompt and coordinated response by the responsible authorities, identification of the species that has caused the damage as accurately as possible as well as a relaxed compensation procedure, while avoiding regular damage compensation for land owners without improvement of preventive measures. The only financial support available to date, which is indirectly aimed at implementing preventive measures, can be received in the Latvian Rural Development Program 2014–2020, in the framework of the measure "Investments in tangible assets", for installation of fences or pasture/shed lighting fixtures together with other building construction works, etc. In Latvia, there is still no compensation system that would be useful in cases where the damage occurred despite the implementation of appropriate preventive measures. For such cases, the Latvian Environmental Protection Fund is the most appropriate source of funding. *See Dr. A. Bath review, comment No 8.

6.7.7. (*Priority I*) Renewal of the Action Plan. Upon expiration of the planned term of Action Plan activities, performance of the tasks and achievements of the conservation aims are to be assessed. The current requirements of the species conservation are to be considered at the time of the plan renewal.

7. Review of planned actions and events

The actions are arranged in the sequence used in Chapter 6, indicating the order number of the event, the scheduled time for execution and the assessment of the required resources.

Action/event	**Priority**	**Due term (necessary time)**	**Estimated cost (EUR)**
6.1. Changes in legislation a) to ensure documentation of hunting effort (number of hunters and duration of hunt during the season) used for lynx hunting; b) to ensure monitoring and sufficient amount of data for planning the maximum allowable hunting quota; c) to avoid the risk that the holder of the hunting rights would be more likely to intensify lynx hunting rather than to protect livestock against possible damage.	I I II	18 months	Within the budget of the responsible authorities
6.4. Evaluation of the progress and impact of the *Rail Baltica* project on the lynx population status.	III	Continual	Within the expenses of the species monitoring, additional analyses of the obtained data – 3 000 per year
6.5.1. Monitoring of the population status: • using material from hunted and found dead or accidently killed individuals and supplementing the methodology with the investigation of kinship structure (DNA analysis) and recording of hunting pressure. • using non-invasive methods by collecting and analyzing the signs and evidences of lynx presence in the wild in the framework of monitoring of game animals. • supplementing monitoring methods with the collection of data on the population by applying a network of camera traps and an annual analysis of information on the number of reproductive females.	I I I	Continual Continual 2 years	60 000 per year 30 000 per year Within the budget of the responsible authorities The activity is conducted in conjunction with the background monitoring of game populations 20 000
6.5.2. Evaluation of the possibility of lynx hunting in a much shorter period, but which is more favourable to species conservation.	I	1 year	3000
6.5.3. Research on species ecology.	II	Continual	15 000 per year
6.5.4. Survey of the needs and attitudes of society on lynx management issues.	III	2 years	30 000
6.6.1. Joint training for the identification of carnivore species in the case of damage to livestock among the responsible specialists, including both identification abilities in nature and sampling for DNA analyses.	II	2 years for improving the system and continual thereafter	10 000 for workshops and training, maintenance of the procedure within the budget of responsible authorities, 1000 per year for DNA analyses

6.6.2. Hunter involvement in large carnivore monitoring, including data collection on hunted animals and acquisition and implementation of non-invasive monitoring methods.	I	Continual	5000 per year for seminars and training
6.6.3. Acquiring species identification skills for lynx body parts (for monitoring of CITES requirements) among the staff of the responsible and involved institutions.	I	2 years for launching and continual thereafter	5000 for development of the procedures, and thereafter within the budget of responsible authorities
6.6.4. Developing a Code of Hunting Ethics.	II	6 months	1000
6.6.5. Informing society on the species status, the course of management and scientific research.	III	Continual	1000 per year
6.6.7. Training for volunteer information providers in the use of non-invasive monitoring methods.	III	1 year and continual thereafter	15 000 for initial coordination actions, 5000 per year thereafter
6.6.8. Public relations and conflict resolution training for interest groups.	II	Once per three years	2000 for external facilitator per case
6.7.1. Establishing a working group for determining the maximum allowable harvest quota for lynx.	I	6 months	Within the budget of the responsible authorities
6.7.2. Engaging in the establishment and work of an international working group on the protection and management of lynx at the Baltic population level.	II	2 days per year	2000 per year
6.7.3. Coordinating and training of staff and volunteers involved in the monitoring.	II	1 week per year	5000 per year
6.7.4. Labelling of lynx game trophies (including previously legally acquired) according to CITES certificates issued by NCA.	II	2 years for introducing the system and continual thereafter	17 000 for introducing and 3000 per year
6.7.5. Supporting non-consumptive exploitation initiatives of the species.	III	1 year	10 000
6.7.6. Development of a registration and mitigation system for damages caused by large carnivores.	II	2 years for developing and introducing the system and continual thereafter	20 000 for developing and introducing the system, 100 000 pilot project for the prevention of carnivore attacks within areas of increased risk of attacks
6.7.7. Renewal of Action Plan.	I	1 year	15 000

