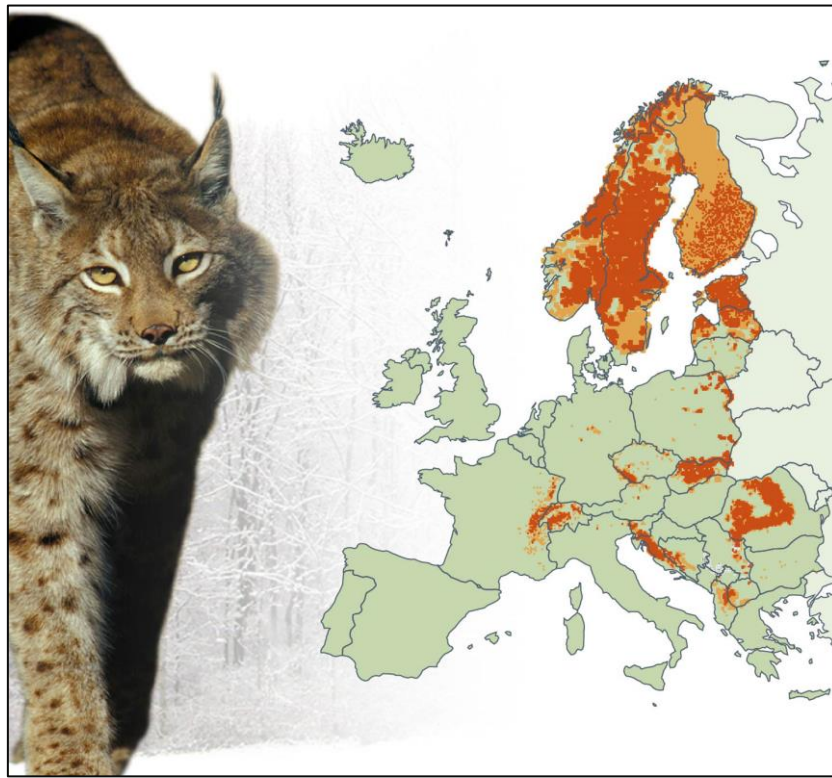




D.T1.2.1

Compendium of existing approaches from other sources including threats, joint barriers and driver assessment



R. Behnke (Editor)



Research Institute of Wildlife Ecology, Vienna

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1 Introduction

The aim of this deliverable is to present an overview of current lynx management approaches and monitoring methods, about challenges and problems arising with the occurrence of the species and for detecting and capturing Eurasian lynx as well as determining their distribution outside the Bohemian-Bavarian-Austrian (BBA), East-Alpine and Dinaric population and the participating countries of the 3Lynx project.

Assessment of these efforts allows for identification of factors that have emerged as barriers and drivers during implementation of active and passive monitoring schemes and informs future choices concerning monitoring, participatory measures for stakeholder involvement and other related topics, which were identified as crucial elements for functional Eurasian lynx management and monitoring schemes.

The compendium lists approaches (and outcomes) in countries of the European Union with Eurasian lynx populations and includes management and monitoring programs that are currently in use, are under development or are planned for the future. Additionally, threats and arising conflict scenarios within the respective countries are mentioned and subsequent conflict management and compensation plans are described, where available, with the goal of identifying and pointing potential options and solutions for conflict mitigation and reduction.

At last, a conclusion provides a summary about the aspects of lynx management and monitoring, that have emerged as the most urgent and important topics in the respective countries/populations, as well as problems or challenges that have arisen. Additionally, the appendix provides overview tables of applied management and monitoring schemes and compensation schemes, as well as existing/arising threats and conflicts for each country and population accompanied by a list of actual literature references, which cites actual approaches and publications allowing easy access of information to deal with the respective topic in more detail.

The review of available management and monitoring schemes within the present compendium will support the 3Lynx project, as well as other prospective projects concerning conservation of Eurasian lynx, with useful information that should guide development and implementation of standardized management and monitoring schemes in the future.

2 Overview Eurasian Lynx in Europe

Distribution range

The distribution range of the Eurasian lynx covers 27 European countries proportionally, occurring in 10 different populations. Six of these populations are small, fragmented and are currently Endangered or Critically Endangered (Alpine, Balkan, Bohemian-Bavarian-Austrian, Dinaric, Jura and Vosges-Palatinian), while the others are of Least Concern and Viable (Baltic, Carpathian, Karelian and Scandinavian). Nonetheless, only five EU countries (Estonia, Latvia, Finland, France (Vosges-Palatinian) and Slovenia (East-Alpine population)) have achieved a Favourable Conservation Status (FCS). For the remaining EU member states, the conservation status is classified as bad or inadequate. Some countries share their population with neighbouring countries with indeterminate or unfavourable status (Mussa et al. 2018).

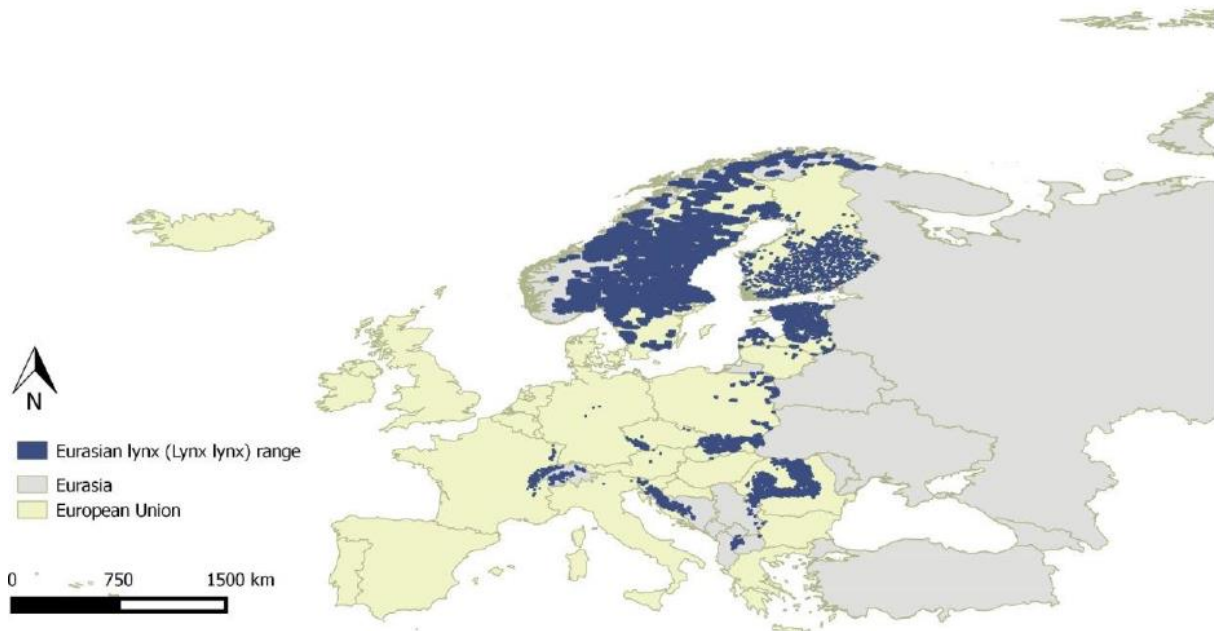


Figure 1. Eurasian lynx distribution range in Europe (Mussa et al. 2018)

Population estimates

The estimated population size of Eurasian lynx in Europe is 9.000-10.000 individuals (excluding animals in Russia and Belarus). The largest lynx populations are comprised of the autochthonous Scandinavian (Sweden and Norway ~ 1.800-2.300) population in the North and the autochthonous Karelian (Finland~ 2.500), Baltic (Estonia, Latvia, Lithuania, NE-Poland, Ukraine ~ 1.600) and Carpathian (Bulgaria, Czech Republic, Hungary, Montenegro, Poland, Romania, Serbia, Slovakia and Ukraine ~ 2.300 - 2.400) population in the East (Kaczensky et al. 2013).

Distribution & estimated population size of Eurasian lynx populations in Central Europe			
Name	Country	Size (km ²)	Approx. population size
Baltic Population	Estonia, Latvia, Lithuania, Poland, Ukraine	60.000	~1.600 individuals¹ Estonia: 600 - 800 ind. ⁸ Latvia: > 600 ind. Lithuania: 120 - 150 ind. ¹³ Poland: 30 - 40 ind. Ukraine: 80-90 ind.
Balkan Population	Montenegro, Albania, Kosovo, Macedonia, (Serbia, Bulgaria)	1.600	20 - 39 individuals¹ Albania: 5-10 Kosovo: 2-4 Macedonia: 15 - 27 Montenegro: ?
Bohemian-Bavarian-Austrian Population	Austria, Germany, Czech Republic	6.000	60 – 80 individuals¹ Czech Rep.: 30 - 45 Germany: ~20 Austria: 5 - 10
Carpathian Population	Romania, Slovakia, Poland, Ukraine, Czech Republic, Hungary, Serbia & Montenegro, Bulgaria	104.000	2.200 - 2.300 ind.¹ Romania: 1200-1500 Slovakia: 269 ⁷ Poland: ~100 Ukraine: 350-400 Czech Republic: 13 Hungary: 1-3 Serbia: 50 Bulgaria: ≥ 11
Dinaric Population	Slovenia, Croatia, Bosnia and Herzegovina	10.000	80 - 100 ind.¹ Slovenia: 10-15 ind. Croatia: 30 - 60 ind. Bosnia-Herzegovina: 40(90?) Ind. ⁹
East-Alpine Population	Italy, Slovenia	3.400	~10 ind.¹
Jura Population	France; Switzerland	11.000	100 ind.⁶; 61 ind. (+/-13)^{1,2}
Karelian Population	Finland	not available	2.430 – 2.610 ind.^{1,4}
Scandinavian Population	Norway, Sweden	not available	1.500 – 1.700 ind. Norway: 56 family groups (330 ind.) ¹¹ Sweden: ~200 family groups (1.200 – 1.300 ind.) ¹⁰
Vosges – Palatinian Population	France; Germany	500 ; 1600	<10 ind.⁶; 6 – 12 ind.¹²
Western-Alps – Population	Switzerland, France	12.600 ⁵	144 ind. (+/- 8)¹; 15 ind.⁶

Table 1. Distribution and estimated population size of the Eurasian Lynx (*sources listed on next page)

	Country	Region	Number of sites	Reintroduction	Period	M/F	Telemetry	Population survey
1	Switzerland	Northern Alps	2	O + U	1971–1973	4:4	No	No
2		Western Alps	2	O + U	1975–1976	2:?	No	No
3		Eastern Alps (Grisons)	1	U	1972 et 1980	2:2	No	No
4		Jura	3	O + U	1972–1974	5:5	No	No
5		Plateau	1	U	1989	3	No	No
6		Eastern Alps	1	O	2001	3:3	Yes	Yes
7	Italy	Alps (Val Savaranche)	1	O	1975	2:0	Yes	No
8	Slovenia	Kocevje	1	O	1973	3:3	No	Yes
9	Austria	Alps (Styrie)	1	O + U	1977–1979	6:3	Yes (4 individuals)	interrupted
10	Germany	Harz	?	O	2000–2001	4:8	No	No
11		Bavarian Forest	?	U	1970–1972	5 to 9?	No	No
12	Czech Republic	Bohemian Forest	?	O	1982–1989	11:7	No	No
13	Poland	Kampinski National Parc	?	O	1993–1994	2:5	Yes	No
14	France	Vosges	4	O	1983–1993	12:9	Yes	Yes

O, official release; U, unofficial release; M, male; F, female.

Table 2. Lynx reintroductions in Western Europe since the beginning of 1970s (Vandel et al. 2006)

All other populations in Central Europe derive from reintroduction scenarios and are of smaller size, as they were generated from a small founder population 20 - 40 years ago. The current population size is as follows: East-Alpine (Italy, Slovenia ~ 10), Western-Alps (Switzerland ~ 160), Vosges-Palatinian (France, Germany ~ 10 - 20), Jura (France, Switzerland ~ 160), Bohemian-Bavarian (Austria, Germany, Czech Republic ~ 60 - 80), Dinaric (Slovenia, Croatia, Bosnia and Herzegovina ~ 80 - 100) and Balkan population (Albania, Kosovo, Macedonia, Montenegro, Serbia, Bulgaria ~ 40-50).

Currently, populations of greatest conservation concern are the East-Alpine and Dinaric populations, whose responsible countries are partners within the 3Lynx project and who are facing scenarios of inbreeding (inbreeding coefficient 0.30 in Slovenia) and Vosges-Palatinian (facing reduced genetic diversity with an inbreeding coefficient of 0.06) and the fifth autochthonous one, the Balkan lynx population, which numbers only 27-52 individuals according to recent research projects conducted in Albania, Kosovo, Serbia, Montenegro and Macedonia (Černe 2017, Bull et al. 2016; IUCN/SSC 2015).

¹Kaczensky et al. (2013), ²www.kora.ch (2015), ³Vandel et al. (2006), ⁴www.luke.fi (2017), ⁵Zimmermann et al. 2011, ⁶Bauduin et al. (2018), ⁷Kubala et al. (2018), ⁸Remm et al. (2018), ⁹Kunovac and Omanović (2018), ¹⁰Hemmingmoore (2018), ¹¹<http://www.environment.no>, ¹²Huckschlag (2018); ¹³Balčiauskas (2018)

3 Overview of monitoring schemes within different lynx populations of Europe

Scandinavian Population (Norway, Sweden)

Monitoring in the Scandinavian population is based on snow-tracking, camera-trapping in reference areas, analysis of lynx harvest data, collection of livestock depredation cases and genetic analysis (of non-invasively collected samples such as scat and hair in Sweden only) additionally supported by radio telemetry.

Karelian Population (Finland)

In Finland, snow-tracking and radio telemetry is employed.

Baltic Population (Estonia, Latvia, Lithuania and Poland)

In Estonia, Latvia, Lithuania and Poland, estimates are mostly based on snow-tracking (counting females with offspring), supported by camera trapping (in Białowieża Forest/Poland) and analysis of harvest bag data for Estonia and Latvia, which have defined open seasons for Eurasian lynx.

Carpathian Population (Czech Republic¹, Bulgaria, Hungary, Romania, Poland, Serbia, Slovakia)

For the Carpathian Population, which is considered to be one of the best preserved and largest Eurasian lynx populations in Europe, monitoring and population number estimates are based mainly on hunting ground counts (analysis of hunting bags), snow tracking and 'guesstimates'. Although Poland has employed radio-telemetry in research projects and uses camera-trapping (see Carpathian population - Poland), in most countries that accommodate the Carpathian population, non-systematic monitoring and management approaches prevail. Thus, Romania uses snow-tracking and systematic camera-trapping, snow-tracking and DNA-analysis in reference areas, Slovakia used hunters' reports and expert estimates before conducting the first camera-trap surveys during 2011 -2015 and implementing systematic monitoring and subsequent statistical analysis modeled on the Swiss lynx monitoring scheme (Rigg and Kubala 2015; Kubala et al. 2017). The applied scheme of the Czech Republic, as project partner within 3Lynx, can be found in D.T 1.2.1. In Hungary for several years, researchers from Aggtelek National Park have been monitoring the presence of lynx via snow tracking; other than that monitoring relies on questionnaires answered by game and hunting ground managers and the newly-instituted and sporadic use of camera traps within the National Park and at the border to Slovakia. In Serbia and Bulgaria, no official or additional population estimations by systematically applied monitoring techniques have been established (consequently, the methods currently described in these countries are only applied in specific research projects).

Alpine population (France, Germany, Switzerland)

Within the Alpine population of Switzerland and France as well as Italy, camera-trapping (including capture-mark-recapture (CMR)) in reference areas and density extrapolation is combined with the collection of different data sets validated (stratified monitoring) using the criteria developed by the Status and Conservation of the Alpine Lynx Population (SCALP) project (Molinari-Jobin et al. 2012; Kaczensky et al. 2013).

Jura population (France, Switzerland)

For the Jura population, which consists geographically of a sub-alpine mountain range located north of the Western Alps of Switzerland, a similar monitoring scheme is applied as for the Alpine population but without validating the collected data using the criteria developed by the Status and Conservation of the Alpine Lynx Population (SCALP) project (Molinari-Jobin et al. 2012; Kaczensky et al. 2013).

Vosges-Palatinate population (France, Germany)

Within the monitoring scheme applied for the Vosges populations (France) no SCALP criteria is applied. The monitoring scheme applied in the Palatinate forest (Germany) is using the criteria developed by the Status and Conservation of the Alpine Lynx Population (SCALP) project (Molinari-Jobin et al. 2012).

Balkan Population (Albania, Macedonia, Kosovo)

The Balkan Lynx Recovery Programme for the Balkan population institutionalizes a monitoring scheme derived from a scheme applied in the Alps and Jura populations, consisting of camera-trapping (including capture-mark-recapture (CMR) in reference areas and density extrapolation), combined with the collection of different data sets (e.g. data from chance observations, mortality data, lynx kills etc.) validated using the criteria developed by the Status and Conservation of the Alpine Lynx Population (SCALP) project (Molinari-Jobin et al. 2012).

Dinaric Population (Croatia, Bosnia and Herzegovina, Slovenia²)

The basic monitoring methods applied in the Dinaric population are camera trapping and snow tracking (all three countries), genetic sampling (Croatia, Slovenia), expert opinion and guesstimates (Slovenia only).

^{1, 2} the applied management and monitoring schemes applied within the Dinaric population for Slovenia, as well as the East-Alpine (Italy and Slovenia) population are already described in D.T 1.2.1 - Compendium of existing approaches within partnership including joint barriers and driver assessment.

4 Main conflict scenarios and threats in Europe

Livestock depredation

Livestock depredation rates and resultant conflict scenarios are low for most of the lynx populations and respective countries. In the Alpine and Jura populations, minor damage occurs: usually less than 100 domestic animals are killed per year in total. Only the Scandinavian and Karelian populations are facing major depredation problems of livestock (sheep) and semi-domestic animals (reindeer). For instance, in Norway, about 7.000-10.000 sheep and 3.000-8.000 reindeer are verifiably attributed to predation by large carnivores, including the lynx, incurring costs of up to 2.1 to 2.9 Mio for sheep and 1.1. to 3.4 Mio. € paid in in the form of direct compensation for losses annually (Kaczensky et al. 2013). In theory, compensation is paid for all killed animals that are examined and documented by the regional Norwegian Nature Inspectorate officers. Normally, death must be confirmed as being caused by lynx; however, lynx are assumed to be responsible even though evidence to support this accusation is lacking. In 95% of the cases where compensation is paid, lynx involvement was not confirmed or the predated animal was never found (archnetwork.org).

In 2009, Sweden paid ~17.500 € for depredation of sheep (approx. 40 - 100 sheep/per year have been attacked by lynx since 2001 (Widman et al. 2017)). An additional ~3.5 Mio. € was paid as economic incentive to reindeer herders to encourage acceptance of lynx in their ancestral environment. In 2011, Finland paid 15.600 € for 25 domestic animals and ~827.000 € for 554 reindeer verifiably killed by lynx (see respective passage on compensation schemes in Finland/Karelian Population, as well as Norway and Sweden (Scandinavian Population)) (Kaczensky et al. 2013).

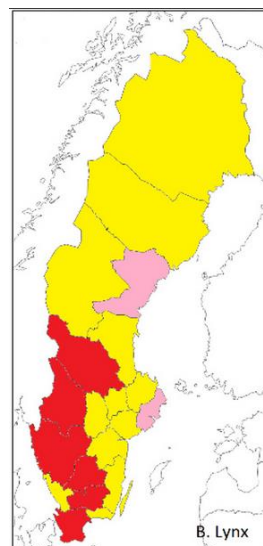


Figure 2. Geographical distribution of compensation cost for depredation caused by Eurasian lynx in different counties of Sweden, evaluated at the variable levels for 2012. Yellow: 1-5, pink: 6-10, red > 10 losses) (taken from Widman and Elofsson 2018)

Perception of lynx as competitors in ungulate hunting

Another highly relevant threat to Eurasian lynx pertains to its role as a predator of ungulates (mainly roe deer and chamois) and the subsequent influence on ungulate availability, aggregation and densities, as well as the perceived role as competitor to recreational hunting of ungulates. This conflict can be considered as a primary source and key factor for evolving conflict scenarios within the populations of the 3Lynx partnership and other existing populations resulting in negative attitude and resentment towards the species (see respective countries, informations concerning conflicts, conflict mitigation, participatory measures and threats).

Habitat fragmentation and suitability

The severe and early destruction and fragmentation of forest habitats due to human development and activities is been a leading factor in the extirpation from Western Europe of several of large, forest-dependent mammalian species, such as the Eurasian lynx. However, during the 20th century, much of the areas intensively used by forestry and industrial enterprises in the past experienced rapid, large-scale reforestation and recovery leading to reintroduction, respectively recolonization scenarios by large carnivores, in areas known to be frequented by them in the past. A persisting problem is habitat fragmentation, Eurasian lynx are often particularly sensitive to it. Thus, ecological corridors (wildlife crossings etc.) may help to connect local populations, ensuring gene flow and retaining viable meta-populations. Therefore, an important action in lynx management is to identify and integrate spatial information on lynx habitat connectivity into national and international-level planning. While legislation and procedures concerning spatial planning are well developed, there is still a gap in expert knowledge when it comes to ensuring connectivity between habitat patches for lynx.