8. Assessment of the effectiveness of population restoration of the species, habitat management and implementation of other measures

The planned activities are related to the fulfilment of requirements demanded by international legislation. The establishment of a working group on Baltic large carnivore management, promotion of protection measures against damages caused by large carnivores, as well as standardization of the monitoring methods and involving the public in data collection and

reporting of the results will form the basis for maintenance of a favourable species conservation status at the Latvian scale and within the Baltic population. Implementation of the Action Plan will help to realise the measures foreseen in the EU "Platform on Coexistence Between People and Large Carnivores" developed by representatives of European Union Member States and signed on the 10th of June 2014 in Brussels, which aims to support the ways and means of minimising and, as far as possible, resolving conflicts between people's interests and the presence of large carnivores through the exchange of knowledge and cooperation in an open and constructive form and with reciprocal dignity. The agreement was signed by the Commissioner for Environment of the European Commission and leading representatives of nature conservation, farmer, and land owner and hunting organizations. The success of the Action Plan implementation will be confirmed by the fact that lynx conservation will not have an impact on the economy and that the government will not be required to provide additional funding for the continuation of species conservation measures, as the majority of them are part of the functions already provided for in legislation and in the main duties of the responsible institutions.

9. Implementation of species conservation plan

The main activities are arranged in the sequence used in Chapter 6, indicating the year of launch, the institutions involved (the responsible institution underlined), stakeholders and type of cooperation.

Action/event	**Start of execution***	**Involved institutions**	**Form of cooperation**
Changes in legislation.	Together with the consideration of the next amendments in relevant laws	Ministry of Agriculture, Ministry of Environment and Regional Development, State Forest Service, Nature Conservation Agency	Working group, involving public partners
Evaluation of the progress and impact of the *Rail Baltica* project on the lynx population status.	Not predictable	State Forest Service, Ministry of Transport, scientific institution responsible for monitoring, users of hunting rights	In the framework of the functions by supervisory authority and contractual work
Monitoring population status by using materials from individuals hunted and found dead.	2017	Ministry of Agriculture, State Forest Service, LSFRI "Silava", users of hunting rights	In the framework of the functions by supervisory authority and contractual work
Monitoring of population status by applying non-invasive methods in the framework of game monitoring.	2018	State Forest Service, JSC "Latvia's State Forests", users of hunting rights, scientific institution responsible for monitoring, volunteer informants	Exchange of information, functions of the supervisory authority, pilot projects under LIFE and ERAF programs
Evaluation of the possibility of lynx hunting in a much shorter period, but which is more	2020	LSFRI "Silava", Ministry of Agriculture, State Forest Service, users of hunting rights	Within contractual works

favourable to species conservation.			
Research on species ecology.	2017	LSFRI "Silava", university students and PhD students	Within contractual works as well as MSc and PhD theses
Survey of the needs and attitudes of society on lynx management issues.	2025-2026	LSFRI "Silava", university students and PhD students	Within contractual works as well as MSc and PhD theses
Acquiring species identification skills for lynx body parts (for monitoring of CITES requirements) among the staff of the responsible and involved institutions.	2019	Nature Conservation Agency, State Forest Service, State Border Guard, State Customs, LSFRI "Silava"	Within the framework of the functions by supervisory authorities and pilot projects
Training for the identification of carnivore species in the case of damage to livestock among the responsible specialists, including both identification abilities in nature and sampling for DNA analyses.	2019-2020	State Forest Service, Nature Conservation Agency, LSFRI "Silava", municipalities	Within the framework of the functions by supervisory authorities and pilot projects
Involvement of hunters in large carnivore monitoring.	2017	State Forest Service, Ministry of Agriculture, public organizations representing users of hunting rights	Changes in legislation, framework of the functions by supervisory authorities and pilot projects
Developing a Code of Hunting Ethics.	2018	Public organizations representing users of hunting rights, Ministry of Agriculture, society of forest owners, State Forest Service	Working group
Informing society on the species status, the course of management and scientific research.	2017	All involved institutions and organizations	Regular release of information on websites, information to the press services
Establishing and supporting (e.g. by public relations training) a working group for determining the maximum allowable harvest quota for lynx.	2017	State Forest Service, Nature Conservation Agency, LSFRI "Silava" or other institution conducting the monitoring, Environmental Advisory Council, JSC "Latvia's State Forests", Latvian Forest Owners' Association, Cooperation Council for Farmer Organizations, public organizations representing users of hunting rights	Working group after SFS initiative
Engaging in the establishment and work of an international working group on the conservation and management of lynx at the Baltic population level.	2019	Nature Conservation Agency, Ministry of the Environment and Regional Development, Ministry of Agriculture, LSFRI "Silava"	Seminar for representatives
Labelling of lynx hunting trophies (including previously legally acquired) according to	2018	Nature Conservation Agency, State Forest Service	Within the framework of the functions by supervisory authorities and pilot projects

CITES certificates issued by NCA.			
Support for non-consumptive exploitation initiatives of the species.	2019	Department of Tourism of the Investment and Development Agency of Latvia, association "Lauku ceļotājs"[Country Voyager]	Consultations, information exchange
Development of a registration and mitigation system for damages caused by large carnivores.	2019-2020	Ministry of Agriculture, State Forest Service, Ministry of the Environment and Regional Development, Nature Conservation Agency, Latvian Association of Local and Regional Governments, Cooperation Council for Farmer Organizations, municipalities, LSFRI "Silava"	Establishment of a working group within the framework of the functions by supervisory authorities and pilot projects

* On the initiative of the responsible institution and in agreement with the cooperation partners, the implementation of the measure can be initiated more quickly if possible and necessary.

10. Deadlines for the implementation and review/evaluation of the species conservation plan

The Action Plan is developed for implementation of lynx conservation and management measures for the next 10 years (2018–2028). It is advisable to start assessment of the implementation of the current Action Plan in 2025 to prepare tasks and plan the necessary funding for renewal of the Action Plan.

References

Anderson Z., Ozolins Ya., Pupila A., Bagrade G. 2003. The East European and Caucasian parts of lynx range (the western group of regions): Latvia. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 92–104 (in Russian/English).

Andersone Ž., Ozoliņš J. 2004. Public perception of large carnivores in Latvia. *Ursus* 15(2): 181–187.

Andersone-Lilley Z., Ozolins J. 2005. Game mammals in Latvia: Present status and future prospects. *Scottish Forestry* 59(3):13–18.

Andren H., Linnell J.D.C., Liberg O., Andersen R., Danell A., Karlsson J., Odden J., Moa P.F., Ahlqvist P., Kvam T., Franzen R., Segerstrom P. 2006. Survival rates and causes of mortality in Eurasian lynx (Lynx lynx) in multi-use landscapes. *Biological Conservation* 131 (1), 23–32.

Azarov V.I. and Shubin N.G. 2003. The Central-Siberian part of the area (the Medial group of regions): The Western Siberia. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 249–282. (in Russian/English).

Bagrade G. 1999. Lūšu populācijas morfometriskais raksturojums, skaita dinamika un izplatība. Bakalaura darbs. Rīga: LU, 68 lpp.

Bagrade G. 2001. Daži lūšu (*Lynx lynx* L.) bioloģijas aspekti Latvijā. Maģistra darbs. Rīga: LU, 62 lpp.

Bagrade G. 2009. Latvijas kaķu un suņu dzimtas savvaļas sugu helmintofauna. Promocijas darbs. Rīga: LU, 128. lpp.

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

Bagrade G., Ruņģis D.E., Ornicāns A., Šuba J., Žunna A., Howlett S.J., Lūkins M., Gailīte A, Stepanova A., Done G., Gaile A., Bitenieks K., Mihailova L., Baumanis J., Ozoliņš J. 2016. Status assessment of Eurasian lynx in Latvia linking genetics and demography – a growing population or a source-sink process? *Mammal Research* 61 (4): 337–352.

Baumanis J., Ornicāns A., Stepanova A., Ozoliņš J. 2012. Association between roe deer and lynx abundance in Latvia. In: Recent problems of nature use, game biology and fur farming. Proceedings of International Scientific and Practical Conference. Kirov, VNIIOZ, RAAS, pp. 135–136.

Bērziņa D. 2016. Eirāzijas lūša Lynx lynx uzturēšanās vietas parametri vidē. Maģistra darbs. Rīga: LU, 75 lpp.

Bischof R., Nilsen E.B., Brøseth H., Männil P., Ozoliņš J., Linnell J.D.C. 2012. Implementation uncertainty when using recreational hunting to manage carnivores. *Journal of Applied Ecology* 49: 824–832.

Bluzma P. 1999. Estimation of the state of lynx and wolf populations in Lithuania. *Acta Zoologica Lituanica* 9 (1): 35–41.

Boitani L., Alvarez F., Anders O., Andren H., Avanzinelli E. et al. 2015. Key actions for Large Carnivore populations in Europe. Institute of Applied Ecology (Rome, Italy). Report to DG Environment, European Commission, Bruxelles. Contract no. 07.0307/2013/654446/SER/B3.

Bouyer Y., Gervasi V., Poncio P., Beudels-Jamar R. C., Odden J., Linnel J. D. C. 2014. Tolerance to anthropogenic disturbance by a large carnivore: the case of Eurasian lynx in south-eastern Norway: Lynx tolerance to human disturbance in Norway. *Animal conservation* 18 (3): 271–278.