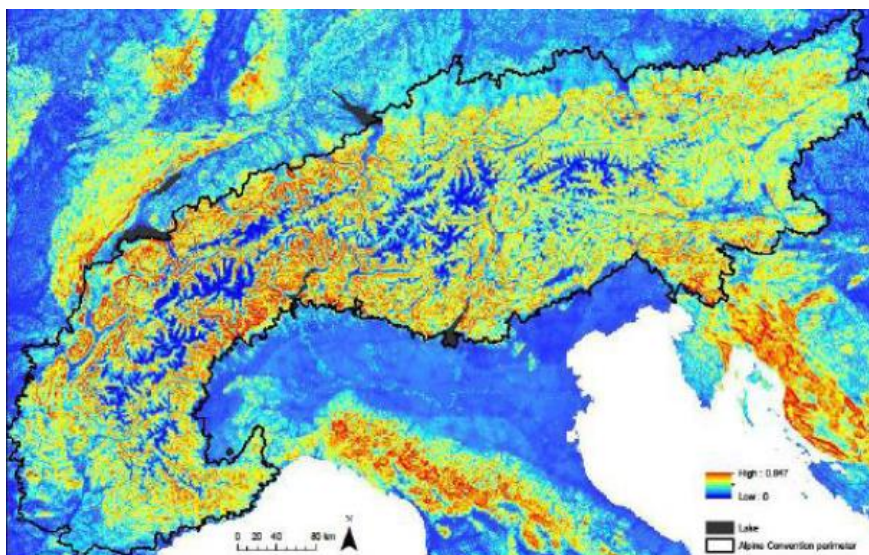


Figure 3. Lynx habitat suitability map (MaxEnt). Red = highly suitable habitat, blue = low suitable habitat (Becker 2013)

Mitigation and Conflict reduction

A range of methods exist to counteract the effects of livestock depredation, e.g. enactment of hunting quotas adjusted to the actual population size of lynx in countries with stable, viable and rather large populations (e.g. Finland, Norway, Lithuania, Latvia, Estonia and Sweden) and compensatory payments (e.g. Finland, Sweden, Norway). Along with other measures, these instruments contribute to successful conflict management. Within many countries, especially in (South-) Eastern Europe, management methods and schemes to increase public awareness and acceptance of the species and reduce illegal killings have not yet been implemented or improved; but awareness of existing drivers and joint barriers responsible for illegal poaching of lynx, which represents the main reason for stagnant populations in many areas, has already increased, and in many regions participatory processes and stakeholder involvement towards a better collaboration and dialogue between different interest groups have already been initiated and/or are about to be implemented with a medium-term view.

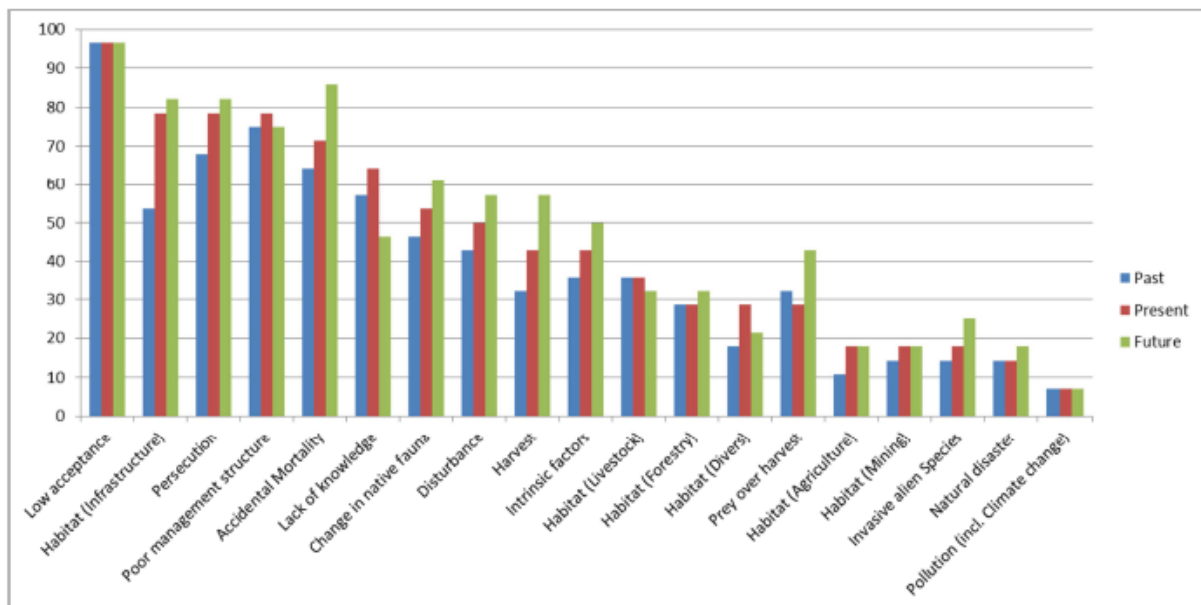


Figure 4. Driver assessment relevant for Eurasian lynx populations within Europe with the drivers grouped into 19 main categories - n=22 questionnaires (Kaczensky et al. 2013)

Driver and Driver Assessment

The most relevant drivers and resulting threats to Eurasian lynx populations and conservation efforts in Europe, as already mentioned above, are low levels of lynx acceptance largely due to existing conflicts with hunters and land users/livestock herders. This results in illegal persecution and is augmented by habitat loss and fragmentation due to infrastructural development, poor management structures, execution of policies and legal frameworks in certain countries, as well as mortality caused by traffic accidents.

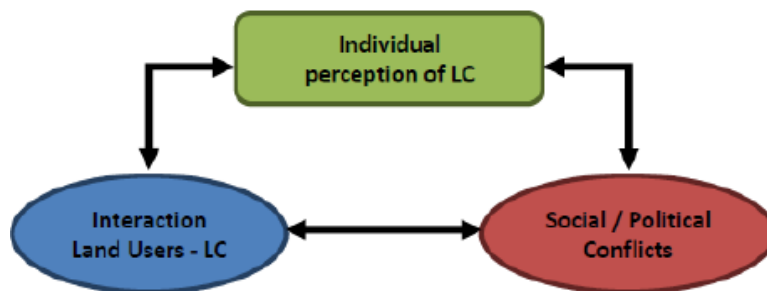


Figure 5. Various levels where factors influencing attitudes towards large carnivores are based on (Schnidrig et al. 2016)

5 Population level cooperation

For most of the populations, cooperation between scientists of different countries that share lynx occurrence has already been established and guarantees exchange of information and knowledge transfer. Current collaborations and projects aim for a unified management and monitoring approach to increase comparability of results and outcomes and the reintroduction of additional individuals to address prevalent extinction and inbreeding scenarios. As well as the essential establish- or improvement of stakeholder involvement and participatory measures within current and future Eurasian lynx management schemes in order to increase acceptance and common knowledge and disintegrate the negative attitude, as in the current 3Lynx and LIFE Lynx projects encompassing the BBA, East-Alpine and Dinaric population. In 2009, additional transboundary political agreements were signed by the Alpine countries, under the Alpine Convention called the WISO platform (Wildlife and Society). Since then, the platform has aimed to develop a common strategy for the management of the Alpine populations of lynx, wolf and bear (Kaczensky et al. 2013). But cooperation on official and management authority level is still developable, with the existing ones for the Scandinavian (SCANDLYNX) and Alpine populations (SCALP) as good examples. Another approach for a population-wide conservation strategy was presented by the BALKAN Lynx Recovery Programm developed for the Balkan population, which started the first implementation phase in 2006 and which is about to finish its fourth implementation phase in 2018 (see below).

In 2017-2018 the main topics of the platform are:

- Promoting information exchange, dialogue and coordination between the contracting parties and authorities, as well as involved wildlife managers, hunters and foresters,
- Sustainable damage prevention and compensation through reporting and exchange of national and regional applied approaches and schemes and good practices;
- Analysis of possible use of the Agricultural Fund for Rural Development to finance damage prevention measures,
- Further development of coordinated, Alpine-wide genetic monitoring programs for large predators,
- Promoting initiatives to prevent inbreeding in Alpine subpopulations of lynx.

(<http://www.alpconv.org>)

Following cooperation schemes exist for management and monitoring of European lynx populations between the different countries, sharing a population:

Balkan Population:

Technical cooperation among experts and researchers has been developed and established in the framework of the Balkan lynx recovery programme (2006-ongoing) ensuring a close cooperation among scientists and experts from Albania and Macedonia, partially initiated and supported by foreign NGOs (KORA and Euronatur). In 2008 and 2009 respectively, the document “Conservation Strategy and National Action Plans for the conservation of the Critically Endangered Balkan Lynx” was prepared by experts and authorities of both countries, with the support of the Council of Europe. The partnership was started by experts and then extended to the conservation NGOs and other relevant agencies working within the countries (Blanco 2012).

Future recommendations

Improve the, between 2013-2016 established cooperation between NGOs from Albania, Macedonia, Kosovo and Montenegro (within the Balkan Lynx Recovery Programme) by extension of the cooperation to national authority level responsible for the conservation of wildlife within the countries (e.g. Ministries of Environment and Forestry, hunting associations/federations, state inspectorates for environment and hunting etc.).

Baltic Population:

Established exchange of information among the EU countries, but no extensive research/monitoring and management cooperation. A partnership on basis of rather private contacts and on personal level between experts, with a strong cooperation existing between Estonia, Latvia, Lithuania and Poland regarding lynx research.

Additionally, there is a long-lasting personal cooperation between Polish and Belarusian scientists from the Mammal Research Institute of the Polish Academy of Science in Bialowieza (MRI), Bialowieza NP, the Scientific and Practical Center of the National Academy of Sciences of Belarus for Bioresources (SPC NAS of Belarus for Bioresources) in Minsk and the Belorussian part of Bialowieza NP.

On political level though, cooperation for a coordinated lynx management is lacking.

Future recommendations

For improvement of coordination of lynx management and monitoring it is necessary to start a partnership of EU countries of the Baltic population with non-EU countries Russia, Belarus and Ukraine to introduce common monitoring standards, as well as to coordinate lynx hunting and the validation of plausible hunting quotas between Belarus, Latvia, Estonia and Russia to create bi- or multi-lateral Baltic lynx working groups (Blanco 2012).

Carpathian Population:

Cooperation in regard of monitoring in the border region between Slovakia and Poland exists, but no management cooperation. For the other countries, there is no specific cooperation regarding lynx research, monitoring nor management.

In spite of starting different cooperation initiatives (e.g. Swiss-Slovak Cooperation Programme) there are no commonly agreed monitoring methods, nor common management projects, but to some extent research projects focusing on genetics between countries (see Carpathian population: Poland).

Future recommendations:

To improve cooperation schemes between the countries, it is necessary to create bi- or multi lateral lynx working groups in order to introduce common monitoring standards for the lynx subpopulations of the Carpathian population or at least a common annual assessments of population size and distribution area based on national surveys (Blanco 2012).

Dinaric population:

Intensive scientific and management cooperation exists between Slovenian and Croatian scientists and management professionals, while official cooperation among authorities exist but is not so well developed.

Several research and management projects were implemented in cooperation between the two countries resulting in a much better understanding of the lynx population status and harmonized monitoring techniques, which lead to increased effectiveness of monitoring and management efforts in both countries by joining data allowing better supported conclusions and a better understanding of population-level dynamics, while addressing important management and research questions for the population.

Bosnia and Herzegovina lack capacity for both research and monitoring, but there are occasional cooperations between Croatian/Slovenian and BiH reserchers.

Future recommendations:

For improvement of coordination in research and monitoring it is necessary to integrate Bosnia-Herzegovina into ongoing conservation efforts. Initially, capacity building is needed, management and monitoring would be greatly improved if regularly applied using unified methods and implementing a common database in all three countries. In terms of lynx management issues, national governments should organize meetings, study the strategic documents already prepared by scientists (e.g. Majic-Skrbinsek et al. 2008). Aditionally, improvement would be provided, by regularly including representatives from neighbouring countries in management and conservation decisions.

Jura Population:

There is little cooperation in terms of monitoring, research and management for the Jura population between France and Switzerland. Experts of both countries follow the monitoring standards established by the SCALP project (Molinari-Jobin et al. 2011). Blanco (2012) mention cooperation between french experts and the Swiss NGO KORA for a better interpretation of camera trap data. Efforts were made to have joint data collection, hence camera-trapping surveys were conducted in parallel in adjacent study areas located along the national border. However, no joint analyses were conducted so far but attempts are underway. In the frame of the German-French-Swiss Oberrhein Conference (ORK), a lynx working group has been established to define common norms for the conservation, management and monitoring of lynx in the Jura Mts., Vosges, Palatinian Forest and Black Forest (von Arx, pers. comm).

Vosges-Palatinian Population:

Since 2015, cooperation between France and Germany exists within the LIFE Lynx Palatinate Forest Project. Prior in 1998, these two parks achieved the creation of a transboundary biosphere reserve. The project is based on the sequential release of 20 lynx in total into the Palatinate Natural Park on the German side with the expectation, that they will breed and migrate across the border into the Vosges du Nord Natural Park on the French side. Responsible body of the EU LIFE project is the Nature and Environment Foundation Rhineland-Palatinate (SNU). Together with its project partner Sycoparc (Syndicat de Coopération pour le Parc Naturel Régional des Vosges du Nord), various (cross-border) public relations activities are being implemented. One of the key foci lies on close cooperation between German and French stakeholders (especially hunters, shepherds or other livestock owners) to establish self-contained long-term acceptance of the lynx in the Natural Parks and its surroundings.

Since 2017, cooperation between France (CROC¹, ONCFS) and Germany (SNU) also exists for GPS monitoring of lynx released in the Palatinate forest who install their home ranges in the French Vosges mountains (prey survey, VHF, etc.). This cooperation must continue and might be formalized to strengthen it.

¹ Centre de Recherche et d'Observation sur les Carnivores (www.croc-asso.org)

Alpine Population:

The technical cooperation of lynx monitoring and research in the Alps is performed through SCALP, an ongoing programme aimed to co-ordinate the lynx monitoring and the conservation activities in the Alps. The long-term goal is to assist the existing reintroduced populations to expand and recover throughout the Alps in co-existence with people.

The process is advanced and supervised by the SCALP Expert Group, which unites lynx experts - scientists and wildlife biologists with different backgrounds and affiliation from each Alpine country.

The ongoing cooperation is resulting in an efficient population-based monitoring and management and forms the scientific basis for lynx conservation in the Alpine region (following the ideas of the Guidelines for population level management plans for large carnivores).

Additionally, WISO a transboundary arrangement signed by the Alpine countries under the Alpine Convention, established to work for integrated policies and approaches for the sustainable development of the Alpine Space, deals with large carnivores and wild ungulates.

Future recommendations

Lynx monitoring is satisfying in most Alpine countries, but not in all. Consequently, improvement is needed, regarding the coordination of management within the Alpine Convention by applying a common definition of goals and a solidary implementation of conservation actions. This is politically very difficult to achieve, because of the different national agendas and political constraints within the Alpine countries (Blanco 2012).

Karelian Population:

For the Karelian Population exists no technical nor management coordination between Finland and Russia, which are sharing the population.

Scandinavian Population:

Cooperation between Sweden, Norway (and partly Finland) started as a coordination of research funding for large carnivore research in the 1980s and has developed from mainly scientific collaboration into management coordination (Blanco 2012).

Consequently, there is a close collaboration in research and monitoring between Sweden and Norway (see Scandinavian population: Cooperation - Scandlynx). Both countries use similar monitoring methods, with some small differences. A group of experts of both countries work to harmonize the methods with the aim to apply the same monitoring methods in Sweden and Norway.

Positive outcomes of the cooperation between Sweden and Norway is a much better foundation for management decisions. The joint research program has also led to larger data set and possibilities to compare data on population level.

Future recommendations:

In order to improve the coordination from a technical point of view, a common annual lynx status report is needed. This report should also forecast the effects of different harvest levels at different management scales (regional, national and Sweden/Norway combined). Additionally, cooperation requires more meetings considering the effects of some management actions, e.g. harvest quotas, which are not coordinated on population level.

6 Lynx populations in Europe

Balkan Population

(without Kosovo, no information on lynx management and monitoring schemes in the Kosovo area could be obtained)

Albania

Existing approaches (monitoring and participation/stakeholder involvement)

Extensive monitoring with questionnaire baseline surveys (2006-2007), snow tracking and camera-trapping in selected regions (2008 - 2011) is applied by the national non-governmental environmental organization PPNEA (Protection and Preservation of Natural Environment in Albania). This organization has been active during the last years in monitoring lynx and other large carnivores protected by law (Ibrahimi 2017). Derived from these efforts is some C1-evidence in the form of camera-trapping photographs and lynx killed as trophies in the northern and eastern parts of the country. Monitoring efforts through extensive camera-trapping during 2009-12 allowed confirmed identification of at least three different lynx individuals roaming the country (from only four camera-trap pictures in total) (Trajçe and Hoxha 2012).

The European Status report on large carnivores suggests a population size of less than 5-10 individuals (Kaczensky et al. 2013). An official estimation of the lynx population in Albania was presented at the Annual Report on the State of Environment for 2009 as consisting of 33 individuals. Two years earlier within the “Lynx Action Plan- Albania”, Bego (2007) estimated an approx. population size of 28 individuals (MoE 2010; Bego 2007). This represents a discrepancy between official information given by state authorities and expert evaluations in regard to lynx population size in Albania. There was however no detail given on the methodology implemented in this assessment.

The “Balkan Lynx Recovery Programme” (BLRP) started in Macedonia and Albania in 2006 (with its fourth implementation phase ending in 2018). The project's main goals were: survey and monitor the Balkan Lynx within Albania, while collecting basic information on Balkan Lynx distribution and presence, estimating population trend, abundance, prey availability as well as developing a range wide Conservation Strategy and National Action Plan, defining areas along the European Green Belt in the Balkan Lynx distribution area and lobby for their proclamation as protected areas. Additionally, the project aimed to build professional partnerships consisting of relevant stakeholders in the field of nature protection within Albania (Breitenmoser et al. 2008). A second phase of the Balkan Lynx Recovery Programme started in 2010 as a continuation of the previously defined goals and activities.

The need for verification data on Balkan Lynx biology and ecology led to the first scientific project called: “Status, ecology and land-tenure system of the critically endangered Balkan lynx in Macedonia and Albania”.

The project was supported by the Swiss National Science Foundation under the SCOPES programme (Scientific Cooperation between Eastern Europe and Switzerland). The project started in 2010 and lasted until the end of the second phase of the BLRP in 2012.

During this period, a wildlife monitoring network consisting of interested stakeholder groups and knowledgeable people within Albania was formed. Around the same time, in March 2011, the PPNEA lynx team set four cameras in the southern slopes of Munella, Albania, and a picture of a captured Balkan lynx was obtained on 26 March 2011. This was the first evidence of a live Balkan lynx in the wild in Albania (after finding just stuffed and in illegal captivity held individuals), proving the existence of the species and their survival within the country after the the 1990s (Trajçe and Hoxha 2011). Later on, PPNEA conducted two additional camera-trapping surveys, one intensive in 2014/2015 and an extensive one in 2014-2016, with an increase in collected capture events, with in total 76 lynx photographs taken in the same area (Trajçe et al. 2016).

The third phase of the BLRP project, which took place between 2013 - 2016 focused on raising awareness at local, national and international levels, as well as education-based approaches for pupils in primary schools (Melovski et al. 2015).

Continued camera-trapping surveys throughout the fourth phase of the project (2016-18) in the Munella Mountains and surrounding regions have proven the existence of a sub-population of Balkan lynx in Albania, consisting of at least 4 individuals. Further evidence of Balkan lynx in Albania has been recorded through camera-traps in the Shebenik-Jabllanica National Park in the Eastern part of the country in 2012 (two camera trap pictures) and in Nikaj-Mertur region, northern Albania, in 2017.

Cooperation

In 2006, there were attempts on a governmental level to sign a Memorandum of Understanding (MoU) for the protection of the Balkan lynx between the two relevant ministries, the Ministries of Environment in Albania and Macedonia. The initiative failed due to lack of support on a governmental level to bring the issue forward (Spangenberg et al. 2011).

Due to the critical situation of the Balkan Lynx, an international partnership of Albanian and Macedonian NGOs in cooperation with Swiss, Norwegian and German partners, has been implementing the Balkan Lynx Recovery Programme since 2006 (Balkan Lynx Recovery Program - www.catsg.org/balkanlynx).

Within the framework of the Balkan Lynx Recovery Program, a range wide strategy for the conservation of Balkan lynx is being developed, followed by country specific Action Plans for both Albania and Macedonia (Balkan Lynx Strategy Group 2008). These plans provide the basis for current and future actions in regard to conservation and management of the Balkan lynx in its distribution ranges within these countries (Kaczensky et al. 2013).

The aim of this long-term project is to secure the survival of the species through research, awareness and policy actions, local community involvement and institutional partnership building. The programme is now strongly established in the region, being widely known among institutions, authorities and the wider local population (Trajçe 2013).

The work of the programme has become a reference point for wildlife conservation in Albania and Macedonia, particularly in respect to partnership building and research actions. Involvement of young researchers and volunteers has been promoted since the start of the programme.

The Balkan lynx initiative is the first project that employs a 'species conservation' strategy for promoting nature conservation at trans-boundary levels in this part of Europe. This is unique as: (i) it brings attention to a region that has extraordinary biodiversity values but at the same time, where very little conservation work has been done and (ii) promotes greater cooperation within the frame of nature conservation between countries that have troubled historical and political relations. The broad scope of the project is achieved by working simultaneously in three directions (i) actions for lynx research and protection, (ii) site/habitat protection and management and (iii) integrating human dimensions in wildlife conservation. Actions for lynx research have introduced for the first time the use of camera-trapping and radio-tracking for field ecology research in the southwest Balkans (Trajçe 2013).

Collaboration has been established among the relevant ministries of Albania and Macedonia (Ministry of Environment and Physical Planning and Ministry of Agriculture, Forestry and Water Management). Various stakeholder groups in neighbouring Macedonia, have been included in survey and monitoring activities as well and are being organised within a monitoring network in Albania and Macedonia, composed of hunters, foresters, game wardens, veterinarians, shepherds and journalists (Kaczensky et al. 2013).

In regard to site protection, the project goes beyond classical protected areas, and combines them with a whole-landscape approach where initiatives for sustainable use of natural resources are promoted in the wider landscape matrix. The project combines ecological science with a strong social science component by looking in depth at the public attitudes and relationships prevailing towards the lynx (Trajçe 2013).

Joint barriers/conflicts

Within the local, rural population of Albania, lynx are not regarded as a major source of conflict, even when illegal killing occurs. Questionnaire surveys conducted during 2006-07 indicate that lynx depredation is a rare phenomenon, with only 3 people out of 320 interviewed confirming known lynx depredation cases (Trajçe et al. 2008, Keçi et al. 2008).

In 2010, a human dimension study conducted by PPNEA to determine public attitudes of the rural population towards large carnivores revealed that the general public opinion towards lynx is predominantly positive and support for their conservation was high (Trajçe 2010).

Compensatory measures

Currently, there is no form of compensation system in action, and there are no prevention or mitigation measures undertaken by management authorities to address the issue of livestock depredation. Traditional livestock herding with shepherd and guarding dogs remains in place. A few initiatives have been implemented in recent years by local NGOs to promote traditional breeds of livestock guarding dogs and donate pure bred animals to a number of shepherds in central and south Albania (Kaczensky et al. 2013).

Threats

According to the European Committee status report on large carnivores from 2012, illegal killings, loss of prey base and forest degradation seem to be the main factors that have led to the drastic decrease and near extinction of the Balkan lynx within the country. These main threats that appear to influence lynx presence need to be addressed as soon as possible, in order to safeguard a recovery area in Albania for Balkan lynx in the near future. Higher priority for nature conservation on national agendas of official bodies and commitment of governmental institutions within Albania must be urgently endorsed and strengthened (von Arx 2015).

Macedonia

Existing approaches (monitoring and participation/stakeholder involvement)

Between 2007 and 2009, a baseline survey covered the whole western region of Macedonia, interviewing the local community about lynx presence (Ivanov et al., 2008; Melovski et al., 2013). In 2008, 2010, 2013, 2015 and 2018 an intensive camera-trapping study in Mavrovo NP was conducted enabling the project to come up with population size assessment in a referent area and calculate lynx density. These results were then extrapolated to the whole potential distribution range in order to come up with a population size range. This led to the first official Balkan lynx IUCN Red List Assessment (Melovski et al., 2015). Subsequent semiintensive and opportunistic use of camera-traps confirmed lynx presence and reproduction in Jablanica, Stogovo and Karaorman Mts. Presence was also confirmed in Suva Gora and Karadzica Mts. as part of the Jasen Protected Area in the central-western part of Macedonia, as well as Pelister National Park. Despite camera trapping efforts in Galichica NP in the south-western part of the country, no evidence of lynx presence was recorded. Ongoing radio-telemetry study in Macedonia resulted in 5 live-caught and GPS-tagged individuals (Melovski et al. in prep.).

During the monitoring scheme implemented under the guidance of KORA and other bodies and conducted within the Balkan Lynx Recovery Program, the population size of the Balkan lynx was estimated taking 2 data-sets into account: 1) the Baseline Survey questionnaire in the western part of the country and 2) the camera-trapping survey in the reference area (Mavrovo NP) (see above). The baseline survey questionnaire assisted in mapping and pointing out the most current distribution area of Balkan lynx by implementing SCALP criteria 1 and 2 - data and assessing the minimum area of occupancy, as well as category 3 data which resulted in an assessment of the maximum area of occupancy ((IUCN 2008; Molinari et al. 2003).

The need for verification data on Balkan Lynx biology and ecology led to the first scientific project called: “Status, ecology and land-tenure system of the critically endangered Balkan lynx in Macedonia and Albania”.

The project was supported by the Swiss National Science Foundation under the SCOPES programme (Scientific Cooperation between Eastern Europe and Switzerland). The project started in 2010 and lasted until the end of the second phase of the BLRP in 2012.

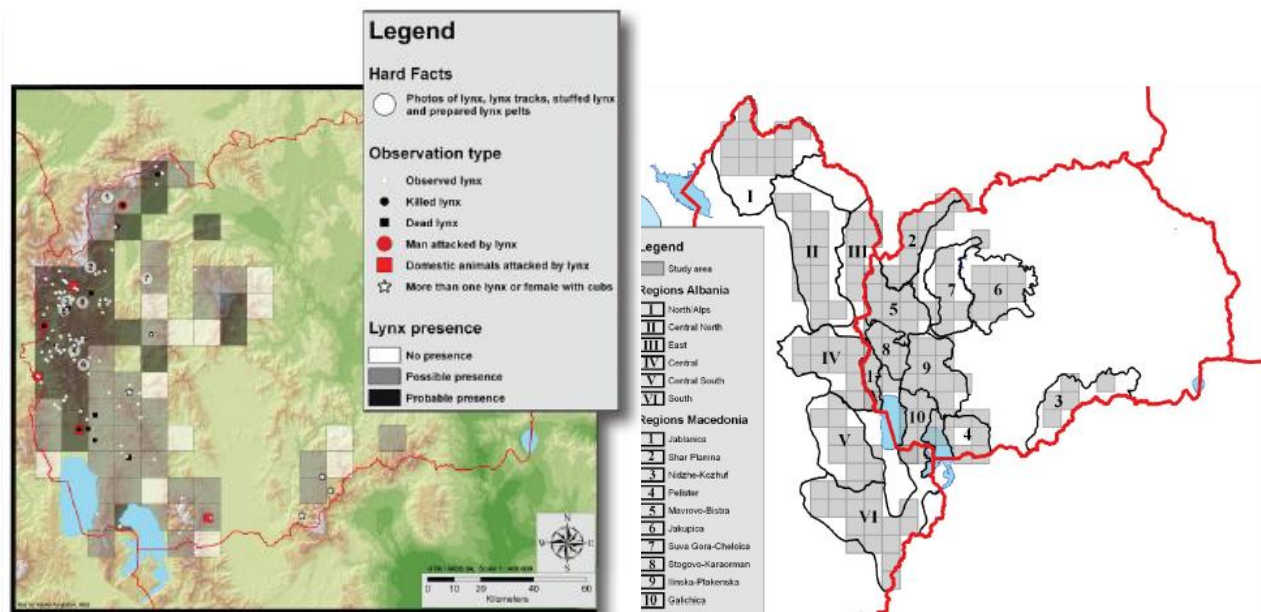


Figure 6. Lynx presence and different types of lynx observations in the survey area and study area of baseline survey executed in Albania and Macedonia (Ivanov et al. 2008)

In 2015 and 2017, according to the Macedonian Ecological Society, Macedonia had one proof of reproduction (one cub detected in a den, while locating a, with GPS-collar equipped, female) in Mavrovo National Park and one cub stoned by a local shepherd in the Munella Mts. This was the first “hard fact” evidence collected regarding lynx in the Balkan Population of Macedonia within a decade (Bolevich 2017). Only three lynx photographs identified within the extensive camera-trapping monitoring sessions from 2009-12 indicated that the species was still present in Macedonia.

Compensatory measures

A compensation system is in place, and damages on livestock are only compensated if caused by strictly protected species like the lynx (or brown bear). However, the implementation applies for damages caused by bear (and few cases of damages caused by lynx), which are easily recognizable as caused by the particular species. Bears are causing much more conflicts than lynx. One of the possible problems is the lack of education, because there is a general lack of awareness of the system in general (results from the Baseline Survey) (Lescureux et al. 2011). Additionally, the Macedonian Ecological Society has initiated a few projects where livestock guarding dogs were given to the shepherds in the southern part of the country in an effort to reduce the occurrence of poisoning of lynx (Keci et al. 2008).

Cooperation

Since 2006, a program for the recovery of the Balkan lynx has been implemented by Albanian and Macedonian NGOs in collaboration with Swiss, German and Norwegian partners (Balkan Lynx Recovery Program - www.catsg.org/balkanlynx). Within the framework of the Balkan Lynx Recovery Program, a range wide strategy for the conservation of Balkan lynx is being developed, followed by country specific Action Plans for both Albania and Macedonia (Balkan Lynx Strategy Group 2008). These documents have been elaborated under the auspices of the Council of Europe and provide the basis for current and future actions in regard to lynx conservation and management in the lynx distribution ranges within these countries (see above: Albania - cooperation for further details (Kaczensky et al. 2013).

Joint barriers/conflicts

According to consulted scientific literature and other sources, few conflicts are associated with lynx in Macedonia. Only a few cases of livestock depredation by lynx have been reported from Macedonia and conflict levels associated with lynx are low (Lescureux and Linnell 2010, Kaczensky et al. 2013).

The studies of Lescureux and Linnell (2010) revealed a general lack of knowledge about lynx presence and ecology, thus indicating that the future conflict management must include a special focus on education and participative measures, which are listed as goals in the second phase of the ongoing Balkan Lynx Recovery Programme (www.catsg.org/balkanlynx).

Driver assessment/Threats

The very small population size (individuals confirmed by camera trapping in 2010, couldn't be confirmed in 2013) is fragile in the face of illegal killing and is also threatened by a depletion of prey base as well as a potential degradation and fragmentation of habitats caused by infrastructural projects, forest conversion, limited range disturbance and traffic accidents (Melovski 2012).

Montenegro

Existing approaches (monitoring and participation/stakeholder involvement)

Baseline Survey Montenegro (2000)

Data about the Balkan lynx presence in western Montenegro was first collected in 2000 using questionnaires given to experts (biologists, forestry and hunting officials), specially trained associates in the field, as well as the local community. In 2004, Paunović and Milenković, mentioned within the Lynx Survey Europe an approx. population size of 30 individuals.

It would be very important to get more information about the recolonisation processes and the origin of the individuals (supposed to immigrate from Bosnia-Herzegovina to Serbia and Montenegro), since these areas belong to the potential range of the critically endangered Balkan population (Paunović and Milenković 2004).

Prior to 2013, no conservation strategy had been elaborated, with the only existing measure being legal protection of the Balkan lynx.

To assure the survival of Balkan lynx, beginning 25 July 2013, the Centre for protection and research of birds of MNE (CZIP), in cooperation with Public Enterprise for National Parks of Montenegro (PE NP MNE), started implementing the “Balkan Lynx Recovery Programme” (BLRP) in Montenegro by conducting the Baseline Survey containing a series of logical questions related to wildlife that were answered by local people, who were chosen based on their affinity for nature (Đurović and Perović 2013).

The main aim of the Baseline Survey was to assess the distribution and relative abundance of lynx and other large carnivores, in addition to potential prey species like wild ungulates and lagomorphs, by means of interview techniques.

Based on the scientific literature data on lynx presence, the central and northern parts of Montenegro were selected for the Baseline Survey in 2013. The investigated area included: three national parks in MNE - NP Prokletije, NP Durmitor, NP Biogradska gora - and their surroundings, mainly mountainous areas (hunting areas) where lynx presence can be expected.

The following profiles were chosen as most relevant for the conduction of the questionnaires: veterinarians, game wardens, foresters, hunters, shepherds, farmers, livestock breeders, beekeepers, naturalists, shop owners and others.

The next step for the BLRP-team was the set up of camera traps in the ecologically most feasible parts for the Balkan lynx in Montenegro (Đurović and Perović 2013).

Based on the baseline survey conducted in 2013, National Park Prokletije and its surroundings were evaluated as one of the most promising areas for finding lynx. NP Prokletije is situated in south-east Montenegro and lies in the border area with Albania and Kosovo. The last known lynx in Montenegro was killed in 2002, in the area of Prokletije, which has been a protected area since 2009.

From the end of December 2014 until middle of May 2015, the BLRP team set up 10 camera traps, but no indication of lynx presence from these cameras could be obtained (Đurović and Perović 2015).

Compensatory measures

No compensation systems or prevention methods are applied in the country. Lynx depredation on livestock seems to be very rare. For lynx, other measures might be more important, but a compensation system would probably reduce the conflict potential between local inhabitants and large carnivores in general.

Cooperation

Cooperation with Bulgaria, Albania and Serbia (coordination of a systematic monitoring) as well as with FYR Macedonia and Bosnia-Herzegovina are key to get more reliable information about lynx in the border areas of the respective countries and share the gathered results to plan conservation measure for the Balkan Lynx.

Joint barriers/conflicts

In 2002, political and economic instability had a negative influence on the implementation of management and conservation measures (Paunović 2002). Furthermore, Serbia and Montenegro faced political problems that hindered development of unified nature conservation efforts (Paunović 2002). In the field of nature conservation and protection, Montenegro is still in the process of fixing efficient capacity building. However, with the mentioned Balkan Lynx Recovery Programme initiated in 2006, Macedonia and Albania experienced a development of large carnivore conservation structures by adapting and implementing effective monitoring and management methods towards an improved protection scheme for the critically endangered subspecies (see cooperation: Albania).

Driver assessment / threats

Attacks on livestock are almost unheard of. Poaching is a regular incident, and is not connected to the very rare attacks on livestock. Illegal killings are considered to be the major threat for the lynx in Montenegro. Between 1996 and 2001 an average of two cases per year were reported, but there may have been at least five, threatening the small population with extinction (Paunović 2002). Trajçe (2013) adds habitat degradation and a decline in prey base, due to hunting activities as additional threats hindering a positive population development of the Balkan Lynx in the area.

Serbia

Existing approaches (monitoring and participation/stakeholder involvement)

In 2008, Paunovic et al. (2008) stated that the Carpathian population within Serbia was estimated at around 30-40 individuals with an increasing trend. According to his own collected data (applied methods are not mentioned) and the database of the Natural History Museum, of Belgrade, Serbia, documentation of the Hunting Association of Serbia as well as statistical data from the government, the Carpathian lynx population occupied in 2008 northeastern and eastern Serbia. The Balkan population was censused at that time distributed in southwestern Serbia especially in the Province of Kosovo-Metohija.

In 2016, in the existing political climate, there had been no recent population estimation and also no population trend assessment, because application of standardized monitoring was not possible. Thus, there was at that time no official estimate of population size or monitoring for the species in the country. The best available guesstimate had been made by experts from Serbian research institutions, NGOs as well as independent individuals, based on density extrapolation and small-scale camera trapping (Ćirović and Paunović 2016).

As result, Ćirović and Paunović (2016), mentioned an approximate distribution area of 8000 km² containing 40-60 individuals with a stable population and distribution range.

Although a national project entitled “Geographical aspects of lynx populations in Serbia” (2010-2012) was installed in order to assess the distribution and conservation status of the lynx in Serbia and to set up the basis for species monitoring, no results could be obtained during research for the present compendium. According to sources not mentioned in the status report on large carnivores (Kaczensky et al. 2013), the current status and trend is a consequence of recovery of habitats and prey base due to large rural depopulation in eastern Serbia, the disappearance of large livestock herds, afforestation of pastures and reduced human presence in lynx habitats. The range remains almost the same in size, but habitat quality is improving.

In 2007, an Action Plan was prepared for Eurasian lynx in Serbia, which listed increased monitoring and knowledge of regular population parameters as well as application of active and appropriate lynx management as main goals within its strategy. In 2013, due to poor enforcement of legislation and lack of capacity in management structures it still had not the status of an official document (Kaczensky et al. 2013). During research for the present compendium, no information on any progress towards an implementation of this action plan was found.

The Republic of Serbia recognizes and supports global strategic goals for biodiversity, by adopting a Biodiversity Strategy of the Republic of Serbia for the period 2011 - 2018. In this document a proposed Action Plan for the Protection and Conservation of the Lynx (*Lynx lynx*) in Serbia is mentioned again, but during research for the present compendium no documentation could be obtained either.

Compensatory measures

In 2008, Paunovic et al. (2008) stated, that a system of identification and evidence, as well as compensation measures for damages of livestock caused by large carnivores is entirely absent, which leads to a bad public attitude and an unjustified bad reputation of large carnivores in Serbia.

Furthermore, he stated that many of the cases of damage caused to livestock are actually attributable to stray dogs instead of lynx or wolf.

In 2016, Ćirović and Paunovic reported that a compensation scheme exists, but is in general not working. Thus, for damages caused by protected species in protected areas compensatory measures are applied by governmental bodies and identification of these damages are performed by experts. Based on these experiences, Ćirović and Paunović (2016) recommended installing a compensatory system, where the damage to livestock caused by a game species (e.g. wolf) is paid by the institution managing the respective area. Consequently, compensation for killed livestock within this area should be paid by the hunting association to the aggrieved livestock owner (predominantly for damages caused by wolf, because it is the only game species within Serbia).

Cooperation

Limited local management actions are mainly applied through the Public Enterprise Srbijašume, which manages state forests and forested land within Serbia and is under the jurisdiction of the Ministry of Agriculture, Forestry and Water Management (MAFWM). In the National Parks and other protected areas, the lynx is under the jurisdiction of the Ministry of Energy, Development and Environmental Protection (MEDEP).

Joint barriers/conflicts

Conflict between lynx and livestock breeders is almost unknown in Serbia, hence interviews and surveys addressing this issue indicate that conflict levels related to damages on livestock caused by lynx are low. There exists also no central information on livestock depredation in the country (Yilmaz et al. 2015). According to Kaczensky et al. (2013), there is just one reported case of a chicken killed by a lynx in 2010.

Contrary to that, Paunovic and Milenkovic (2004) stated 6 years earlier, that a current positive trend in the lynx population in Serbia is likely to be eroded by illegal killings, due the mentioned conflict of proposed and often wrongly accused damages caused by lynx to livestock, as well as the role of large carnivores, Eurasian lynx and Grey wolf as competitors with hunters of ungulates (roe deer and chamois).

In 2016, Ćirović and Paunović stated, that a lack of monitoring and research, which results in a lack of information concerning the distribution of lynx was another factor adding to further uncertainty about the status of the species in Serbia.

Driver assessment / threats

Due to non-standardized monitoring and lack of historical and current data, which is a consequence of insufficient monitoring and research activities in an unsettled political climate, as well as poor enforcement of legislation and lack of capacity in management structures, the current lynx presence and distribution in Serbia is still relatively poorly known. Therefore, it is difficult to assess the threats (Paunović et al. 2008). Losses are difficult to document, but illegal killings (in all forms - shooting, trapping, poisoning) are believed to be one of main threats (a few cases have been documented during the last 10 years, with many more been reported but not confirmed). Although the majority of hunters are in favour of the return of lynx, acceptance for the presence of “another overprotected predator” seems low.

Major threats exist in form of overexploitation of forests, land conversion for infrastructural projects, over-harvesting of wild prey populations and accusation of direct competition for prey, traffic accidents, change in native species dynamics (directly impacting habitat quality), habitat degradation and fragmentation, limiting dispersal and promoting low population densities (Ćirović and Paunović 2016).

The anthropogenically altered valley of the Velika Morava River, which divides Serbia into an eastern and western part of lynx occurrence, is explicitly mentioned by Ćirović and Paunović (2016) as main barrier for dispersal and reason for impaired movement.

Baltic Population

Estonia

Existing approaches (monitoring, participation/stakeholder involvement)

Population size in Estonia is estimated based on the number of unique annual reproduction units. Thereby, number of reproductions is based on the mapping of sight and track observations in all of Estonia. Additional, monitoring includes data of harvested/dead individuals (parameter as site, sex, age, reproductive status) and data collected from permanent winter-track count transects (nearly 400 annual snow tracking transects, 12 km each are inspected), as well as damage surveys, independent track observations in certain areas and telemetry (Männil 2017). Additionally, 400 - 900 chance observations of lynx family groups are each year reported (Remm et al. 2018). Basic monitoring data are collected by hunters and personnel of protected areas and are analyzed in the Estonian Environment Information Centre, which is mainly responsible for large carnivore monitoring, including lynx. The annually published monitoring report provides advice and recommendation for the implementation and application of annual conservation measures and sustainable harvest numbers of large carnivores in Estonia with management decisions largely based and backed up on estimated number of family groups (Kaczensky et al. 2013; Remm et al. 2018).

In Estonia, the lynx population is regulated by hunting with a defined open season from 01.12. - 28.02. Hunting is restricted, consequently prohibited in certain areas (e.g. nature protection areas), typical harvest number are 90 - 100 individuals (Remm et al. 2018). There is a valid national action plan for Eurasian lynx Conservation and Management for the period of 2018 - 2028 elaborated and in action (Ozolins et al. 2017). Management of lynx falls under the jurisdiction of the Environmental Board of the National Ministry of the Environment. Within the ministry, there is a working group for Large Carnivore (LC) management, consisting of different stakeholders, which advise the ministry in order to establish and implement the large carnivore policy.

Cooperation

A close cooperation exists with Latvia, sharing information about lynx reproductive events near the Estonian-Latvian border. In this form, information on population trends on both sides is shared.

In 2012, a common project with NGOs from Estonia (Estonian Fund for Nature) and Poland (WWF Poland) was undertaken, to reinforce the local lynx population in North-Western Poland with translocations of wild individuals from the Estonian part of the population. In winter 2012, three individuals were translocated and at least two more were planned in winter 2013.

Population management on transboundary level involves:

- regular information exchange on lynx management (census, hunting bags) with Latvia
- common research with Poland and Latvia on Baltic lynx population genetics
- translocations of Estonian wild lynx to NE Poland

Joint barriers/conflicts

The main conflict, the lynx is seen as a major competitor to hunters with regard to predation on wild ungulates especially in periods of low roe deer density (consequences of harsh winters) (Lõhmus et al. 2002). Lynx depredation on livestock is rare in Estonia and doesn't cause any remarkable conflict (Kaczensky et al. 2013; Ozoliņš et al. 2017).

Compensatory measures

Since 2007, compensation for damages on livestock has been paid by the state: the responsible body is the Environmental Board, and the source for compensation payments is the Environmental Investment Centre. Cases are inspected by trained experts of the Environmental Board; if kill by a lynx is confirmed, 100% of the market value is paid as compensation (<https://www.kik.ee/en/financed-projects>).