Bouyer Y., San Martin G., Poncin P., Beudels-Jamar R. C., Odden J., Linnell J. D. C. 2015. Eurasian lynx habitat selection in human-modified landscape in Norway: Effects of

different human habitat modifications and behavioral states. *Biological Conservation* 191: 291–299.
Bunnefeld N., Linnell J. D. C., Odden J., Van Duijn M. A. J., Andersen R. 2006. Risk taking by Eurasian lynx (Lynx lynx) in a human-dominated landscape: effects of sex and reproductive status. *Journal of Zoology* 270: 31–39.
Breitenmoser U., Breitenmoser-Wursten Ch., Okarma H., Kaphegyi Th., Kaphegyi-Wallmann U., Muller U. M. 1998. The Action Plan for the Conservation of the Eurasian Lynx (*Lynx lynx)* in Europe. Gland: WWF International. 46 pp.
Breitenmoser U., Breitenmoser-Würsten C., Lanz T., von Arx M., Antonevich A., Bao W. Avgan B. 2015. *Lynx lynx*. The IUCN Red List of Threatened Species 2015: e.T12519A50655266.http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12519A50655266.en. Downloaded on 18 June 2017.
Breitenmoser U., Breitenmoser-Würsten Ch., Okarma H., Kaphegyi Th., Kaphegyi-Wallmann U., Müller U. M. 2000. The Action Plan for the Conservation of the Eurasian Lynx (*Lynx lynx*) in Europe. – Nature and environment, No. 112, 69 lpp.
Breitenmoser-Würsten C., Vandel J.M., Zimmermann F., Breitenmoser U. 2007. Demography of lynx *Lynx lynx* in the Jura Mountains. *Wildlife Biol* 13: 381–392.
Breitenmoser-Würsten Ch., Obexer-Ruff G. 2003. Population and conservation genetics of two reintroduced lynx (*Lynx lynx*) populations in Switzerland – a molecular evaluation 30 years after translo-cation. *Environ Encount* 58: 51–55.
Chapron G., Kaczensky P., Linnell J.D.C., von Arx M., Huber D. et al. 2014. Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science* 346(6216): 1517–1519.
Danilov P.I. 2005. Game animals of Karelia: ecology, resources, management, protection. Moscow: Nauka, 340 pp. (in Russian).
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, pp. 31–52. (in Russian/English).
Deksne G., Segliņa Z., Jahundoviča I., Esīte Z., Bakasejevs E., Bagrade G., Keidāane D., Interisano M., Marucci G., Tonanzi D., Pozio E., Kirjušina M. 2016. High prevalence of *Trichinella* spp. in sylvatic carnivore mammals of Latvia. *Veterinary Parasitology* 231:118-123. doi: 10.1016/j.vetpar.2016.04.012. Epub 2016 Apr 12.
Garner A., Rachlow J.L., Hicks J.F. 2004. Patterns of Genetic Diversity and Its Loss in Mammalian Populations. *Conserv Biol* 19 (4): 1215–1221.
Gaross V. 1994. Vilku un lūšu ietekme uz briežveidīgajiem dzīvniekiem Kurzemē. *Meža Dzīve* 3 (208): 10–15.
Gaross V. 1997. Ekoloģisko, bioloģisko, antropogēno u.c. faktoru ietekme uz Latvijas briežveidīgo dzīvnieku un plēsēju populācijām. *Mežzinātne* 7 (40): 108–123.
Grevé K. 1909. Säugetiere Kur-, Liv-, Estlands. Riga: W. Mellin u. Co. 183 S.
Henriksen H., Andersen R., Hewison A.J.M., Gaillard J.M., Bronndal M., Jonsson S., Linnell J.D.C., Odden J. 2005. Reproductive biology of captive female Eurasian lynx *Lynx lynx. European Journal of Wildlife Research*. 51 (3):151–156.
Hellborg L., Walker C.W., Rueness E.K., Stacy J.E., Kojola I., Valdmann H., Vilà C., Zimmermann B., Jakobsen K., Ellegren H. 2002. Differentiation and levels of genetic variation in northern European lynx (*Lynx lynx*) populations revealed by microsatellites and mitochondrial DNA analysis. *Conserv Genet* 3: 97–111.
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*). *Journal of Zoology* 265: 63–71.

Huck M., Jędrzejewski W., Borowik T., Miłosz-Cielma M., Schmidt K., Jędrzejewska B., Nowak S., Mysłajek R.W. 2010. Habitat suitability, corridors and dispersal barriers for large carnivores in Poland. *Acta Theriologica* 55(2): 177–192.

Ingelög T., Andersson R., Tjernberg M. (Eds.) 1993. Red Data Book of the Baltic region. Part 1. Södertölje: Fingraf ab. 95 pp.