Driver assessment / threats

In the near future, there are no significant threat scenarios that might impair a favourable conservation status for the lynx population in Estonia. Still, there are some aspects that have to be considered from the stakeholder viewpoint: marginal predation on livestock, reduction of primary prey base (roe deer) due to low densities/harsh winter conditions could seriously hinder prey population recovery causing a negative attitude towards the species followed by pressure to increase the hunting quotas and/or increase of illegal killings (Kaczensky et al. 2013; Remm et al. 2018).

Latvia

Existing approaches (monitoring and participation/stakeholder involvement)

The lynx population estimate is based on cohort analysis of hunting bags (<http://www.csb.gov.lv/en/statistikas-temas/>). All legally shot or found dead lynx are reported to the State Forest Service and national distribution maps (10 x 10 km EEA grid), which are based on these records, are plotted.

Cells with kills of reproductive females and/or kittens are defined as “permanently” occupied; those with kills of other age and sex groups are defined as “sporadically” occupied. In addition, 40-50% of the annual hunting bag is examined and analysed on laboratory scale for exact animal age and female fecundity (Ozoliņš et al. 2008). Thus, cohort analysis can be carried out by mutual comparison of age structure, birth and survival rates in annual samples. The National Action Plan for the Conservation of the Lynx in Latvia was last updated in 2017 (Ozoliņš et al. 2017).

Hunting

In Latvia, according to the Law on the Conservation of Species and Biotopes, the lynx is classified as a specially protected species whose use is limited. Exploitation of lynx occurs in accordance with the hunting law, and lynx is listed among game animals. The hunting season for lynx is open from 1.12 - 31.3. Quotas are set and controlled by the State Forest Service under the Ministry of Agriculture.

According to the circumstances and lynx population densities, quotas may be generally used for the entire territory or divided into local sub-quotas accounting for uneven densities. For this reason, quotas have been set locally higher in the north along the Estonian border with an abundant lynx population, while they were decreased in central and southern districts along the Lithuanian border.

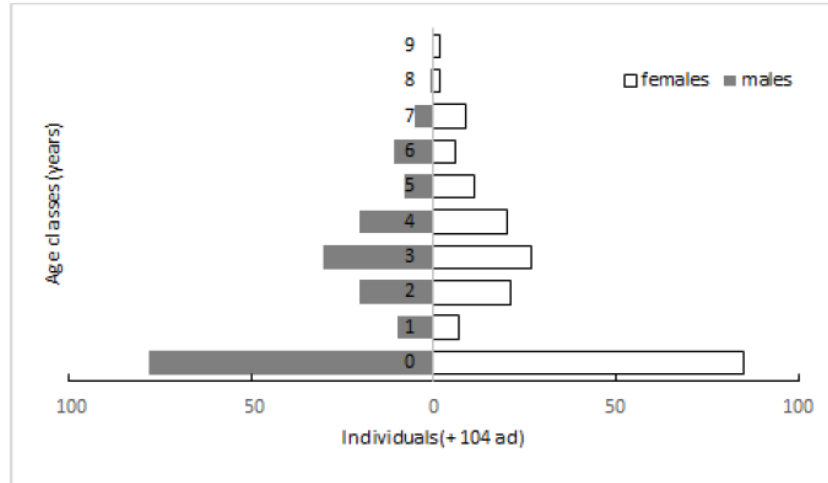


Figure 7. Sex and age structure of lynx hunted in Latvia from 2006 to 2015 (altogether 1188 lynx were hunted; 530 collected for research, brackets contain number of adult animals of unknown age (Bagrađe et al 2016)

If necessary, the hunting quota is adapted to local and seasonal hunting limitations or bans in those hunting areas (districts, forestry units) where lynx are rare or where they have been over-hunted to the extent that hunting could threaten the local population's renewal as well as in cases where lynx distribution and density are especially important for the existence of the continuous Baltic lynx population.

Fines for poaching

The fine for poaching (incl. a hunted animal not reported to the State Forest Service in line with hunting regulations/open season) is 5 minimal monthly wages if the killing occurred during the hunting season or 10 minimal monthly wages if poaching occurred during the closed season or in a protected area (Ozoliņš et al. 2017).

Compensatory measures

Within the current action plan, the development of schemes for prevention and compensation in cases when a lynx has attacked/killed livestock is planned (Ozoliņš et al. 2017)

Cooperation

In 1999, a joint project between the Estonian and Latvian Funds for Nature, entitled "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.

From 2003 to 2007, research projects on the territorial behaviour of lynx using radio telemetry 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.

Since the beginning of the 2000s, in collaboration with researchers from other countries, a study on lynx genetics was initiated in Latvia. In 2014-2015, within the project of the Human Resource Excellence for Research of the European Social Fund, a genetic monitoring system of wild species for large carnivores was launched. The first results on lynx genetic relationships were published in 2016 (Bagraade et al. 2016).

Joint barriers/conflicts

Problems with damages to livestock are non-existent or minor with only a few cases of livestock depredation reported, consequently conflict situations between lynx and farmers are infrequent. 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 lynx is still considered as a threat to other forest animals by hunters, with particular concern regarding negative impact on roe deer, hare and capercaillie populations (Ozoliņš et al. 2017).

Attitudes based on hunters' observations that lynx act as competitor preying on ungulates (mostly roe deer and especially during deep snow conditions) are the main reason for predator control. This problem can be mitigated by providing information about the ecology of lynx, as well as raising public awareness and involving hunters in monitoring activities such as reporting lynx sightings and providing dead individuals for monitoring (Valdmann et al. 2005).

Driver assessment / threats

Hunting is the main factor limiting lynx population in Latvia. However, harvest schemes have been sustainable, and the future of the population depends on success of adaptive management based on comprehensive monitoring and spatial continuity of the Baltic lynx population (Kaczensky et al. 2013).

Lithuania

Existing approaches (monitoring and participation/stakeholder involvement)

In Lithuania, the species has not been hunted since 1979 and has been included in the Red Data Book of Lithuania (Endangered Species) since 2000. In the official survey data of 1994 - 2003, lynx numbers were reported as being around 100. Two partial surveys in 2003 and 2004 showed lynx numbers being 19 and 32 respectively (Bukelskis et al. 2004). In 2004 and 2005 questionnaires were distributed in schools of Lithuania asking about lynx population size and distribution (Balčiauskas et al. 2010).

Respondents answered, that there were 20 - 50 lynxes in the country. Full-area snow surveys in 2007 and 2008 confirmed that the lynx population in Lithuania was very small (30 - 40 individuals) (Balčiauskas 2018). In south and central Lithuania, Eurasian lynx was entirely

absent (Balčiauskas et al. 2010). Consequently, the answer of the respondents was accepted as correct, Kaczensky et al. (2013) stated later a population size of 50 (\pm 10).

According to Balčiauskas et al. (2018), a citizen science project supported by the Nature Research Centre and Lithuanian Hunters and Fisher Association was carried out in 2015-2018. In order to collect direct observations as well as chance finds (such as footprints, found prey, scats etc.) and apply intensive camera trapping to gather photo/video evidences of large carnivores, including Eurasian lynx. Through this approach, 200 lynx observations from the public were obtained by 2017.

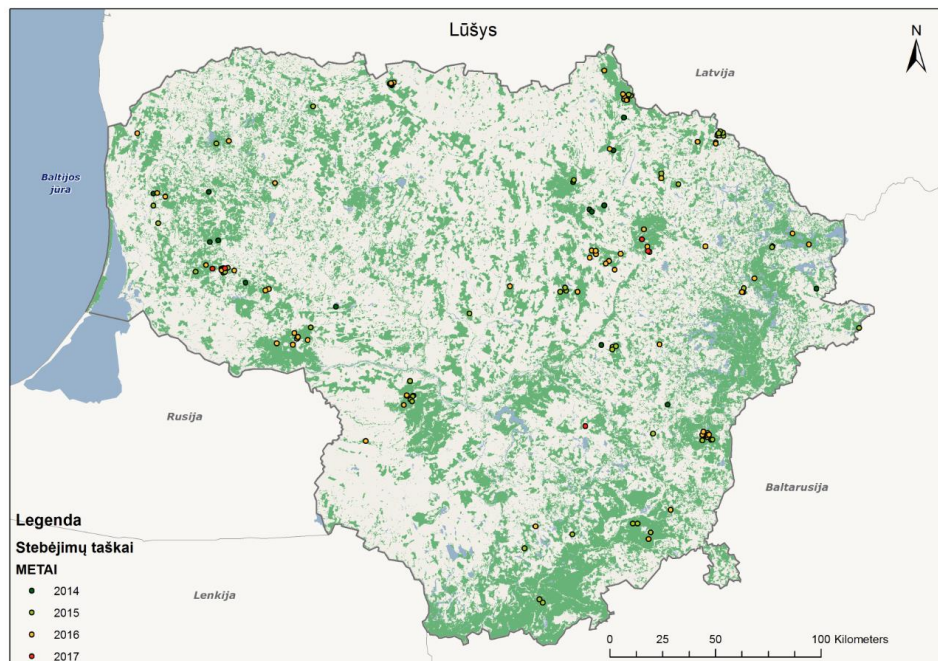


Figure 8. Observations of lynx in Lithuania - 2015-2017 (Balčiauskas, n.d.)

Compensatory measures

16.300 Litass (~4721 €) in fines must be paid for the destruction of a lynx in Lithuania; imprisonment is also possible. For this reason, a pair of poacher in the Anykščiai region was imprisoned two years ago for the destruction of a lynx (MoE Lithuania 2013).

Cooperation

The republic of Lithuania has signed various agreements with neighbouring countries (e.g. Latvia, Russian Federation, Estonia) regarding cooperation in the field of environment, as well as a memorandum of understanding with Estonia regarding environmental protection, although lynx are not explicitly mentioned (www.am.lt).

Joint barriers/conflicts

According to Balčiauskas et al. (2010) lynx is not involved in conflicts with farmers and cattle breeders in the Baltic region and causes no damages to livestock (Kaczensky et al. 2013). Thus, fear for personal safety might be a crucial factor. Unsurprisingly, carnivore - human issues are more important in rural areas where the chance of encountering a lynx is higher (Balčiauskas et al. 2010).

Driver assessment / threats

Fragmentation of habitats and distribution range by land conversion (agricultural lands) and infrastructure (highways) as well as fencing in the border region of the republic of Belarus (100 km fenced) (Saklaurs 2008) provide notable threats to lynx populations.

Poland

Existing approaches (monitoring and participation/stakeholder involvement)

In the late 90s, the only source of information about the state of lynx populations were hunting inventories, which due to the inclusion of large predators under protection, were abandoned because the Polish Hunting Association ceased to be the institution responsible for these species and have not continued large carnivore inventories.

In 2000, a nationwide monitoring of the lynx (and wolf) population started by an initiative of the Mammal Research Institute of the Polish Academy of Sciences (MRI PAS) and the Association for Nature 'Wolf'. Coordination of monitoring efforts and data analysis was performed by the same institutions, while most of the data collection was carried out by the staff of state forests, national parks services, MRI PAS (in the premises of Bialowieza Forest) and members of AN 'Wolf'. The methodology and intended outcome of the lynx (and wolf) monitoring was developed by experts from the MRI PAS and AN 'Wolf'. In 2000, before the implementation of the monitoring scheme on a larger level, the methodology was tested in north-eastern Poland and presented to the General Director of State Forests with the proposal to involve state forest institution as one of the main contractors in the planned monitoring efforts.

Description of the methodology, along with basic information about the purpose of the monitoring (census of the population size and territories of lynx and wolf in Poland), the ecology of both species, tracks and signs of the species, data sheets in form of an ("Guideline for the monitoring of lynx and wolf") were submitted to the Regional Directors of State Forests, forest inspectorates, national parks and presented on a project website (Mysłajek and Nowak 2013).

Collection of observations and chance finds

Monitoring efforts started in winter 2000/2001, with the assessment of territories and population size for both species. The inventory was conducted for entire forest complexes, (respectively not just for individual units of economic administration, forest or game shooting inspectorates). Within the whole forested areas, for an easier organization of monitoring efforts, 75 units for the designated monitoring were established, including 430 forestry districts and 23 national parks. The units were separated from each other with clear natural or anthropogenic barriers, that could represent barriers for lynx and wolf occurrence.

In each area a coordinator was assigned, who led the work of all units (forest districts and/or national parks) located within his/her boundaries. Additionally, in each forest inspectorate/national park, a person was identified responsible for data management (e.g. organization of conducted counts, data collection). The monitoring was based on two core activities: collection of any observations and signs of presence during the whole year and coordinated snow tracking in winter.

Year-round observations were recorded in special data sheets and included any reliable information about lynx and wolf observation, e.g. alive or dead found individuals, occasional finds such as tracks, scats, urine markings, claw scratch marks, signs of oestrus, remains of prey, attacks on livestock, dens, burrows, acoustic signs etc. The data sheets of a given region were collected in the forest inspectorates and sent to the MRI PAS on a quarterly basis for subsequent data analysis (Mystajek and Nowak 2013).

Snow tracking was conducted simultaneously in the first half of winter once or twice a season, at the latest 12 hours after a fresh snowfall within all forest inspectorates of a particular monitoring unit. Based on year-round observations, in each region, units most frequently frequented by lynx and wolf were determined, and they were selected to be checked first. After completion of the tracking, filled out forms and generated maps were passed on to forest inspectorates. Thereupon, the responsible person prepared a consolidated map of the detected lynx and wolf tracks, all found resting places and other findings. Consequently, all completed forms and consolidated maps of winter tracking were transferred by the end of March each year, as well as a map with year-round observations at the end of each quarter. Forest inspectorates which did not detect presence of large predators sent information on lack of occurrence of the species once a year (Mystajek and Nowak 2013).

At the end of the year, the collected information gathered within the database was exported in form of a GIS layer. Based on the location of breeding sites, high concentration of urine, faeces or scratch markings locations, central territories were identified and indicated. To illustrate them in the maps, lynx family groups, territorial sizes of approx. 120-150 km² were adopted and for males approx. 250 km².

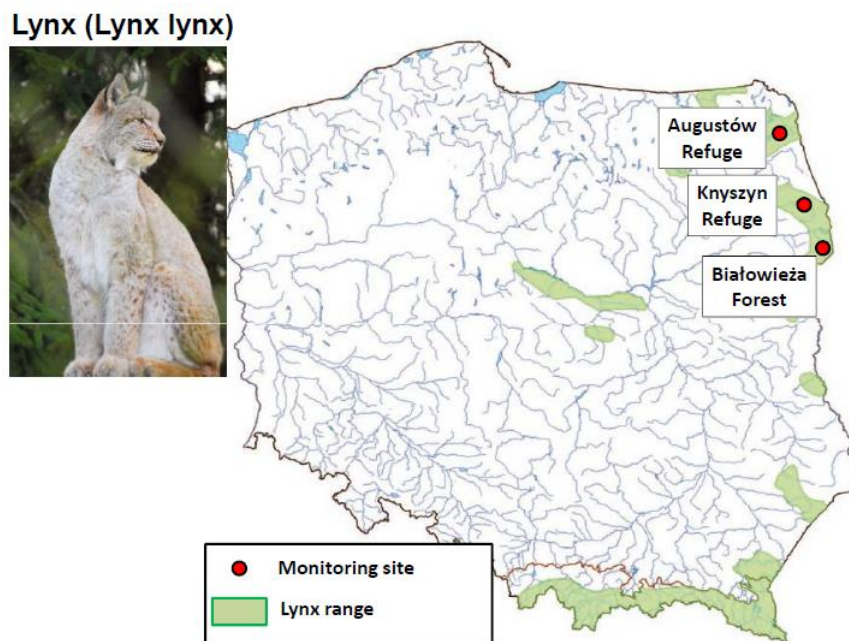


Figure 9. Lynx distribution range in Poland (Borowik, n.d.)

The monitoring ended in 2016 and collected approx. 30.000 datasets and aided in appointing dozens of Natura 2000 sites, which nowadays protect essential lynx and wolf habitat in Poland. The methodology tested in the project became basis for the development of recommendations for management and monitoring of lynx and wolf in designated conservation sites under the Natura 2000 network (Mysłajek and Nowak 2013).

In 2004 and 2005, questionnaires were distributed in schools of Poland asking about lynx population size and distribution. The answer of Polish respondents to the questionnaire, that there were 100-- 500 lynxes in the country was accepted as correct (Balčiauskas et al. 2010). In 2010, according to the Central Statistical Office (Główny Urząd Statystyczny), it was estimated at 285 individuals (CSO 2012).

Since 2006, within the framework of the State Environmental Monitoring System, animal species such as the Eurasian lynx have been monitored. Based on this scheme, lynx are regularly monitored within their refuge areas of occurrence, in Augustów, Knyszyn and Białowieża forest (with 50 camera trap locations in Białowieża forest).

In 2014/2015 were 32 records of lynx in Białowieża recorded; in 2015/2016 13 records and in 2017 10 records - indicating a decreasing population size, which could be related to low abundance of its main prey - roe deer as well as to changing forest structures (formerly open and heterogene structured areas are conversing into dense forest) (Schmidt 2018).

It is planned to conduct an every 5-year inventory based on snow-tracking and direct observations of females with kittens, in order to establish information on the reproductive potential of lynx population within selected reference areas in Poland including number of females with cubs (family groups) and the mean number of cubs per female (Borowik et al., n.d.).

Joint barriers/conflicts

In Poland, very few cases of lynx attacking livestock are reported and poses not a severe problem, according to Mysłajek and Nowak (2013), the species does not seem to have any economic significance on livestock breeding. Still, it affects negative attitude towards the species among farmers (Yilmaz et al. 2015).

Compensatory measures

Only a few cases of lynx depredation on livestock are known. Regional Directorates for Environmental Protection are responsible for the estimation and compensation of damage caused by lynx and for reporting of accidental mortality in every province. In national parks, directors are responsible for damage compensation.

The amount of compensation payments for damages caused by large carni voresreaching on average 200.000 € annually for the entire country, with 0.1 to 4 % caused by lynx (Yilmaz et al. 2015; Schmidt, pers. comm.).

Driver assessment / threats

The most important threats are connected with habitat fragmentation caused by infrastructure development, accompanied by habitat loss, and a disruption of ecological corridors suitable for migration and dispersal. Locally, homogenization and loss of habitat diversity (within forest structures, a lack of undergrowth, dead and fallen trees), loss of potential prey base by overhunting and human caused disturbance and mortality (e.g. disturbance by mushroom/berry pickers in rearing phase, poaching, collisions with vehicles) are influential drivers and threats as well (Mysłajek and Nowak 2013).

Cooperation

Since 2009, the Polish government started several attempts to develop a transborder cooperation for large carnivore populations in Poland and neighbouring countries. In spring 2011, a bilateral Polish-Slovakian seminar was organised in Krakow by the Polish General Directorate of Environment, where the situation of wolves, bears and lynxes in both countries were presented and discussed.

The recommendation to establish the Large Carnivore working group was agreed on this meeting. In addition, Poland develops co-operation with Slovakia and Ukraine within the framework of International Biosphere Reserve “Eastern Carpathians” concerning the improvement of nature conservation methods in this part of Carpathians (Blanco 2012).

Carpathian Population

Romania

Existing approaches (monitoring and participation/stakeholder involvement)

Nonsystematic population estimates are performed in winter and spring using snow tracking with a particular focus on family groups. An analysis of the population is structured by sex and age.

By the end of spring, hunting permit holders are required to provide an annual estimation of the number of lynx frequenting their hunting grounds. These estimations are compiled on a larger scale by the Environmental Protection Agency (EPA), and the data is centralized at regional and national levels providing an approximate population size.

Taking into consideration the challenging habitat features of the Carpathians in Romania, high population densities (~ 1500 ind.) and the biological characteristics of lynx, intensive monitoring methods currently used within small populations, are not applicable on a larger scale (Kaczensky et al. 2013); but, considering that the estimation are made based on hunter reports (without any scientific control), the estimated population size could be overestimated.

A management plan for lynx populations in Romania was prepared in 2007 under the Ministry of Environment coordination, but the final document is not accessible to the public (unofficial information). There is no information about the implemented measures from the action plan.

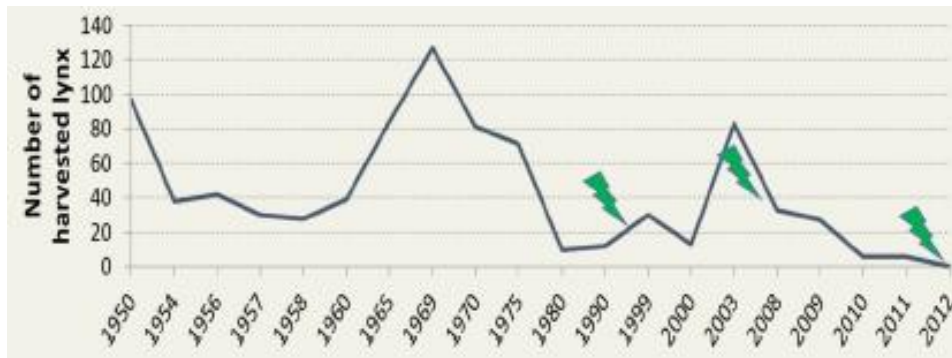


Figure 10. Number of harvested lynx prior to protection schemes established in 1999 (under the EU-Habitat Directive), 2008 and 2012 (final abandonment of hunting the species, that is officially protected under EU regulation) (Papp et al. 2016)

A series of measures have been adopted by consulting involved and relevant stakeholder, such as the Ministry of Environment and Forestry, universities, National Administration of Forest (RNP), NGOs, hunting organisations and others.