Jaunbirze S., 2004. Lūsis *Lynx lynx* Latvijā – sabiedriskā viedokļa aptauja. Bakalaura darbs. Rīga: LU, 54 lpp.

Jaunbirze S. 2006. Eirāzijas lūsis *Lynx lynx* – sabiedriskais viedoklis – drauds Latvijas lūšu populācijai? Maģistra darbs. Rīga: LU, 48 lpp.

Jędrzejewski W., Schmidt K., Milkowski L., Jedrzejewska B., Okarma H. 1993. Foraging by lynx and its role in ungulate mortality: the local (Bialowieza Forest) and the Palaearcticviewpoints. *Acta Theriologica* 38 (4): 385–403.

Jędrzejewski W., Nowak S., Schmidt K., Jędrzejewska B. 2002. Wolves and lynx in Poland. Results of a census in 2001. *Kosmos. Problemy Nauk Biologicznych* 51: 491–499.

Jędrzejewski W., Jędrzejewska B., Okarma H., Schmidt K., Bunevich A.N., Milkowski L. 1996. Population dynamics (1869–1994), demography, and home ranges of the lynx in Bialowieza Primeval Forest (Poland and Belarus). *Ecography* 19(2): 122–138.

Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H., Linnell J. (eds). 2013. Status, management and distribution of large carnivores – bear, lynx, wolf and wolverine – in Europe. Part 2 - Species Country Reports. Report: 1-201.

Kalniņš, A. 1943. Medniecība. Latvju grāmata, Rīga. 704 lpp.

Kawata Y., Ozoliņš J., Andersone-Lilley Z. 2008. An analysis of the game animal population data from Latvia. *Balt For* 14(1): 75–86.

Kawata Y. 2008. Carrying Capacities of Large Carnivores in Latvia. *Acta Zoologica Lituanica* 18(1): 3–9.

Kozlo P.G. 2003. The East European and Caucasian parts of lynx range (the western group of regions): Byelorussia. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 118–137 (in Russian/English).

Kozlovskiy I.S. 2003. The East European and Caucasian parts of lynx range (the western group of regions): The Vyatka-Kama Region. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 168–217 (in Russian/English).

Kronītis J. 1987. Medību saimniecība. Bušs M. un Vanags J. (red.) Latvijas meži. Rīga: Avots, 148–162.lpp.

Kvam T. 1991. Reproduction in the European lynx, *Lynx lynx*. *Zeitschrift für Säugetierkunde* 56(3): 146–158.

Kudaktin A.N. 2003. The East European and Caucasian parts of lynx range (the western group of regions): The Great Caucasus. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 226–249. (in Russian/English).

Lange, W. L. 1970. Wild und Jagd in Lettland. Hannover-Döhren: Harro von Hirscheydt Vrlg. 280 S.

Linnell J.D.C., Andersen R., Kvam T., Andrén H., Liberg O., Odden J., Moa, P. F. 2001. Home Range Size And Choice Of Management Strategy For Lynx In Scandinavia. *Environ Manage* 27: 869–879.

Linnell J.D., Broseth H., Odden J., Nilsen E.B. 2010. Sustainably harvesting a large carnivore? Development of Eurasian lynx populations in Norway during 160 years of shifting policy. *Environ Manage* 45(5): 1142–1154.

Linnell J., Salvatori V., Boitani L. 2008. Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070501/2005/424162/MAR/B2).

Linnell J.D.C., Skogen K., Andersone-Lilley Z., Balciauskas L., Herfindal I., Kowalczyk R., Jedrzejewski W., Mannil 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., Swenson, J. E., Landa, A., Kvam, T. 1998. Methods for monitoring European large carnivores – a worldwide review of relevant experience. NINA Oppdragsmelding, 549, 38 pp.

Lõhmus A. 2002. Management of Large Carnivores in Estonia. *Estonian Game* No 8A, 71 pp.

Männil P., Kont R. 2012. Action plan for conservation and management of large carnivores (wolf Canis lupus, lynx Lynx lynx, brown bear Ursus arctos) in Estonia 2012-2021. Estonian Ministry of the Environment. *Estonian Game* No 12, 120 pp.

Matīss J. 1987. Latvijas mežainums. – Latvijas meži, Bušs M., Vanags J. Rīga: Avots, 83-95.

Matyushkin E.N., Podolskiy S.A., Tkachenko K.N. 2003. The Far East part of the area (eastern part of regions): The South of Far East. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 423–472 (in Russian/English).

McNeely J.A., Miller K.R., Reid W.V., Mittermeier R.A., Werner T.B. 1990. Conserving the world's biological diversity. IUCN, Gland, Switzerland; WRI, CI, WWF-US, the World Bank, Washington D.C.

Mihailova L. 2013. Vilku *Canis lupus* un lūšu *Lynx lynx* populāciju demogrāfiskā stāvokļa novērtējums Latvijas teritorijā, balstoties uz auglības rādītājiem. Rīga: LU, 43 lpp.