These measures which are foundations of the national management plan of Romania include:

- The classification of the areas in which lynx are present
- The evaluation of existing or planned infrastructure impact, regarding the impact on lynx and the adoption of measures in order to decrease the impact
- The protection of lynx by law, including the prevention and the compensation of damages
- The initiation of an information and education campaign, focused on some specific target groups, at local and national levels
- Consultation with the interest groups for the management actions established, needed in the conservation of the species
- Improving the monitoring program
- Establishment of some special areas for lynx conservation, with a minimum size of 300 - 400 km² each with reduced human activity designed to ensure population stability

In 2010, Rozyłowicz et al. (2010) investigated the habitat use of a mature female lynx equipped with a GPS collar. The individual was monitored for a period of 305 days in the northwestern section of Vrancea Mountains. The outcome resulted in an estimated home range of 486 km², a significantly larger area than what had been recorded previously for Romania (Rozyłowicz et al. 2010).

During the WOLFLIFE project, the study area was during three survey periods (Nov.-Dec.; Jan.-Feb.; Mar.-Apr) surveyed for lynx tracks and signs, with data collected on 63 transects (615 km) in winter 2014/2015; 73 transects (828 km) in 2015/2016 and 65 transects (645 km) in 2016/2017. Thereby, 200 tracks (associated with urine, scats and scratch marks) were found (Corradini et al. 2017), as well as 25 camera trap records and 44 noninvasive collected genetic samples of lynx were obtained (Sin & Corradini 2018).

The genetic samples, collected in several pilot study areas (with a total surface of 4000 km²), allowed the identification of 12 lynx individuals (9 males and 3 females). The survey was focused on wolf, with lynx data being collected opportunistically, when encountered along the transects planned for wolf monitoring. Therefore, the collected data was not meant to be used for lynx population estimates, but to give some insights on lynx presence in the area, and look for possible wolf-lynx interactions (Sin, pers. comm).

Since November 2017, lynx surveys are being conducted in several pilot study areas (4-600 km² each) across the Southern sector of the Eastern Romanian Carpathians. The data is being collected in the frame of the LIFE Lynx project (2017-2024), and implies the simultaneous use of snow-tracking (systematic), camera-trapping (opportunistic) and genetic analyses to obtain minimum lynx numbers, as well as other information regarding the studied population (sex and age structure, health status). At the end of the first season (Nov. 2017-April 2018), over 40 km of lynx tracks, 28 noninvasive DNA samples and 30 independent camera-trap records have been obtained. Data analysis is still going, so no results have been made public so far (Sin, pers. comm.).

Hunting

In Romania, Eurasian lynx was a game species until ratification by EU legislation as fully protected species. Prior to protection, the applied hunting was non-selective, with no impact on damage mitigation but a potentially negative impact on population size, distribution area and population structure. Due to all the missing information about the lynx hunting impact on the prevailing population, the hunting of lynx under the derogation system was stopped in 2012. Since then the species is fully protected (without derogations), while trophy hunting of wolf and bear were after several stops in the 2000 continued in 2017) (Higgins 2017).

Compensatory measures

Romania provides compensation payments for damages on livestock/domestic animals caused by lynx. All kills have to be verified and documented by trained experts (forest guards) (Kaczensky et al. 2013). According to Papp et al. (2016), it is not entirely functional, due to excessive bureaucracy, prolonged time until compensation payments are received and potential cases of fraud; damages that are not reported.

Assessment of damages to livestock and preventive measures

In summer of 1998 to 2000, during the Carpathian Large Carnivore Project (CLCP), surveys of damages caused by large carnivores to livestock were conducted. The surveys showed, that damages to livestock caused by lynx was insignificant in every year, while the main responsible predators (wolf and bear) killed 2 % of all herded sheep in 1998 and 1999 (Mertens and Promberger 2000).

In Romania, traditional livestock guarding schemes are still quite well preserved, with dogs and shepherds guarding the herd and the sheep being penned at night. But several problems impair proper livestock guarding negatively: first of all livestock guarding dogs are not actively trained; as soon as they are big enough, the pups are put in the flock together with the adult dogs and they are supposed to learn from the other dogs how to guard the sheep. Other factors are salaries, food for the shepherds and the rent for pasture raising the costs for husbandry on an expensive level compared with the incomes from livestock rearing. Resulting from this situation, there are often not enough shepherds present, to guard the herds. And as the rented pasture doesn't offer sufficient area for the number of sheeps, they are kept in forested areas, being more exposed to attacks of large carnivores (Yilmaz et al. 2015).

Cooperation

Romania joined the Convention on the Wildlife and Natural Habitat Conservation in Europe, which was ratified in Bern on the 19th of September 1979 by Law no. 13/1993. After 2007, Romania became part of the EU and, regardless of the rather large size of the lynx population in the country, the species became strictly protected under the Habitats Directive. Romania entirely abandoned trophy hunting of lynx in 2012.

With the understanding, that actions concerning lynx population management in Romania can influence lynx populations in neighboring countries as well, Romania has committed, under the umbrella of the "Carpathian Convention", to a management scheme that keep the Carpathian population stable.

Driver assessment / threats

In 2013, illegal killing of lynx was considered to represent less than 5 documented cases per year, as not threatening the population in any way, and traffic accidents were also a rare occurrence, but it exists no register/system, that documents traffic accidents that involve wildlife or cases of poaching, consequently a higher number can be assumed (Kaczensky et al. 2013).

In 2016, Papp et al. mentioned anthropogenic induced reduction of habitat connectivity, conflict with humans/hunter (as competitor for hunting roe deer) and poaching as main threats. Still, the lynx population of Romania is at the moment large and viable with approx. 1200 - 1500 individuals. Primary habitat is suitable and largely unfragmented by major traffic corridors. Poaching occurs, but at a low level, presenting no evident threat nor affecting the population. Over the past years, several lynx have been killed in traffic accidents.

Slovakia

Existing approaches (monitoring and participation/stakeholder involvement)

Since 2009, Slovakia implements systematic camera trapping (in Štiavnica Mountains, Veľká Fatra, Muránska planina, Strážov Mountains) GPS telemetry, snow tracking and the collection of noninvasive genetic samples to assess the status of Eurasian Lynx in the country (Kubala et al. 2018).

The project “Living with Carpathian Spirits” arose as a pilot study to adapt a systematic lynx monitoring scheme from Switzerland to the lynx population in the Slovakian Carpathians. The project was implemented from May 2013 to February 2015 by the Slovak Wildlife Society (SWS), KORA and Bojnice Zoo.

The field work within the project was based on camera trapping, snow tracking, genetic sampling and telemetry, which were conducted in two reference areas. Thus, a total of 843 images of lynx were obtained during the project. In winter 2013/2014, in the Štiavnica Mountains, a total of seven independent lynx were captured; in Veľká Fatra, nine independent lynx were captured. Three of the individuals were also captured the following winter along with four “new” individuals. Results of genetic analysis showed no significant inbreeding in the population.

Additionally, during the project, an educational programme was implemented for the lay public including 20 different events with a total of 12.500 participants. A teachers’ manual, mobile exhibition and information panels were prepared. Eight training events for volunteers and students were also realized, providing information about the project and practical demonstrations of the applied monitoring methods.

The results of this project aimed entirely towards the adaption and application of the Swiss systematic lynx monitoring scheme to the Carpathian lynx population of Slovakia. It confirmed that the methodology for research and monitoring of Eurasian lynx developed by KORA in Switzerland was a feasible and pertinent approach for estimating population parameters in the Carpathian lynx population as well. The importance of further research within the Carpathian lynx population of Slovakia was highlighted by the relatively low estimates of density in both study areas. The values obtained so far for independent (i.e. adult individuals) represent an unfavourable conservation status of the lynx population in Slovakia (Rigg and Kubala 2015; Kubala et al. 2017).

Outcome of pilot project

Consequently, the Slovak Wildlife Society recommended the implementation of a similar system in Slovakia. Therefore, they selected several reference areas, within which intensive monitoring by camera trapping and subsequent capture - recapture analysis at intervals of 1-3 years should be applied with the aim of reliably estimating density, abundance and population trend.

Subsequently, it is possible to extrapolate the collected data by modelling to the whole distribution range with lynx occurrence and to estimate comprehensively the current status of the Eurasian lynx population in the Slovak Carpathians (Rigg and Kubala 2015).

According to Rigg and Kubala (2015), a robust monitoring and management system for lynx conservation in Slovakia should include deterministic camera trapping, genetic analysis, snow tracking and telemetry in the near future. This would rely upon cooperation among interest groups, who often have diverse opinions on the management of large carnivores (e.g. nature protection agencies and hunters), and among which teamwork is vitally important and should be encouraged through collaboration within monitoring networks.

For future genetic monitoring in Slovakia, Rigg and Kubala (2015) recommend the systematic collection of samples from all mortalities and captures. This should be accompanied by the collection of morphological and demographic data, since many traits may reveal changes in levels of inbreeding. Key parameters should include reproduction, survival, longevity, health and cause of mortality.

Additionally, non-systematic monitoring in order to allow to census population estimates for lynx in the Tatra National Park (Nizke Tatry NP), an area which reflects essential habitat for Eurasian lynx in Slovakia, was referenced by Ondrus and Adamec (2009). They didn't mention the applied monitoring methods (except the collection of genetic samples). Additionally, a large carnivore monitoring project took place in the Beskydy Mountains of Slovakia. It aimed to track large carnivores as Eurasian lynx with camera traps and accurately map their presence on the basis of data collected. The project aimed to correctly estimate population numbers for large carnivores (Dubrulle, n.d.).

In the Lower Tatra (NAPANT) and Tatra (TANAP) National Parks, genetic samples were collected (method not explicitly explained), which were subsequently analysed (Ondrus and Adamec 2009). The analysis of genetic samples in Slovakia resulted in the identification of 40 individuals between 2009-2016, in total were 51 individuals genotyped since 1985 (invasive and noninvasively) (Krojerová and Duľa 2018).

Between 2011 and 2014, 4 individuals in PLA Beskydy were equipped with GPS/GSM collars (equipped with activity and mortality sensor) to allow for an assessment of spatio-temporal activity and movement patterns as well as territorial use and the identification of migration corridors (Krojerová and Duľa 2018). From November 2016 to January 2017, intensive deterministic camera trapping was applied. The camera traps were placed for an 80-day period in the border region of Slovakia and the Czech Republic (PLA Kysuce/PLA Beskydy) and Slovakia and Poland (PLA Kysuce/PLA Horná Orava) in order to allow the assessment of population size and density. These efforts were accompanied by an opportunistic camera-trapping scheme, with camera traps placed at lynx marking sites, game trails and kill sites for an entire lynx year, which supported the intensive camera trapping efforts in order to assess population dynamics within the Carpathian population in Slovakia (Krojerová and Duľa 2018).

Future implementations and planned steps after finishing the pilot project

Facilitate the implementation of a lynx health surveillance program in Slovakia, potentially employing protocols for veterinary procedures that were proposed by Swiss colleagues during the project. Furthermore, several other recommendations cited below have been formulated.

Additional steps to be achieved include: the organization and promotion of carcass collection, including lynx killed in traffic accidents; the development and adaptation of protocols and datasheets; the setting up of necropsy procedures; the establishment of a database and organization of a document/data archive; the organization of a sample archive; and the organization of regular meetings with goals and deadlines, formulation of agreements and documentation of minutes.

Compensatory measures

Ondrus and Adamec (2009) mention damage compensation (after investigation) schemes, without describing specific terms and forms of application in cases of damages caused by Eurasian lynx (State Nature Conservancy of the Slovak Republic 2016). In Slovakia, if necessary, problem individuals can be shot by special permit (no further detailed information on measure is available) (Ondrus and Adamec 2009)).

Between 2006 and 2011, 18.360 € compensation was paid for 92 sheep demonstrably killed by lynx (Kaczensky et al. 2013).

Livestock guarding dogs

In 2000, the Protection of Livestock and Conservation of Large Carnivores (PLCLC) initiative started a project with livestock guarding dogs. LGDs were present at almost all upland sheep farms of Slovakia, but very few were free-ranging and attentive to sheep. LGDs were used in following guarding schemes: first permanently chained near the sheep herd or farm buildings, which provided some protection, mainly by barking to alert shepherds at night; secondly, they were chained during the day but released at night and third, they were left free to roam the premises they are intended to guard. The project revealed that the presence of LGDs alone did not necessarily deter large carnivores from attacking and didn't stop all losses, but the mean and maximum reported losses at flocks with one or more free-ranging LGDs were significantly lower than those at other flocks in the same regions. As involved LGD breeds, Caucasian Shepherd Dogs were perhaps more likely than Slovensky Cuvac to exhibit aggressive protective behaviour which made them potentially more effective at repelling determined predators. A successful outcome, by bonding pups uprearing them of an young age with livestock, they are intended to guard, was not guaranteed (Yilmaz et al. 2015).

Many farmers and shepherds were reluctant to undertake extra work in order to implement more effective preventive measures against large carnivores, even where high losses had been reported. Several external factors hindered the application of LGDs, including dogs being shot by hunters, encounters with tourists/hikers and farm visitors as well as socio-economic changes both within the livestock industry and on a broader scale. The outcome implied the subsequent implementation of a programme assisting in addressing these problems by explaining the role and behaviour of livestock guarding dogs to affected stakeholders in more detail (Yilmaz et al. 2015).

Cooperation

The project initiated by the Swiss-Slovak Cooperation Programme, that aimed to adapt systematic monitoring from Switzerland, was funded 90% of eligible costs, with additional cooperation and financing provided by the Karl Mayer Trust, The Wolves and Humans Foundation and Slovak Wildlife Society (SWS).

Joint barriers/conflicts

Conflict between lynx and livestock breeders (sheep, goats) exists, but it is minimal for lynx (with wolf being the main driver for conflict concerning livestock depredation - with an estimated 1.625 lost sheep annually to wolf compared with 4 sheep killed annually by lynx) (Rigg et al. 2011). Guard dogs assist in preventing attacks and/or mitigating problems with large carnivores (LC), and livestock (see above) and domestic animals are also protected by electrical fencing.

According to Kubala et al. (2018) main threats relate to habitat fragmentation caused by amongst other factors caused by forestry activities, building of infrastructure (roads/highways), with the worst highway being D1 Ružomberok - Poprad, which dissects Lower Tatra NP (NAPANT) and Tatra NP (TANAP) with only one existing green bridge, causing traffic accidents with migrating wildlife and large carnivores. An increase in recreational activities within the NP of Slovakia - new ski resorts, golf courses, hotels also represents a threat (Ondrus and Adamec 2009) and illegal hunting.

Driver assessment / threats

The results of pathological examinations of carcasses found within the “Living with Carpathian Spirits”-project showed that infectious diseases, congenital malformations in young animals and poaching are definitely issues currently faced by the Western Carpathian lynx population. This underlines the importance of implementing a well-organized lynx health surveillance programme in Slovakia, the overall goal of which is to carry out adaptive management based on scientific data (Rigg and Kubala 2015).

Additionally, Krojerová and Duľa (2018) mention several incestuous matings, especially in the Javorniky family group identified by genetic analysis of noninvasively collected genetic samples.

Another factor posed pollution with heavy metals. according to Ondrus and Adamec (2009), collected tissue samples of lynx in Lower Tatra and Tatra NP contained high amounts of cadmium. These residues of heavy metal can be traced back to the times before the fall of the Iron Curtain, where steel works, power and heat stations, as well as coal mines were the main source of pollution concentrated in the Western and Northwestern Carpathians. In the upper montane forest zone of the northwestern part of the Beskid Mountains and the Western Carpathians were the most drastic effects observed. Large volumes of contaminated acid mine waters and degraded wastewaters were evacuated in streams, spreading within the respective drainage basins and having harmful consequences for the natural environment. In periods of maximum activity, estimated losses were of 50- 60 kg/t of lead, about 75kg/t of zinc, 60 kg/t of copper, accompanied by significant amounts of tellurium, phosphorus, mercury and cadmium (Carpathians Environment Outlook 2007).

Hungary

Existing approaches (monitoring and participation/stakeholder involvement)

Prior to the 1980s, the official nature conservation authority of Hungary considered it unnecessary to collect data on an extinct species. So there is a gap of several decades regarding lynx occurrences in Hungary within available literature (Szabó and Gadó in Rig and Kabala (2015)).

In the 1980s, possibly even in the 1970s, lynx reappeared in northeast Hungary. Szabó and Gadó knew this only from an increasing number of illegal killings reported by rural and local populations. Some of these reports were no more than hearsay. According to Szabó and Gadó, the lynx in Hungary originated and were in close connection with the population in Slovakia, with individuals migrating from Štiavnica Mts. - Börzsöny, Slovak Karst - Aggtelek and Slanské Mts. and Zemplén Mts. in Slovakia.

Monitoring

In 2001, a field monitoring system was established with the data collected by a network of experts (LIFE Nature Project). Three levels of data collection were defined: (i) regular examination by qualified people (field survey to look for tracks and signs on previously assigned transects six times a year), (ii) other observations in the area by qualified or professional people, and (iii) information from other sources, which are not or cannot be verified.



Figure 11. Lynx occurrence in Aggtelek and Slovak Karst in winter 2014-2015 based on snow tracking (Szabó and Gadó in Rigg and Kubala 2015).

The results so far confirmed the above described situation, i.e. that the occurrences are sporadic and sometimes unverifiable, and that a more detailed survey is needed using additional methods. The most urgent conservation action in Hungary would actually be to gather more information on lynx occurrence (Szemethy and Markus 2004).

In Aggtelek National Park and Zemplén Protected Landscape Area, Szabó and Gadó (in Rigg and Kubala 2015) followed lynx tracks primarily by snow tracking (Fig. x). They describe circumstances as “not always favourable, for example sometimes there is no car available so we use also a horse or skis during the year”. In Borzsony, a colleague, Laszlo Daranyi, was also tracking lynx that was probably a single individual (Szabó and Gadó in Rigg and Kubala 2015).

In 2015, according to Szabó and Gadó (in Rigg and Kubala (2015), potential lynx habitats were found in the whole Northern Mountain Range from the Danube to Zemplen.

Compensatory measures

There are no compensation systems and, as there is no need, no damage prevention methods are applied in the country (Szemethy and Markus 2004).

Cooperation

Szabó and Gadó (in Rigg and Kubala (2015) mention data collection by a network of experts with regular meetings to unify methods (among other methods the use of camera traps) and discuss results and outcomes.

Joint barriers/conflicts

The public acceptance of lynx is better than for wolves. Nevertheless, strong prejudices still exist. To increase public acceptance, it is important to work with school children, but the most urgent task is to change hunters’ attitudes (Szabó and Gadó in Rigg and Kubala 2015).

Migration across the Slovakian border has especially important for lynx occurrence in Hungary, and international collaboration should therefore be enhanced. Potential habitat suitability, prey base in Hungary, and the corridors to the Carpathian population in Slovakia need to be assessed in order to develop an appropriate conservation strategy. Furthermore, a close co-operation with countries neighbouring Slovakia regarding lynx conservation has to be established. The future of the lynx in Hungary depends entirely on the management of the species in southern Slovakia (because lynx individuals monitored in Hungary derive from the Carpathian population in Slovakia), which at the moment is uncertain (Szemethy and Markus 2004). A strategic co-operation could motivate and support rational conservation and management of the species on both sides of the border.

Another barrier that is mentioned, are the used camera traps, the number and quality of the obtained pictures, which is not sufficient for individual identification and subsequent population analysis (Szabó and Gadó in Rigg and Kubala 2015).

Driver assessment / threats

The main reason that Eurasian lynx is not distributed on a larger scale within the Hungarian part of the Carpathian Mountains, is due to illegal hunting (Szabó and Gadó in Rigg and Kubala (2015). Consequently, the population is very small and fragile (12 individuals only) and requires further development. In 2004, Szemethy and Markus (2004) stated habitat fragmentation (intensive forestry and road construction), human disturbance through increasing tourism and recreational activities, intensive game management and extensive livestock breeding as threats, livestock depredation cases are hardly known (Kaczensky et al. 2013).

Bulgaria

Existing approaches (monitoring and participation/stakeholder involvement)

No official estimation of population size or monitoring for lynx exists in Bulgaria. Balkani Wildlife Society, based in Sofia, state on their website that they are monitoring 13 mammalian species, but the lynx is not among them (<http://balkani.org>). Until 1999, the lynx was periodically reported and observed with traces of their presence located in the western to central Balkan Mountains.

These individuals probably originated from the Carpathian Population. Unconfirmed data for lynx presence deriving from the Balkan population originates from south-west Bulgaria (Osogovo, Rui, Kraishte, Maleshevska and Vlahina mountains) (Zlatanova and Genov 2001). Information usually came from local people, but hard facts and evidence were to a great extent missing. In the winter of 2002/2003 a team of BALKANI Wildlife Society registered lynx tracks in Mid West Bulgaria.

In 2008, Balkani Wildlife Society collected and analysed hair samples, and lynx presence was proven in Western Stara planina based on subsequent DNA analysis (90% certainty).

In 2008 and 2009 the Department of Zoology and Anthropology of Biological Faculty, Sofia University initiated the first two research projects in Bulgaria based on camera trapping funded by the Scientific Research Fund of Sofia University.

In this project, lynx existence based on hard facts (C1) was irrefutably proven, when camera-trap pictures of two individuals were recorded in the Osogovo Mountains. For these projects, four camera traps, two with regular flashlight and two with infrared flashlight, were used (Zlatanova et al. 2009). Additionally, as cited by Kaczensky et al. (2013), between 2008 - 2011, two individuals were recorded in the Western Stara Planina Mountains (near the border with Serbia; one by tracks and one illegally killed) and tracks of a mother with cub was found in the central part of Bulgaria (Nature Park Bulgarka, part of the Central Balkan area).

In 2013, the lynx occurrence in the country was estimated by experts at a minimum of seven resident individuals and at least two reproducing pairs (prior to Nov 2011). The trend is unclear, although most probably the number is increasing (Kaczensky et al. 2013).

As of 2013, there is no information on applied management and monitoring schemes within Bulgaria for Balkan Lynx. According to Kaczensky et al. (2013), a Natura 2000 project in 2011-2013 was the first to try to assess the presence and conservation status of the lynx in Bulgaria and to set up the basis for species monitoring. During research for the present compendium, the author couldn't find any information on the results of this project.

Today, observers feel certain that the species has returned to the country, but additional, detailed and long-term research is needed (<http://balkani.org> - 2018).

Compensatory measures

In 2000, a program was applied by the Bulgarian NGO Fund Wild Flora and Fauna (FWFF), in order to implement a compensation scheme, if a large carnivore killed livestock. To apply for compensation payments, the farmers had to implement three criteria a) guarding dogs had to be used with the herd, b) the herd had to be always herded by a shepherd and c) the herd should never be left outside the corrals during the night. The FWFF provided 20 Karakachan dogs in the project with highly satisfying results. It was proved that predators did not attack the herds with well-trained mature Karakachan dogs (Yilmaz et al. 2015).

Cooperation

Local management actions are applied through the Regional Inspectorates of Environment and Waters (RIEW) and National Parks authorities, which are responsible to MOEW (Kaczensky et al. 2013).

Joint barriers/conflicts

The main conflict persists with lynx in Bulgaria is with hunters over predation on wild ungulates, mainly roe deer (Kaczensky et al. 2013). But predation on livestock poses another serious conflict (with bears and wolves mostly responsible for killings), not only because of the number of killed livestock but an increased motivation of breeders/herders to kill large carnivores in response, even by using poison baits, which are illegal in Bulgaria (Yilmaz et al. 2015).

Driver assessment / threats

The dated lynx survey 2001 conducted by Zlatanova and Genov (2001) identified as main threat for lynx illegal killings (shooting, trapping, poisoning), with many cases remaining undocumented, some reported, but not confirmed. Although the majority of hunters are in favour of the return of lynx, there is generally low acceptance for the presence of “another predator” as well as for a rapid decrease in prey base due to over-harvesting of prey populations. Other threats persisting: direct competition for prey, large-scale wood plantations and/or clear-cutting, change in native species dynamics (directly impacting habitat quality), pest control (poisoning), limited dispersal and low densities (Strandzha Mountains), lack of knowledge about species numbers, trends or species ecology, poor enforcement of legislation and lack of capacity in management structures (Kaczensky et al. 2013).

Dinaric Population (without Slovenia¹)

Croatia

Existing approaches (monitoring and participation/stakeholder involvement)

In Lynx Management Plan for the period 2010 - 2015 population size was estimated to 30 - 60 individuals, mostly based on expert opinion. In 2013 national IUCN lynx status was changed from nearly threatened to critically endangered, based on Sindičić et al (2013) and expert background study.

Since 1978 mortality is monitored with available lynx carcasses collected, measured and sampled. Thus in 1978, the first dead lynx was recorded (after reintroduction of Eurasian Lynx into neighbouring Slovenia in 1973), and by 2013 total mortality of 232 animals has been recorded (Sindičić et al. 2016).

Camera trapping as lynx research method is used since 2007, but national level monitoring with camera traps was established only in 2018. Data from about 200 cameras (owned and operated by different projects, public institutions, companies, NGOs and hunters) are gathered by LIFE Lynx project team. All monitoring data is publicly available at internet database <http://lynx.vef.hr>.

In 2013 Croatia joined SCALP initiative and is preparing yearly reports.

Research activities (mostly based at Faculty of Veterinary Medicine University of Zagreb) are focused on lynx morphology, activity and movements, genetic variability, feeding habits, diseases.

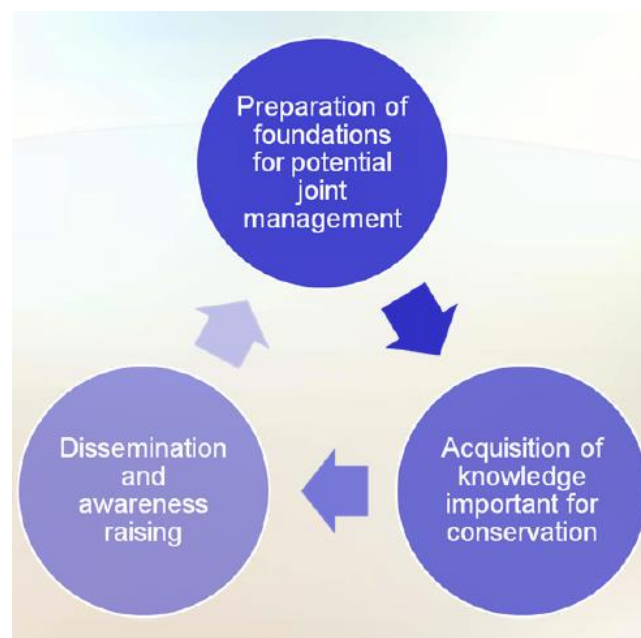


Figure 12. Main objectives within the DinaRis Project (Skrbinšek et al., n.d.)

¹already described in D.T1.2.1 Compendium of existing approaches within the partnership including joint barriers and driver assessment

A lynx emergency team is managed by national authorities and regularly trained by scientist. They primarily assist in mortality monitoring, cases of orphaned lynx cubs and occasionally with field monitoring activities.

The Joint Management Plan included joint monitoring efforts, an online database with cartographic interface, collection of lynx presence data and a systematic collection of genetic materials (among them, noninvasive collection of hair samples via hair traps). Additionally, a webpage was created, brochures about lynx in the Dinarics were published and interactive exhibitions for elementary school children and info panels about lynx on existing educational trails were installed.

A movie, lectures about lynx for the general public, and communication over media via press releases complemented the toolbox used to increase public awareness within the project (Majić-Skrbinšek, 2008).

In 2010 National Lynx Management Plan for the 2010 - 2015 period was published but due to lack of finances many activities were not implemented. At the moment a new management plan is being developed in cooperation with all interest groups.

Compensatory measures

A team of trained experts examines and evaluates each case of damage on livestock supposedly caused by large carnivores, including lynx. The evaluation serves as the basis for subsequent compensation payments but also represents a part of the monitoring efforts (Kaczensky et al. 2013). Nature Protection Law (1994, 2003) ensures compensation is paid from the national budget for domestic animals killed by lynx, while damage on wild prey is not compensated (Sindičić et al. 2009). Consequently, for hunters, each roe deer taken by lynx is a loss for which they cannot request compensation.

Cooperation

Informal and project-based partnership between Slovenia and Croatia regarding research and monitoring. Researchers from both countries are in constant contact, exchanging data and other informations on the distribution and occurrence of lynx, performing common monitoring and research as well as conservation projects for lynx and other large carnivores. As far as management is concerned, there is less collaboration, although there are more or less regular meetings also at administration level regarding transboundary management.

Researchers from Croatia and Slovenia also prepared a transboundary management plan for lynx, but it was never accepted by the government of both countries (Blanco 2012).

In 2005, DinaRis, an initiative to start transboundary cooperation between Croatia, and Slovenia for the Management, Conservation and Research of the Dinaric Lynx Population was initiated. The general goal was to establish a network of partnerships in the Northern Dinarics, which contribute towards promotion and long-term conservation of the existing lynx population. The DinaRis Project included the development of a joint management and research platform in Croatia and Slovenia. Within the project foundations, a potential joint lynx management plan was proposed, bilateral workshops were held and various institutes of both countries concerned with conservation participated.

In this context, the most important questions posed: which factors cause a decline in lynx numbers, what are the species requirements, and how can knowledge about lynx and public support for conservation be promoted (Majić-Skrbinšek et al. 2008)?

While full cooperation with Slovenia for evaluation of the Dinaric population exists on a scientific level, political agreement on management is expected to develop when Slovenian side elects to accept the process.

Joint barriers/conflicts

Current conflict with livestock is very low, and no damages to livestock have been reported since 2006. This is partly explained by low lynx numbers (30-60 individuals) but is also due to limited livestock herding activities within the lynx distribution range, which is mainly backed by proper husbandry schemes supported by guarding dogs used by local farmers who have always lived with large carnivores. The acceptance by hunters is the main socio-economic limiting factor for the increase of lynx population. In 2005, 40 % of hunters surveyed believed that lynx caused unacceptable damage to roe deer populations (Skrbinšek et al., n.d.).

An additional barrier in the process of efficient population estimation and planning of conservation efforts, many resident lynx have part of their range in neighbouring countries (Slovenia and Bosnia and Herzegovina), which makes it difficult to follow a unified conservation guideline. But projects like LIFE Lynx are trying to overcome this obstacle.

Driver assessment / threats

Based on mortality monitoring conclusions about existing threats were determined and, in the period of 1978-1998, prior to protection of the species, most observed causes of death were human-related, with shootings (mostly legal) accounting for the greatest percentage of these deaths. From 1999 to 2013 (after gaining the status of legal protection) significantly lower yearly mortality was recorded but with increase in recorded poaching cases (Sindičić et al. 2016).

Genetic variability of lynx in Croatia and Slovenia was researched using historical samples from trophies and invasive and non-invasive samples of present population (Sindičić et al. 2013). Low genetic variability and significant levels of inbreeding were found, so authors concluded that a synergy of human-induced mortality, including shooting prior to 1998 (before protection) and illegal killing (post protection 1998-2013), a reduction in genetic variation, with the population deriving from only three pairs reintroduced in 1973, act as main factors for the current decline of the Dinaric lynx population (Sindičić et al. 2012; Polanc et al 2012). Additional threats are low prey availability and, to a certain degree, competition with bears, that often take over prey killed by lynx (kleptoparasitism).

Reinforcements with new individuals from from Slovakia and Romania are necessary and urgent and will be part of the ongoing efforts within the current LIFE Lynx project (2017-2024) executed by Croatia, Italy, Slovenia, Slovakia and Romania.

Bosnia and Herzegovina

Existing approaches (monitoring and participation/stakeholder involvement)

According to the dated Lynx Survey Europe, which was conducted for Bosnia- Herzegovina by Soldo and Lucic (2004), population numbers were estimated using data collected by hunters and foresters/forestry offices (derived from numbers on animal mortality mostly caused by hunting), collection of observations of animals and collected tracks/foot prints. Legislation for forestry and hunting was still missing at that time, and consequently there was no reliable network of information (Soldo and Lucic 2004). Kaczensky et al. (2013) adds snow tracking as applied monitoring method on national level and camera trapping on a regional scale.

In 2017, the distribution of Eurasian Lynx in Bosnia-Herzegovina was surveyed by questionnaire among all hunting and forestry organizations who have (or had) lynx in their hunting grounds (Trbojević and Trbojević 2018). The interviews were conducted with 51 different organizations (hunters, forestry, NGO's) in September/October 2017. In addition to the questionnaire, SCALP criteria were used to assess the reliability of given information on lynx presence. The presence of lynx was confirmed by 29 organizations, and Trbojević and Trbojević (2018) assume from the results of the interviews an approximate number of 90 lynx inhabiting 9900 km² within Bosnia-Herzegovina. The interviews additionally revealed 32 lynx cullings in the last 10 years.

To date, no legislation or implemented monitoring and management plans exist for lynx in Bosnia-Herzegovina (Trbojević and Trbojević 2018).

The assumption of an approximate population size of 90 independent lynx in Bosnia-Herzegovina derived from a survey with questionnaires applying SCALP-criteria (in order to assess the reliability of given information on lynx presence), has to be seen under qualified acceptance and seems rather overestimated. A baseline survey leave uncertainties and might be biased, lacking hard facts and sound evidence, while relying heavily on assumptions and statements of the questioned stakeholder group in order to address precise population estimates. Consequently, these assumptions adopted from the questionnaire by Trbojević and Trbojević (2018) have to be supported in the near future by systematic camera trapping and genetic sampling to verify these rather overestimated population size for Eurasian lynx in Bosnia-Herzegovina.

Compensatory measures

No information on compensatory systems or damage prevention methods to livestock could be obtained.

Cooperation

Improved knowledge about lynx in Bosnia-Herzegovina would allow the establishment of guidelines to support future existence of lynx in the country and the entire lynx population, of which Bosnia-Herzegovina shares an important part. In 2004, Soldo and Lucic, mentioned the need for “a sensible co-operation with Croatia, Slovenia, and Serbia and Montenegro” in order to support conservation efforts for the Eurasian lynx within Bosnia-Herzegovina (Soldo and Lucic 2004).

Joint barriers/conflicts

In the early 2000s, the political and economic situation in Bosnia-Herzegovina was not in favour of conservation concerns. The country consisted of two administrative divisions, the Federation of Bosnia and Herzegovina (further divided into 10 divisions) and the Serbian Republic, both with their own laws. Marginal damages to livestock (goats, sheeps) with no exact data available (Kaczensky et al. 2013).

Driver assessment / threats

Major threats to the lynx population in the country were accredited prior to 1996 to legal hunting and trapping, shooting, war and civil unrest (during the Yugoslav wars). Between 1996-2001 threats were identified as legal hunting/trapping, shooting, vehicle and train collision, lack in ungulate prey base, which according to the authors of the lynx survey for Bosnia-Herzegovina will continue in the future (Soldo and Lucic 2004).

In 2014, a lynx was shot by hunters in eastern Bosnia, despite the species being protected in the country (LCIE 2014).

Jura Population

France

Existing approaches (monitoring and participation/stakeholder involvement)

The monitoring methods have been standardised since the beginning of the 1990s using a network of ca. 3500 trained local assessors, who are in charge of collecting signs of presence and surveying the distribution ranges of lynx within the french distribution range of the species year-round. They are aligned by 10 regional coordinators and one national coordinator on a regular base (Drouet-Hoguet 2018). The core population, largest and most active population is located in the Jura Mountains. Every find is described and sent to the central state agency, "Office national de la chasse et de la faune sauvage" - (ONCFS), who is in charge of the validation process. Methods employed are direct observations and collection of non-invasive samples such as tracks, foot prints, scats and hair, snow tracking, and radio telemetry (between 1995-1999 in the Jura Mts., nine lynx were followed by means of radio-tracking). Specifically, lynx presence was studied with data from the "réseau lynx" (network of trained local correspondents who collect, verify and transmit data to departmental coordinators) (Vandel et al. 2004).

Since 2010, Capture-Mark-Recapture (CMR)-based estimates of abundance and density are derived from four large study areas (several hundred km²), which are intensively surveyed with camera-traps to allow individual identification of animals by their coat patterns (Kaczensky et al. 2013). Annual assessment of regular and occasional presence of lynx took place in biennial periods from 2014 - 2016 and 2015-2017 in 10x10 km grid cells, with permanent camera trap placement schemes (at least 2 signs of presence collected for each period) and non-permanent camera trap placement schemes (at least 2 signs collected for 1 period). Between 01.04.2014 - 31.03.2017 a total of 1084 signs of lynx presence were collected in the Vosges (with an area occupied by lynx of 500 km²), French Alps (1100 km²) and Jura Mountains (6800 km²) (Equipe ONCFS d'animation du Réseau Loup-Lynx 2018).

In 2018, a predator-prey program was initiated, to understand the influence of hunting (human activity) and lynx predation on deer and chamois (as well as ungulate -ecosystem balance) more precisely. Therefore were 10 lynx with radio collars equipped ((Drouet-Hoguet 2018).

Compensatory measures

Financial compensation of damage assessed by experts of the "réseau lynx": Judgement according to situation observed by experts when visiting a place with proposed lynx kills. In case of a disagreement between livestock breeder and expert, a departmental commission takes the decision for or against compensation payment.

Surrounding circumstances contributing to a final judgement (livestock, if or if not killed by a large carnivore) are rarely recorded. A technical opinion by the examining expert is then given: attack attributed to lynx (100% compensation) or probable/doubtful (75% compensation) or not confirmed/examination not possible (no compensation). The Ministry of Environment is responsible for the compensation payment.

Preventive methods

Financial compensation, order to leave national parks, in which persists a risk of encountering large predators during the night, placement of guarding dogs. The latter two measures are however difficult to establish in the context of sheep breeding in the Jura Mts. The procurement of a guarding dog falls under the financial responsibility of the breeder (Vandel et al. 2004).

In the Jura Mountains, sheep are always unguarded and wander freely by day and night. Livestock guarding dogs are not used, which promote damages caused to livestock. A long-term surveillance showed that there was no general lynx-livestock problem in spite of the absence of preventive methods by applying livestock guardian dogs (Yilmaz et al. 2015). Nevertheless, between 2006 and 2011 18.360 € was paid for 92 sheep killed by lynx (Yilmaz et al. 2015).

Removal of problem lynx

Several permissions for the removal of problem lynx have been given by the Ministry of Environment to prevent further attacks in places reporting recurring attacks (two adult lynx) (Vandel et al. 2004).

However, a study conducted by Stahl et al. (2001) about the effect of removing lynx for reducing attacks revealed, after removing in total eight lynx (and two large carnivores thought to be lynx) from an area with increased and repeated attacks on sheep, lead only to a temporary reduction of concentrated lynx damage to livestock. The only way to obtain a durable effect was to introduce, respectively improve sheep herding techniques and fencing.

Joint barriers/conflicts

Mostly with sheep herding and husbandry in the Jura area, according to Kaczensky et al. (2013), averaging less than 75 attacks / year during the last 10 years. Perceived competition in hunting for roe-deer by hunters; a study is needed to determine the basis for opposition from hunters.

Driver assessment / threats

Vehicle collisions and illegal killings (Bauduin et al. 2018).

Switzerland

Driver assessment / threats

Traffic accidents, illegal killing, conflicts with hunters and lack of knowledge about conflict mitigation (IUCN 2018).

See Alpine Population - Switzerland for information on applied approaches, compensatory measures and joint barriers/conflicts.

Vosges-Palatinate Population

Lynx have a tenuous presence in the Southern mountains of the Vosges in France and the Palatinate forest in Germany. Between 1983-1993, 21 lynx (12 males and 9 females) mostly originating from the Carpathian population in Slovakia were reintroduced. Between 1992 and 2003, in the Vosges Massif, 58 lynx were born. Most recent surveys carried out by the Lynx Network in France failed to detect any lynx due to believed widespread persecution, which doesn't rule out any current presence completely.

Moreover, this opportunistic monitoring has been supplemented since 2011 by different field protocols with camera traps to clarify the conservation status of the Lynx in the French Vosges Mountains. Intensive camera trap sessions were organized from the winter of 2012/2013, according to a previously validated protocol in the Jura Massif (see Gatti et al., 2011). The first two intensive surveys were organized in the Hautes-Vosges (winter 2012/2013, Germain et al 2013) and south of the A4 motorway (winter 2013/2014, Germain 2014a, b). The two most recent ones were conducted in the Northern Vosges (winter 2014/2015, Germain et al., 2015, 2016) and in the Middle Vosges (winter 2015/2016, Charbonnel et al., 2017). During these four intensive sessions, no lynx photography was taken.

In 2010, to meet this negative population trend, an association was formed, called "Luchs Projekt Palatinate-Vosges du Nord". This development was accompanied by an action plan following a German conservation perspective for reintroducing lynx in the Palatinate forest NP, combining efforts with Vosges du Nord NP on the French side. The plan envisages, that Eurasian lynx would become a symbol for the transnational biosphere reserve (BR) "Palatinate / Vosges du Nord". Evaluation of habitat suitability indicated, that there were suitable habitats in the cross-border biosphere reserves, with given habitat quality and connectivity, including enough available prey base, hiding places and undisturbed retreats. Mortality due to road transport was considered, as was scientific monitoring and supportive measures after release, including sufficient financial support. At least 10 to 15 animals were recommended to be released in a central area of the Palatinate Forest with the project being promoted on the French side by means of public relations work and habitat improvement measures. With the intention, that lynx would most likely migrate from the reintroduction areas in the Palatinate Forest in Germany across the border into Vosges du Nord biosphere reserve on the French side (Fisher 2017).

A study was carried out, in order to determine whether lynx still had a place in the Vosges, and if the species could form a transboundary population, given the extent of persecution it had suffered by illegal killings (Scheid 2013). In considering the ecology of the lynx, prevailing habitat quality and conditions such as the quantity of prey, it was concluded that Eurasian lynx did have a long-term perspective, linked to certain conditions: reduce lynx mortality caused by traffic accidents, as well as an active persecution of perpetrators accused of illegal killings; restore ecological connectivity within the Palatinate Forest, Vosges Mountains, as well as the neighbouring Jura and Black Forest; improve dialogue with the local hunter associations, monitor and census prey densities in areas frequented by lynx and take into account the presence of lynx when calculating hunting quotas for hunters in areas, where the species occurs; support sheep farmers by informing on damage prevention methods, as well as existing compensation schemes.

Additionally, the provision of a lynx management plan in case of repeated attacks by problem individuals; accompanied by an effective monitoring program, covering topics like reproduction, mortality, territorial use and dispersal, genetic diversity and prey taken accompanied by improved cross-border coordination, especially between the Lynx Network in the Vosges and that of the Palatinate forest (Fisher 2017).

France

Existing approaches (monitoring and participation/stakeholder involvement)

Vandel et al. (2006) estimated population's expansion from the data obtained by a spatial analysis of 616 signs of lynx presence collected from 1988 to 2002. Of the 21 reintroduced lynx in the French Vosges Mountains, four females and six males were able to survive and contributed to the population's establishment. The lynx distribution area covered 1872 km² in 1988-1990 and increased to 3159 km² in 2000-2002. The area's expansion most often started in the reintroduction sites, where as of 1987, the first cases of reproduction were recorded. From 2004 to 2017, a continuous decline of the lynx distribution was ascertained, resulting in <500 km² in 2017 (Equipe ONCFS d'animation du Réseau Loup-Lynx 2018). Thus, twenty years later, and relative to the other lynx population in the Jura, the future of the lynx in the Vosges mountain massif is uncertain. Consequently, in 2016, the "Programme Lynx Massif des Vosges" (PLMV): a specific conservation action plan was initiated to address the uncertain future of the lynx population in the Vosges (Germain and Charbonnel 2017).