Mitchell-Jones A.J., Amori G., Bogdanowicz W., Kryštufek B., Reijnders P.J.H., Spitzenberger F., Stubbe M., Thissen J.B.M., Vohralik V., Zima J. 1999. The Atlas of European Mammals. London, San Diego: Academic Press. 484 pp.

Molinari-Jobin A., Zimmermann F., Ryser A., Breitenmoser-Würsten Ch., Capt S., Breitenmoser U., Molinari P., Haller H., Eyholzer R. 2007. Variation in diet, prey selectivity and home-range size of Eurasian lynx *Lynx lynx* in Switzerland. *Wildlife Biology* 13 (4): 393.

Mordosov I.I. 2003. The Central-Siberian part of the area (the Medial group of regions): Yakutiya. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 290–303. (in Russian/English).

Mugurēvičš Ē., Mugurēvičs A. 1999. Meža dzīvnieki Latvijā. – Latvijas mežu vēsture līdz 1940. gadam. Rīga: WWF – Pasaules Dabas Fonds, 207–247.

National strategy and action plan for the conservation and sustainable use of biological diversity in the Republic of Belarus. Minsk: Belsens Ltd. 1998, 46 pp.

Nilsen E.B., Linnell J.D.C., Odden J., Samelius G., Andrén H. 2012. Patterns of variation in reproductive parameters in Eurasian lynx (*Lynx lynx*). *Acta Theriol* 57: 217–223.

Okarma H. 2000. Ryś. Oficina Edytorska "Wydawnictwo Świat", 80 pp.

Okarma H., Jedrzejewska B., Jedrzejewski W., Krasinski Z. A., Milkowski L. 1995. The roles of predation, snow cover, acron crop, and man-related factors on ungulate mortality in Bialowieza Primeval Forest, Poland. *Acta Theriologica* 40 (2): 197–217.

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

Ornicāns A. 2006. Radio tracking of Eurasian lynx in Latvia: first results and conclusions. – Symposium "Fragmentation of habitats and lynx populations in Europe" Fischbach, Germany /France, 27.-29.01.2006.

Ornicāns A., Andersone Ž., Jaunbirze S., Ozoliņš J., Lapiņš K. 2004. Eirāzijas lūšu *Lynx lynx* populācijas struktūra Latvijas ainavā: pirmie rezultāti. – III Latvijas Ģeogrāfijas kongress Latvijas ģeogrāfija Eiropas dimensijās 2004. gada 5.-6. novembrī, Rīga: Latvijas Ģeogrāfijas biedrība, 55. -57. lpp.

Ornicāns A., Andersone-Lilley Ž., Žunna A. Pupila A., Ozoliņš J., Vaiders A. 2005. Radio tracking of Eurasian lynx *Lynx lynx* in Latvia: first results and conclusions. – The 6th Baltic Theriological Conference, Latvia, 11.-15. November 2005, 38.lpp.

Ornicāns A., Ozoliņš J. 2010. Vidzemē iezīmētu Eirāzijas lūšu (*Lynx lynx*) tēviņu aktivitātes un teritoriālās uzvedības izvērtējums, izmantojot GPS telemetrijas datus. – Latvijas Universitātes 68. konference, 03.02.2010.

Ornicāns A., Ozoliņš J., Andersone-Lilley Ž., Vaiders A., Žunna A., Pupila A., 2008. Movement pattern and home range use by Eurasian lynx *(Lynx lynx)* in Latvia. – The 7th Baltic Theriological Conference, Lepanina, Estonia, 01.-05.10.2008. Abstracts, 111 p.

Ornicāns A., Vaiders A., Ozoliņš J., Žunna A., 2007. Eirāzijas lūša *Lynx lynx* apdzīvoto teritoriju vides raksturojums Latvijā. Latvijas Universitātes 65. konference.

Ozoliņš J. 2001. Implementation prospects of large carnivore action plans in Latvia. In: Human dimensions of large carnivores in Baltic countries, Proceedings of BLCI symposium, 27-29 April, Šiauliai, Lithuania, pp. 49–52.

Ozoliņš J. 2002. Lūša (*Lynx lynx*) aizsardzības plāns Latvijā. Salaspils: LVMI „Silava", ZM Valsts meža dienests, 36 lpp.

Ozoliņš J. 2006. „Appearance from the other side" – strengths and weaknesses of large carnivore management system in Latvia. *Environmental encounters*, No. 60, Proceedings, Transboundary management of large carnivore populations, Osilnica (Slovenia), 15-17 April 2005: 72–74.

Ozoliņš J., Bagrade G., Ornicāns A., Pupila A., Vaiders A. 2007. Eirāzijas lūša (*Lynx lynx*) aizsardzības plāns. Salaspils: LVMI "Silava", 51 lpp.

Ozoliņš J., Laanetu N., Vilbaste E. 2005. Prospects of integrated game management in the trans-border area of North Livonia. Final report (manuscript).

Ozoliņš J., Pupila A., Ornicāns A., Bagrade G. 2008. Lynx management in Latvia: population control or sport hunting? – In: Proc. of 1st Scientific Conference of the North Vidzeme Biosphere Reserve „Economic, social and cultural aspects in biodiversity conservation", 23 November, 2006.

Ozoliņš J., Žunna A., Howlett S.J., Bagrade G., Pilāte D., Ornicāns A., Pēterhofs E. 2016. Population dynamics of large mammals in Latvia with an emphasis on prey-predator interactions. - In: M. Stubbe (ed.), Beiträge zur Jagd- und Wildforschung, Band 41, Halle/Saale: Gesellschaft für Wildtier- und Jagdforschung e.V., S. 59–73.

Priedītis N. 1999. Latvijas mežs: daba un daudzveidība. Rīga: WWF. 209 lpp.

Ratkiewicz M., Matosiuk M., Kowalczyk R., Konopiński M.K., Okarma H., Ozolins J., Männil P., Ornicans A., Schmidt K. 2012. High levels of population differentiation in Eurasian lynx at the edge of the species' western range in Europe revealed by mitochondrial DNA analyses. *Anim Conserv* 15: 603–612.

Ratkiewicz M., Matosiuk M., Saveljev A.P., Sidorovich V., Ozolins J., Männil P., Balciauskas L., Kojola I., Okarma H., Kowalczyk R., Schmidt K. 2014. Long-range gene flow and the effects of climatic and ecological factors on genetic structuring in a large, solitary carnivore: the Eurasian lynx. *PloS one* 9(12), e115160.doi:10.1371/journal.pone.0115160.

Reig S., Jedrzejewski W. 1998. Winter and early spring food of some carnivores in the Bialowieza National Park, Eastern Poland. *Acta Theriologica* 33 (5): 57–65.

Rodriguer A., Carbonell E. 1998. Gastrointestinal parasites of the Iberian lynx and other wild carnivores from Central Spain. *Acta Parasitologica* 43 (3): 128–136.

Rueness E.K., Jorde P.E., Hellborg L., Stenseth N.C., Ellegren H. Jakobsen K.S. 2003. Cryptic population structure in a large, mobile mammalian predator: the Scandinavian lynx. *Mol Ecol* 12(10): 2623–2633.

Rueness E.K., Naidenko S., Trosvik P., Stenseth N.C. 2014. Large-scale genetic structuring of a widely distributed carnivore - the Eurasian lynx (*Lynx lynx*). *PloS one* 9(4) e93675.

Sæther B.E., Engen S., Odden J., Linnell J.D.C., Grøtan V., Andrén H. 2010. Sustainable harvest strategies for age-structured Eurasian lynx populations: The use of reproductive value. *Biol Conserv* 143: 1970–1979.

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. 2004. The large cat in Europe. In: B. Jędrzejewska, J.M. Wójcik (eds.). Essays on Mammals of Białowieża forest. Białowieża: Mammal Research Institute Polish Academy of Sciences, 85–92.

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

Schmidt K., Kowalczyk R., Ozolins J., Männil P., Fickel J. 2009. Genetic structure of the Eurasian lynx population in northeastern Poland and the Baltic states. *Conserv Genet* 10(2): 497–501.

Schmidt K., Ratkiewicz M., Konopiński M.K. 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 Rev* 41: 112–124. DOI: doi:10.1111/j.1365-2907.2010.00180.x

Schmidt-Posthaus H., Breitenmoser-Würsten C., Posthaus H. 2002. Causes of mortality in reintroduced Eurasian lynx in Switzerland. *Journal of Wildlife Diseases* 38 (1): 84–92.

Sindičić M., Polanc P., Gomerčić T., Jelenčič M., Huber D., Trontelj P., Skrbinšek T. 2013a. Genetic data confirm critical status of the reintroduced Dinaric population of Eurasian lynx. *Conserv Genet*: 1–12.

Sindičić M., Gomerčić T., Polanc P., Krofel M., Slijepčević V., Gembarovski N., Durčević M., Huber D. 2013b. Kinship analysis of Dinaric lynx *(Lynx lynx*) population. *Sumarski list* 1-2: 43–49.

Skalski J.R., Ryding K.E., Millspaugh J.J. 2005. Wildlife Demography: Analysis of Sex, Age, and Count Data. Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Elsevier Academic Press, 636 pp.

Smirnov M.N., Noskov V.T. 2003. The Central-Siberian part of the area (the Medial group of regions): The Baikal Coastal Region and Transbaikaliya. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 331–344 (in Russian/English).