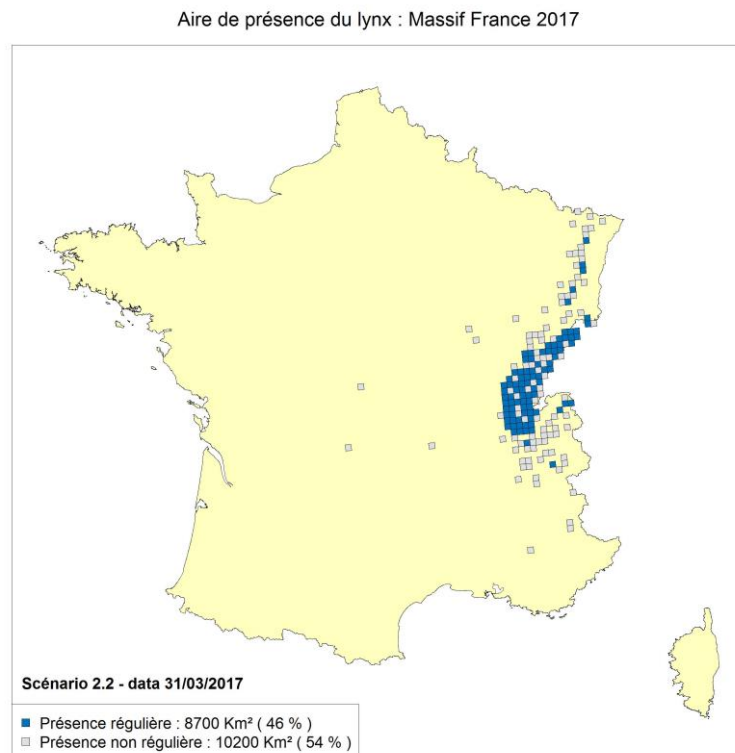


Figure 13. Area of regular (blue) and occasional presence (grey) of Lynx in France (© Réseau Loup/lynx - ONCFS h@p://carmen.carmencarto.fr/38/Lynx_presence_par_maille.map)

The goal of this plan: defining and developing concrete actions to improve the conservation status of the Lynx in the French Vosges Mountains and establish a coordinated and shared monitoring and management approach with local stakeholders. The current two main conservation issues identified are coexistence with hunters and sheepbreeders and then, ecological connectivity and habitat. The drafting phase is ongoing (Germain and Charbonnel 2017).

Compensatory measures

See Jura population - Compensatory measures

Joint barriers/conflicts

Extremely small and vulnerable population (Vandel et al. 2004).

Driver assessment / threats

Similar to the Jura population, but in the Vosges Mountains poaching could present a far more important threat than in the Jura Mts. In this region, the lynx population is numerically lower than in the Jura, the hunting pressure is more important and the mode of hunting (stalking or raised hide) more adapted to spot and shoot lynx than in the Jura (collective hunting with hounds), additionally the low genetic diversity ($H_o = 0.472$; $H_E = 0.473$) of the population (Bull et al. 2015; Vandel et al. 2004).

Germany

Existing approaches (monitoring and participation/stakeholder involvement)

An application for LIFE funding was made in 2013 and accepted by the European Commission in 2014. In 2015, the LIFE Lynx reintroduction project in the Palatinate Forest Biosphere was initiated (“LIFE Luchs Pfälzerwald - Reintroduction of lynx (*Lynx lynx carpathicus*) in the Palatinate Forest Biosphere Reserve”). The main aim of the project is to re-establish a lynx population in the Palatinate Forest, with one of the main objectives, to improve the status of the species in the Palatinate Forest NP and the neighbouring Vosges du Nord NP on the French side following an approach to reconnect lynx populations in Western Europe. This will be achieved through a reintroduction programme involving the release of 20 lynx (10 from Switzerland and 10 from Slovakia). The LIFE Lynx project runs for six years from January 2015 until September 2021 with a budget of 2.7 Mio. € (SNU 2015).

In 2016, the the SNU developed a lynx management plan for the species in the state of Rhineland-Palatinate which was implemented by the ministry of environment.

This document included topics and aspects concerning: the ecology of the species, monitoring and legal situation; diseases, the treatment of injured lynx; conflicts with livestock, hunters and hunting dogs; prevention and mitigation methods for occurring damages to livestock/domestic animals, including the promotion of preventive measures, such as the temporary use of light fences (“Lichtzäune”) - fences equipped with irregular flashing lights; the compensation amounts stated for killed or injured livestock and hunting dogs; as well as including conflict management schemes in regard of illegal killings, as well as adjustment of hunting quotas to account for deer predation by lynx. The plan left, the possibility of relaxing the ban on hunting lynx when favourable conservation status of the population is reached, open ((Ministerium für Umwelt, Energie, Ernährung und Forsten 2016; Fisher 2017).

After extensive preparations, the first three lynx were reintroduced in the Palatinate Forest in July 2016; two females aged 5 and 3 and one male aged 1 year. Ten others have followed so far and at least 7 cubs were born in 2017 and 2018. The released lynx are all equipped with GPS collar. Extensive monitoring accompanies the resettlement, as well as broad public relation work and continuous exchange within the involved stakeholder groups in Germany and France.

Compensatory measures

In November 2016, two incidents of predation on sheep were reported, appropriate financial compensation from the provided compensation fund was made available and viable solutions for damage prevention (such as fully enclosing electrified fencing) were offered (SNU 2016; Fisher 2017).

Cooperation

The LIFE Lynx project co-ordinator is Stiftung Natur und Umwelt Rheinland-Pfalz (Foundation Nature and Environment Rhineland -Palatinate). Project partners include SYCOPARC, WWF France and Germany and Landesforsten Rheinland-Pfalz.

Joint barriers/conflicts

By November 2016, the first two incidents of predation of sheep, proposedly caused by the reintroduced individuals, had been reported, with in both cases deficits in fence protection being identified, and viable solutions such as fully enclosing electrified fencing were provided.

Driver assessment / threats

Threats include traffic accidents and minor incidents of livestock depredation. A released female was run over by a train, another broke the metacarpal bones and had to be euthanized due to the advanced inflammation (Idelberger, pers. comm.; Fisher 2017)

Harz population

Germany

Existing approaches (monitoring and participation/stakeholder involvement)

The Harz Lynx Population has been established between 2000 and 2006 by the release of 24 zoo born individuals within the premises of Harz Nationalpark. Since then the federal state of Lower Saxony and the Hunting Association of Lower Saxony have been collaborating as project partners. Since 2002, lynx have reproduced inside the 2,200 km² large Harz mountain range. Since 2010 the population has expanded beyond the boundaries of the Harz area and national park and today is also found to be dispersing into several neighbouring federal states.

Monitoring efforts follow the national guidelines framed by Kaczensky et al. 2009 and Reinhardt et al. 2015 and is based on direct observations and chance finds reported by the general public. Snow tracking is conducted in the higher elevations of the Harz Mountains and among other methods assists to collect genetic samples (hair, scats, saliva samples from prey remains). In 2014, systematic camera trap monitoring has first been established in the Harz Mountains and later on in several other parts of Lower Saxony, Hesse and Thuringia, known to be frequented by dispersing individuals of the Harz population. Inside the Harz area, camera trapping allows to collect data on lynx density and abundance by capture-mark-recapture analysis.

In the Harz mountains, lynx have a mean density of 2.5 independent individuals per 100 km² Mountains (Middelhoff and Anders 2018). The population has expanded its range from 25 occupied cells of the EU reference grid in 2010 to over 75 occupied cells in 2017 (Bundesamt für Naturschutz 2011, 2018).

Since 2008, a total of 21 lynx have been equipped with GPS/ GSM collars by the Harz Nationalpark in order to receive data, e.g. on animal home range sizes, diets and dispersal routes.

Compensatory measures

Damages are caused by lynx attacking livestock like sheep, goats and game animals in enclosures. At rare occasions lynx and dogs get into conflict across ungulate kills defended by a lynx or dogs getting close to lynx offspring. The average annual amount of money paid for livestock compensation within the last 18 years is lower than 2000.00 EURO. All above mentioned federal states follow similar protocols to examine livestock kills and pay out compensation.

Cooperation

The federal states of Lower Saxony, Saxony-Anhalt, Thuringia, the Hunting Association of Lower Saxony, the Forestry administration of Lower Saxony and the Harz Nationalpark are declared cooperation partners within the lynx project. The Harz Nationalpark is responsible for the monitoring of the species in Lower Saxony and Saxony-Anhalt while the federal states of Thuringia, Hesse and North Rhine Westphalia have established their own monitoring structures.

In all federal states voluntary representatives of local hunting organizations (Lower Saxony, Saxony-Anhalt) and other environment groups or private persons (Thuringia, Hesse and North Rhine Westphalia) support the monitoring by collecting data (chance finds, direct observations, non-systematic camera trapping).

Joint barriers/conflicts

While lynx depredation on livestock occasionally occurs it is not regarded as a major problem. The lynx's predatory influence on roe deer populations is a controversial topic among hunters in the region. The most important conflict however is about the species impact on introduced mouflon populations inside and outside the Harz mountain area. Some of those populations are rather small and all of them have a limited range. Especially in the east of the Harz where mouflon has been introduced more than 100 years ago it plays a relevant role for both hunting and tourism.

Driver assessment/Threats

Habitat fragmentation by traffic infrastructure is the most important threat to the Harz lynx population. The Harz has a high forest cover of more than 75% but the area is surrounded by agricultural landscape with a forest cover of about 25% in the west and the south of the mountain range and much less in the north and the east of the area.

The region dissected by several highways; they do not entirely prevent lynx migration but slow it down and affect its direction (Anders et al. 2016). More than 30% of all dead lynx found between 2000 and 2018 have been overrun by cars or trains.

In 2015 sarcoptic mange had a fatal impact on a small subpopulation of lynx in the Hessian part of the distribution area. The disease obviously killed the few resident females. There has been no evidence of reproduction reported since then (all information O. Anders, pers. comm).

Alpine Population Switzerland

Existing approaches (monitoring and participation/stakeholder involvement)

The Federal Office for the Environment (FOEN) is responsible for the management of protected species like Eurasian lynx.

The institution KORA plans, manages and coordinates research projects on the ecology of carnivores in the modern cultural landscape and their coexistence with humans in Switzerland. For lynx monitoring, KORA use an approach encompassing stratification in space (national level, compartments and smaller reference areas within compartments), in time (e.g. chance observations are gathered year round whereas systematic camera-trapping which is very labor intensive is conducted every two to three years in smaller reference areas) and in the datasets according to the type of observation and their validity (e.g. SCALP criteria) (Kaczensky et al. 2013). The following data sources are available: yearly inquiry of game wardens, sightings and signs, known livestock losses/killed livestock number compensated as lynx kills, opportunistic and systematic camera-trapping. In order to address specific research questions (e.g. spatial analysis habitat use), radio-telemetry is applied. Genetic samples of captured or dead lynx are collected and analysed, and each dead lynx is examined at the Faculty of Veterinary Medicine (Vetsuisse Faculty) of the University of Bern.

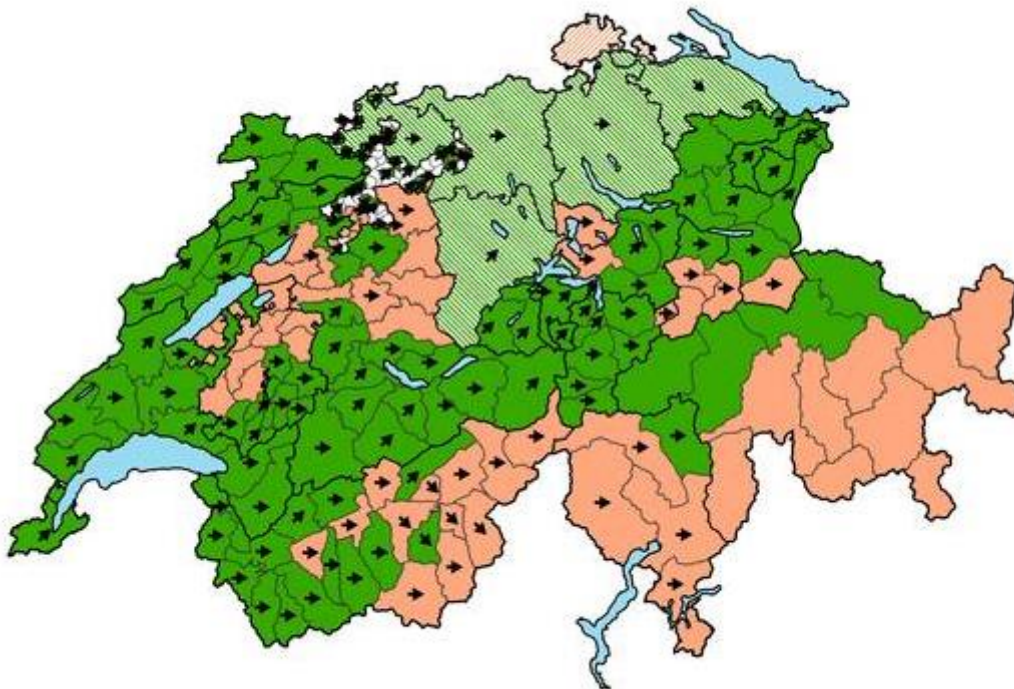


Figure 14. Map of lynx distribution and local trend as derived from an annual inquiry with game wardens and selected contacts (KORA 2016)

Population estimates are based on the ratio of population size (estimated by means of photographic capture-recapture methods) compared with systematic spot sampling and occupied cells based on chance observations. In each reference area, a determined number of camera traps are installed every two or three years for 60 nights to increase the capture-recapture spot sample. Based on the data collected in the field and subsequent statistical analysis, KORA can estimate the actual lynx population size in Switzerland. By regular repetition of the camera trap studies in the reference areas, population changes can be efficiently and transparently monitored.

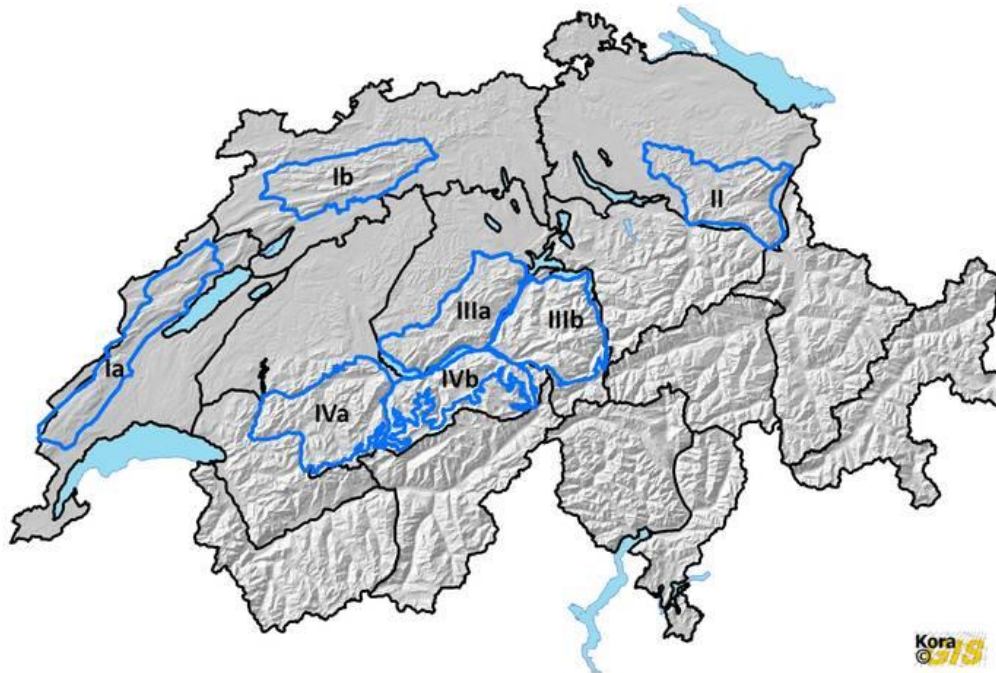


Figure 15. Large carnivore compartments (black polygons) in Switzerland with reference areas (blue polygons) for deterministic camera trapping of lynx. The size of the reference areas is 700 - 1 300 km². For statistical reasons, they should include a minimum of 10 individuals. (Rigg and Kubala 2015)

For the management of lynx in Switzerland, a concept was elaborated in 2000 and adapted in 2004 ("Konzept Luchs Schweiz" - Implementation Assistance of the Federal office for environment for lynx management in Switzerland); a revised version was provided in 2016. The cantons are in charge of the implementation of the concept. To harmonize the implementation, the country was divided into five management compartments. For each compartment, an intercantonal commission (in collaboration with the federal office for environment) coordinates education of the public on lynx ecology, needs and conservation of the species, as well as about occurring problems and conflict mitigation. It also includes monitoring, damage prevention and compensatory measures for the lynx population within Switzerland (Kaczensky et al. 2013).

In 2015, a project on lynx-chamois predator prey relations started, which is executed in collaboration of KORA and FIWI/University Berne. In order to investigate the decreasing chamois hunting bags in various regions of Switzerland. Therefore, in regions, where the lynx is present and the chamois is hunted at the same time following questions arose: Which impact has the presence of lynx and hunting pressure on chamois on the development of the chamois population? How should lynx be taken prospective into consideration in the hunting plan? Until 2018, the project aims to assess, how the impact of lynx predation and human hunting affect chamois populations. In the process, the canton of Berne serves as case study, with the expected result being relevant for other (alpine) regions. The project is on the one hand based on retrospective analysis of already existing data from hunting statistics and existing lynx monitoring (see above), on the other hand on collected lynx predation data, the observation of chamois presence in the field and the estimation of demographic parameters such as survival rates of Eurasian lynx based on deterministic camera trapping data (Zimmermann 2018).

Compensatory measures

Livestock and domestic animals

The Federal Office for the Environment (FOEN) and the cantons established, within guidelines, the conditions for the prevention of damage to livestock and domestic animals caused by lynx. In Switzerland, damages to livestock and domesticated animals caused by lynx are rather limited (mostly affecting sheep, rarely goats). Since 2005, less than one fifth of killed livestock has been deemed as caused by lynx. Therefore, application of nationwide protective measures to avoid damages is not considered necessary. Still, electric fencing, guarding dogs and shepherds are the main prevention methods applied in Switzerland. However, in areas with recurring or increased damage scenarios (“hot spots”), specific measures addressing the situation and prevalent conditions can be waived. These protective measures and their reasonableness are defined within the Guidelines on Herd Conservation, and their implementation is financially supported by the Federal Office for the Environment (BAFU 2016).

Damage to livestock is addressed by the cantonal authorities. Assessment and investigation of each particular case is made by game wardens. The damage to livestock and agricultural crops by lynx is jointly compensated by federal and canton (80% Federal/20 % Canton). The Federal Office for the Environment compensates the damage suffered by the cantons and documents it within the national information platform „Predator Information and Documentation Switzerland“ (GRIDS). A compensation payment for killed livestock is in principle linked to the presentation of the carcass. In dubious cases, cantonal authority may request examination by specialists from the Institute of Animal Pathology, University of Bern.

In the areas populated by lynx, cantons receive compensation of 50 % of the estimated value of the killed animal, if the lynx cannot be excluded as the cause. The amount of compensation to be paid for an individual loss is oriented at the assessment level of national breeding societies.

New World camelids and cervids

Damage to New World camelids and cervids in enclosures will be compensated for the first occurrence. In recurring damage scenarios, the compensation payment is made only if reasonable actions and protective measures that are technically possible, practicable and financially viable were taken to prevent further damage (protection fences, guarding dogs etc.).

After the first incidents in hot spot areas, compensation payments can be extended, if the reasonable, technically feasible, practicable and financially reasonable prevention measures have been previously ensured (BAFU 2016).

Measures for lynx repeatedly causing damages to livestock

Removal of individual lynx that cause significant damage to livestock populations is possible, if there is no other satisfactory solution and the decreed exception does not harm the entire local population within a defined area, and as long as the appropriate herd protection measures have been taken but have proved unsuccessful in preventing another case of damage caused to livestock (BAFU 2016). Thus, if a lynx killed more than 15 sheep within a given area within a year, the canton can ask for a permission to remove the individual. However, this last occurred in 2003 (Kaczensky et al. 2013).

Cooperation

On scientific level, ongoing cooperation exists since decades within the Alps and Jura Mountains in form of the SCALP framework (Status and Conservation of the Alpine Lynx Population). In the Jura Mountains, lynx abundances and densities are jointly estimated by means of camera-trapping in two cross-bordering reference areas of France and Switzerland.

On the political level, the Alpine countries signed a transboundary arrangement in 2009 under the Alpine Convention platform WISO (Wildlife and Society). In 2016, WISO presented recommendations for an internationally coordinated management of lynx populations in the Alps, involved countries are Austria, Germany, Italy, Slovenia and Switzerland (Schnidrig et al. 2016).

Joint barriers/conflicts

In the Alpine and Jura populations of Switzerland, lynx kill livestock and domestic animals only occasionally (see above compensatory measures), indicating that livestock depredation is not a major cause of conflict in Switzerland. The existing conflict with hunting groups is much more prominent, with hunters claiming lynx as competitors when hunting chamois and roe deer. They also claim that too many lynx inhabit certain areas. Consequently, the hunters formed a lobby for population regulations (Enzerink 2017). Dialogue between different interest groups has been initiated, and a common position paper on large carnivore management in Switzerland was signed by the national farmers' and hunters' associations and the two most prominent nature conservation NGOs and was published in May 2012.