Strods H., Zunde M., Mugurēvičs Ē., Mugurēvičs A., Liepiņa D., Dumpe L. 1999. Latvijas mežu vēsture līdz 1940. gadam. Rīga: WWF – Pasaules Dabas Fonds, 363 lpp.

Sunde P., Kvam T. 1997. Diet patterns of Eurasian lynx *Lynx lynx*: what causes sexually determined prey size segregation? *Acta Theriologica* 42 (2): 189 –201.

Sunquist M.E., Sunquist F.C. 2002. Wild cats of the world. London: The University of Chicago Press, 452p.

Sunquist M.E., Sunquist F.C. 2009. Family Felidae. Pp 54-170 in: Wilson D.E. and Mittermeier R.A. eds. (2009). Handbook of the Mammals of the World. Vol 1. Carnivores. Lynx Editions, Barcelona.

Sutherland W.J. 2000. The Conservation Handbook: Research, Management and Policy. Blackwell Science, University Press, Cambridge, 296p.
Tauriņš, E. 1982. Latvijas zīdītājdzīvnieki. Rīga: Zvaigzne, 256 lpp.
Vaiders A. 2007. Lūša *Lynx lynx* aktivitāte un to ietekmējošie faktori Latvijā. Maģistra darbs. Rīga: LU, 36 lpp.
Valdmann H. 2006. Lynx (*Lynx lynx*) and wolf (*Canis lupus*) in the Baltic region: diets, helminth parasites and genetic variation. PhD thesis. Tartu: University of Tartu, 102 pp.
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., Andersone-Lilley Z., Koppa O., Ozolins J., Bagrade G. 2005. Winter diets of wolf *Canis lupus* and lynx *Lynx lynx* in Estonia and Latvia. *Acta Theriologica* 50 (4): 521–527.
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 Nr. 19, 330 pp.
Ziediņš J. 1985. Medību ierīcība Latvijas PSR. Apskats. Rīga: LatZTIZPI, 60 lpp.
Zhiraykov V.A. and Baydavletov R.Zh. 2003. The Central-Siberian part of the area (the Medial group of regions): Kazakhstan. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 344–367 (in Russian/English).
Zyryanov A.N. and Smirnov M.N. 2003. The Central-Siberian part of the area (the Medial group of regions): The Sayan Mountains. – In: Matyushkin Ye.N., Vaisfeld M.A. (eds.) The Lynx: Regional Features of Ecology, Use and Protection. Moscow: Nauka, pp. 313–331 (in Russian/English).
Žunna A., Ozoliņš J., Stepanova A., Ornicāns A., Bagrade G. 2011. Food habits of the lynx (*Lynx lynx*) in Latvia based on hunting data. – In: Stubbe M (ed) Beiträge zur Jagd und Wildforschung, Band 36. Gesellschaft für Wildtier- und Jagdforschung e.V., Halle/ Saale, pp 309–317.

The IUCN Red List of Threatened Species. Version 2017-1. <www.iucnredlist.org>. Downloaded on 18 June 2017

Гвоздев Е.В. 1982. Млекопитающие Казакстана. Том 3, часть 2. Наука, Алма- Ата,104–113.
Гептпер В.Г., Слудский А.А. 1972. Млекопитающие Совеского Союза. Том 2, часть 2. Вышая щкола, Москва, 385–457.
Данилов И. И., Русаков О. С., Туманов И. Л. 1979. Хищные звери Северо-Запада СССР. Ленинград: Наука, 162 с.
Казлаускас Ю., Прусайте Я. 1976. Гельминты животных отряда хыщных (Carnivora) в Литве. *Acta Parsitologica Lithuanica:* 14: 33–41.
Кучерепко С.П. 1988. Хищние звери леса. Агропромзад, Москва, 50–60.
Леснов П.А. 1976. Страные посиупки рыси. *Химия и жизнь* 7: 103–105.
Матюшкин Е. Н. 2000. Следы и метод тропления в изучении крупных хищных млекопитающих. *Зоол. журнал* 79. (4): 412–429.
Новиков Г. А. 1956. Хищные млекопитающие фауны СССР. Москва-Ленинград: Изд-во АН СССР, 293 с.
Соколов В. Е. 1979. Систематика млекопитающих. Отряды: китообразных, хищных, ластоногих, трубкозубых, хоботных, даманов, сирен, парнокопытных, мозоленогих, непарнокопытных. Москва: «Высшая школа», 527 с.
Шевченко Л.С., Песков В. Н. 2007. Морфологическая изменчивость и внутривидовая систематика обыкновенной рыси (*Lynx lynx*). *Збірник праць Зоологічного музею* 39:81–99.

Appendices

John Linnell, Review of the Latvian “Action plan for Eurasian lynx *Lynx lynx* conservation and management” revision for period 2018 to 2028; pdf

Alistair Bath, Review of the Latvian Eurasian Lynx Action Plan; pdf