Driver assessment / threats

Illegal killing due to low acceptance by hunters is supposed to be the most important mortality factor for the lynx population in Switzerland, followed by deaths caused by traffic accidents and habitat fragmentation. An increasingly evident threat is the risk of inbreeding depression: both populations were founded in the 1970s with only a few individuals. These populations now show reduced genetic variability compared to the source population in the Carpathians (Kaczensky et al. 2013; Breitenmoser-Würsten and Obexer-Ruff, n.d.).

Karelian Population

Finland

Existing approaches (monitoring and participation/stakeholder involvement)

National Resources Institute Finland (Luke) is the most important center for large carnivore research in Finland. Luke conducts research in cooperation with many other organisations of Northern Europe (such as NINA in Norway and the SLU in Sweden). The results of this research form the basis for the Finnish Ministry of Agriculture and Forestry's population management decisions. Ecological research on large carnivores in Finland aims to increase the reliability of population estimates with the help of the collected data.

Monitoring of the Karelian lynx population in Finland has been carried out since 1978. Methodology relies on direct observations and collection of indirect signs of presence (such as tracks left by lynx within a single province on a single day or the collection of scats) collected between 1st of September and 28th of February. These are reported by 1.500 - 1.600 voluntary large carnivore contact persons. Observations of litters/family groups are particularly important. To determine the approximate population size, the number of individual litters is estimated from the observational data. The number of litters is then multiplied by area specific coefficients, which describe the proportion of litters in relation to the total number of individual lynx in an area. The proportion of litters out of the total number of individuals varies depending on the developmental phase of a lynx population (newly established population or a population that has already been established and occupies already a certain territory); consequently, the coefficient varies between areas (www.luke.fi).

Focus of monitoring and lynx research in Finland

The main foci of lynx monitoring and research in Finland is population tracking and studying species specific behaviour. In addition to receiving information and estimating population numbers, the collected data support assumptions about age structure, sex ratio and genetic variability of the Karelian lynx population. Research also yields insights into the animals' movement patterns, dispersal, occupancy, habitats, diets and reactions to human activities. Population size is estimated from observations made during snow tracking (extensive and one-off counts) over the entire country and repeating them in various areas in different years. Additionally, foresters of the state company Metsähallitus, reindeer herders and border guard recorded observations of carnivores, including lynx, crossing the country's borders since 1968. Because a sufficient estimation of the population based on the small number of current sightings would be inaccurate, the results of line transects are also used.

Main objective and conservation goals

The objective for the lynx population in Finland is not to reduce the distribution into the reindeer herding area, but to ensure migration and dispersal of lynx between Scandinavia and Russia. The objective, in the management areas outside the reindeer husbandry area, is: to establish a lynx population that allows for natural expansion and the occupation of new habitats in concordance with preserving specific regional features such as traditional Sámi reindeer husbandry (Kaczensky et al. 2013).

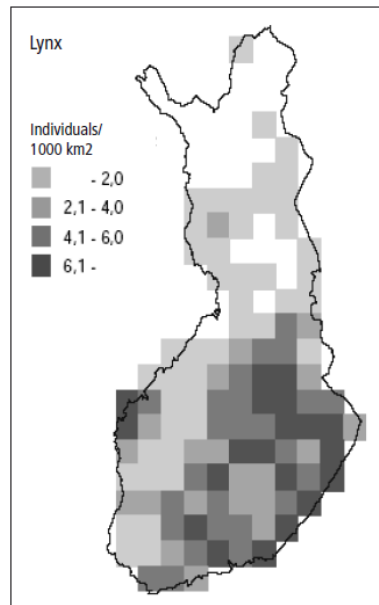


Figure 16. Lynx density in Finland (Ministry of Agriculture and Forestry 2007)

Sub-assessments in smaller areas

Assessing the number of lynx in smaller areas of Finland is difficult and often not possible; consequently sub-assessments follow a different approach than that explained above. These smaller scale assessments do not take place at the level of individual municipalities but rather on small-scale utilising a sub-administrative division of the regional offices of the Finnish Wildlife Agency.

The entire assessment scheme is based on studies of lynx behaviour and biology in Scandinavian countries. This incorporates Finnish conditions in which random observations of litters are often distributed over a long period of time. This method allows for an assessment of the minimum size of the population. In cases where results of separate counts are available (in addition to random observations), this method enables the assessment of the population's average size.

Population modelling

Predictive modelling helps wildlife managers in Finland to decide on the size of the annual hunting quota.

Therefore, the Natural Resources Institute Finland (Luke) has developed a predictive population model to aid the population management in decision-making. This model predicts how different hunting quotas will impact the development of the current lynx population in a four-year time span. In practice, the model provides three alternative hunting rates producing an increasing, decreasing or a stable population. This model was used for the first time in 2012, and it is updated annually with the most recent data (<https://www.luke.fi>).

Minimum lynx population

The method by which an estimate of the minimum lynx population is made is based on a study of the structure of the Scandinavian lynx population (Andrén et al. 2002) in which data were obtained from lynx fitted with radio transmitters and monitored in three different research areas.

The main objectives of the conservation, management and regulation of Finland's lynx population have been stated in the population management plan (Ministry of Agriculture and Forestry 2007).

Compensatory measures

In Finland, the most common domestic livestock killed by lynx (and other large carnivores) outside the reindeer areas are sheep, which are preyed on opportunistically. Damages are reported from calves, to ewes and rams. Large carnivore damages (e.g. to crops, domestic animals, property and reindeer) are fully compensated for by the state of Finland within limits set by the state's budget (Ministry of Agriculture and Forestry 2007).

The Game Animal Damages Act (105/2009) came into effect on 1 December 2009; the Act states that the maximum compensation for an animal killed or put down as a result of a game animal attack is the current value of the attacked animal. This current value is basically the animal's selling or purchase price at the moment it is killed or injured. The values of animals are defined in a separate decree issued by the Finnish Ministry of Forestry and Agriculture.

In order to be eligible for compensation, the applicant's damages must exceed 170 euros for the calendar year. Road accidents caused by large carnivores are no longer covered by the state's compensation scheme, as it is possible to get a separate insurance for those eventualities.

Compensation scheme - domestic dog

In case of a domestic dog killed by a large carnivore, compensation of damage is defined differently (personal and different relationship) than for production animals. The amount for payment to be compensated takes the dog's achievements into account. Here is an example of the value of a dog may be calculated:

The baseline value of a purebred dog is 1.600 euros and the value can be under circumstances supplemented by the following sums:

- +2.500 € for a trained hunting dog that is 1.5 years old or older,
- + 500 € for a dog that has undergone an official medical examination,
- + 100 € for a dog that has received a Good (Yellow) or better rating at a dog show,
- + 500 € for a dog that has completed the bear barking inclination test, and
- + 3.000 € for a dog that has been awarded the title of field trial champion.

Consequently, the current value of a dog that meets all these criteria can add up to 8.200 €.

(www.largecarnivores.fi)

Domestic animal and livestock insurance

In Finland, insurance products are available that also cover damages on livestock and domestic animals, caused by wild animals, which are not covered by the Game Animal Damages Act (see above). The compensation provided by the Game Animal Damages Act is always secondary, but it may compensate for damages that are not covered by the animal owner's own insurance policies. Possible insurance compensations are deducted from the compensations paid by the state.

The state recommends provision for the damage of an exceptionally valuable domestic livestock or dog beyond the state's compensation system, in order to insure these particular animals are considered separately (www.largecarnivores.fi).

Compensation scheme - reindeer

The Ministry of Agriculture and Forestry of Finland is responsible for paying compensations to reindeer owners for damages caused by large carnivores. The compensation is paid directly in cases where the owner recognises the reindeer carcass by its earmark or other identifier, such as a collar. If the reindeer carcass cannot be identified, the compensation is paid to the reindeer herding district where the carcass was found.

The compensation paid for an adult reindeer or a breeding calf killed by a large carnivore is the current value of the reindeer multiplied by one and a half. The additional part is paid out in order to balance the expenses of finding the carcasses. If the owner of a found reindeer carcass cannot be identified, the compensation is paid to the reindeer district where it was found. There is also a system of compensation where the state pays the reindeer herding districts for lost calves based on statistical modelling.

Subsequently, the districts then distribute these funds to the reindeer herders. Furthermore, reindeer herders in districts that suffer repeated and exceptionally heavy reindeer damages are paid elevated compensation where the current value of a reindeer is multiplied by three. The reindeer herding districts eligible for this elevated compensation are defined in administrative decisions made by the Ministry of Agriculture and Forestry. When the Game Animal Damages Act came into effect in 2009, there were four such districts. By 2013, the number had already risen to eight (www.largecarnivores.fi).

Numbers for compensation payments in Finland

In 2011, the total compensation paid for depredated reindeer by all large carnivores combined amounted to 4.9 Mio. Euro, of it caused lynx losses of 554 reindeers totaling 0.8 Mio. Euro (Ministry of Agriculture and Forestry 2012, unpublished). Other lynx-caused damage compensations paid elsewhere in Finland (outside reindeer husbandry area) totalled 15.600 Euro for 25 cases (Kaczensky et al. 2013).

In Finland, in 2016, compensation claims on damages caused by large carnivores reached more than 10 Mio. € paid (<http://ec.europa.eu>).

National Cooperation and Involvement

In Finland, the lynx is subject to hunting law, and the Ministry of Agriculture and Forestry, which determines figures based on research executed by the Natural Resources Institute Finland (Luke), is responsible for setting the hunting quotas. At the regional level, the responsible bodies for game animal management are the provincial units of the Finnish Wildlife Agency's game management districts. The Management Plan for the Lynx Population in Finland was approved in 2006 and published in 2007. The lynx population management plan is part of the Natural Resources Strategy and its implementation under the heading of game management.

Hunting quotas and harvest numbers

Although depredation by lynx is not as extensive as in Sweden and Norway (see respective reports), the hunting quotas and harvest number have steadily increased since 1980. During 1980-1990, a total of 497 lynx were killed. During 1999-2005, on average 51 individuals/year (38-67 lynx/year) were killed (Kojola 2004). Between years 2005-2012 (until end of February 2012), a total of 1539 lynx were killed (with season 2011/2012 listing 404 killed lynx; more recent data not available; Holmala unpublished).

Sustainable harvest quotas are planned and executed according to population estimates based on collected data. Thus, in 2004, about 10-13% of the population (Kojola 2004) was killed by enacted hunting quota.

In 2012, population models demonstrated that the yearly growth of the population had been, on average, 16% (ranging from two to 28%) from 1998-2012 (Holmala and Rintala 2012). Consequently, for the hunting season 2012-2013, the maximum number of permissible derogations was set to some 16% of the estimated minimum population, which should halt the population growth and lead to a stable lynx population (Ministry of Agriculture and Forestry 2012; Kaczensky et al. 2013).

Joint barriers/conflicts

The main conflict over lynx in most of Finland (outside the reindeer husbandry area) is with herders over killed reindeer (outside the reindeer husbandry area lynx cause only a small number of domestic animal losses), hunters over predation on wild ungulates - roe deer and introduced white-tailed deer (Liukkonen et al. 2009).

Drivers assessment / threats

Volunteer Motivation Enhancement

The challenges that the monitoring system is facing is to keep up the motivation of the voluntary carnivore contact persons and to arrange and ensure their training in the long term. Maintaining people's motivation to report sightings is felt to be a problem, especially in areas where the lynx population is dense. As the number of sightings increase, the motivation to report them decreases (Kaczensky et al. 2013). Consequently, activities of the carnivore contact network should be developed so that committed volunteers are motivated, trained regularly and receive productive feedback. Maintaining the carnivore contact system and motivating and training the people involved is the task of the Finnish Game and Fisheries Research Institute in cooperation with the game management districts. Training should be improved, for example, by compiling high quality training material. Carnivore contact persons should receive feedback on their work from the Finnish Game and Fisheries Research Institute, as this is one very important means of motivating people.

Damages to reindeer

Finland's lynx population is no longer as heavily concentrated in the Rovaniemi area as it used to be, and the lynx has spread to other parts of the country as well. In particular, the south-eastern and eastern reindeer herding areas have seen an increase in lynx numbers. Lynx damages have also been on the rise in recent years, and lynx now cause more reindeer damages than wolves (with the wolf still responsible for the highest number of reindeer damages in relation to the size of its population). On the local level, reindeer damages caused by the lynx may be considerable (<http://www.largecarnivores.fi>).

Among the most common causes of death in wild lynx, apart from hunting, are traffic accidents, as well as trapping and illegal killing to a smaller extent (Rassi et al. 2010).

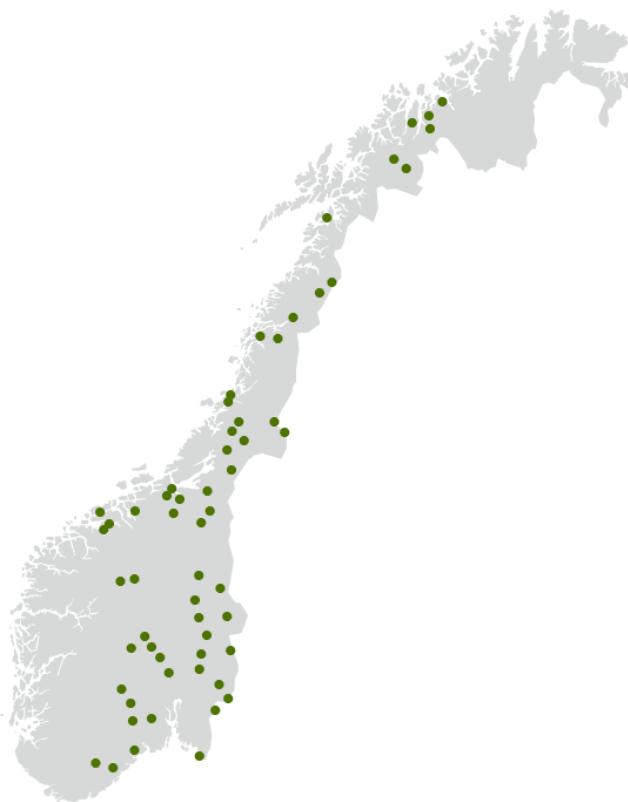
Scandinavian Population

Norway

Existing approaches (monitoring and management, participation/stakeholder involvement)

The lynx population is censused annually, and reproductive events are registered by snow-tracking of family groups since 1995. This is usually performed by local observers, who report to the Norwegian Nature Inspectorate (approx. 200 state nature inspectorates (SNO) rangers validate all tracks of family groups and all shot lynx. Lynx tracks are also censused along fixed line transects in some parts of Norway. The Norwegian Association of Hunters and Anglers is responsible for these observations. Additional presence data is collected by camera-trapping and the collection of all lynx that are shot or found dead in order to support and optimize lynx monitoring. The collected field data are quality controlled by wardens from the State Nature Inspectorate prior to statistical analysis and are analyzed by the Rovdata unit (which was established in 2010 as an independent entity within NINA) at the Norwegian Institute for Nature Research (NINA). A distance rule based on extensive radio-telemetry data is applied to the collected data in order to derive an estimated number of family groups for the entire population within Norway. Subsequently, this is extrapolated to estimate total population size for visualization purposes. All goals and practical wildlife management schemes are based on the number of family groups.

Family groups of lynx in Norway



Source: Rovdata 2017 / environment.no

Figure 17. Number of family groups in Norway (Rovdata 2017)

Since 2005, the population has fluctuated between 65 and 92 family groups depending on the intensity of harvest. The politically determined population target is 65 family groups, and management aims to use hunting schemes with adaptive quota setting to keep the population at this level. In addition, snow tracking each winter by local hunting associations within a national network (of 1948 transects of 3 km length each) is applied, in order to produce an index of abundance as well as records of family groups. (Kaczensky et al. 2013).

Goals of lynx management and monitoring in Norway

Norway's current lynx conservation policy is intended to ensure that the population remains viable and that active and all-round use of resources in uncultivated areas can be maintained, including grazing by livestock and domestic reindeer.

Measures to reduce losses of livestock and domestic reindeer are important in preventing and reducing lynx-human conflicts (see hunting and compensatory measures). Hunting quotas and culling of lynx are both intended as measures to reduce conflict.

Consequently, the Norwegian parliament has set management goals for lynx. The target was set, in 2003, at 65 annual reproductions (family groups). This overall target was then distributed between the eight large carnivore management zones. Regional targets within these zones vary between 0 and 12 family groups. This target is politically determined and based every year on the monitoring data and the results from subsequent data analysis - a hunting quota is set to keep the population at the target. The quota differs between the various management zones based on the surplus relative to the regional targets. Additionally, there is also a limit to the number of females hunted every year. Hunting is allowed in winter between 1st February and 31st March. However, it must stop as soon the quota numbers (within a zone or in total) are reached (number of females or total numbers) (<http://archnetwork.org>). The national level Directorate for Nature Management coordinates management and monitoring between regions. In 2017, 55,5 litters of lynx were registered in Norway before the start of the hunting season, corresponding to about 330 animals. Thus, the annual target of 65 litters was not reached in 2017 (<http://www.environment.no>).

Hunting

For Eurasian lynx, there are specific open hunting seasons. Within this framework, lynx is managed as a normal game species. As the annual quota is set, hunting is allowed between February 1st and April 30th. Quotas are assigned on a fine scaled regional basis, and most areas also include female sub-quotas to prevent over-harvest of this important demographic group. Hunting can be conducted using a range of methods that usually involve large hunting teams and dogs to drive lynx. Live capture box traps are also permitted.

The monitoring data on the status of the lynx population provided by the national level Norwegian Institute for Nature Research (NINA) determines if the regional committees have authority. If a region is below its goal then authority reverts to the Directorate for Nature Management. In addition to lynx shot under the annual quota hunting, a number of permits may be issued for the removal of specific animals in response to acute conflicts with sheep or semi-domestic reindeer during any season.

In Norway during the last 7 years, under this directive, hunters shot between 65 and 154 lynx annually. Very few lynx individuals were killed under “specific problem animal permits” (Kaczensky et al. 2013).

Compensatory measures

Compensation is paid for all domestic animals documented as killed by lynx and for others that are assumed to be killed by lynx. Annually, compensation is paid mainly for lost sheep and semi-domestic reindeer. Direct compensation for losses, which the Norwegian government pays to mitigate the conflict, accounts for around 2.1-2.9 million euros for 7.000 - 10.000 sheep and 1.1-3.4 million euros for 3.000 - 8.000 semi-domesticated reindeer annually (Kaczensky et al. 2013). In theory, the compensation is paid for all the animals that are examined and documented by the regional Norwegian Nature Inspectorate officers. Cases must be confirmed as having been killed by lynx; however, there are many cases in which it is assumed that livestock have been killed by lynx for various reasons including lack of evidence. In 95% of the cases in which compensations are paid, the case has not been confirmed or the livestock is unavailable for assessment.

The direct compensation scheme seems not to be effective in mitigating the carnivore-livestock conflict, as it has not shifted the farming and animal husbandry practices for better and more effective protection of the livestock (although to a very limited extent sheep farmers have begun to adapt their husbandry system to include electric fences). The main mitigation measure to reduce damages to livestock remains, by limiting the size of the lynx population using annual hunting quotas (see above) (Kaczensky et al. 2013).

Livestock guarding dogs

In many countries, the use of guarding dogs within the herd has dramatically reduced the predation of livestock by large carnivores. In Norway, however, guarding dogs on unfenced pastures are not allowed. According to Norwegian “dog legislation”, dogs have to be on a leash from April to August. Also, people are not allowed to train dogs to kill. Therefore, the use of guarding dogs underlies in Norway certain restrictions (Shirkhorshidi 2017).

However, Hansen stated, that livestock guarding dogs, when working in a livestock guarding situation are excluded from the “Dog legislation”. This means, that they are allowed to run free and guard against all four large protected carnivores that are present in Norway. However, sheep are roaming widely on free mountain pastures. Therefore, Hansen recommends a shepherd to patrol the grazing area systematically together with a loose guarding dog or to use LGD within fenced pastures (Hansen, pers. comm.).

Experiences with livestock guarding dogs are based on different studies addressing the efficiency of herding techniques involving livestock guarding dogs in order to reduce livestock depredation in Norway. Thus, in 1999, Hansen and Bakken (1999) initiated a project, where 13 Great Pyrenees were tested for livestock guarding. They were analysed for their shown behaviour towards and against people, livestock, dogs, horses, reindeer and bear, in order to determine, if they were suitable for protecting livestock in Norway. All tested dogs did not show any aggressive behaviour against unfamiliar people. Aggressiveness towards other dogs and livestock was also low. However, 91% of the dogs chased reindeer and 3 dogs intended to chase bears. Their nonaggressive behaviour against people, dogs and livestock and their active reaction towards bears suggested the breed as potentially suitable for livestock guarding purposes. However, the tendency of dogs to chase reindeer was a trait, that could pose conflict potential in reindeer-herding areas.

Another research to study different guarding regimes, by using Great Pyrenees LGDs was carried out in a study area of 3,500 ha unfenced forest/mountain range pasture in primary bear habitat with 2 herds of sheep grazing. The field trial lasted 3 months with 10 Great Pyrenees in total participating in different herding schemes for different time intervals. In this study three working systems were evaluated including loose dogs without the command of a dog handler as guarding scheme A; loose dogs under the command of a dog handler as guarding scheme B; and loose dogs guarding sheep inside a fenced, 1 km² forest pasture as guarding scheme C. Behavioural activity patterns at night and predation data was recorded. Guarding scheme A proved unsuccessful because it was not feasible for Norwegian conditions (with dogs have to be legally kept fenced or on a leash - see above). Sheep dispersed too widely and dogs ranged too far, causing conflicts in nearby settlements, as well as with wildlife and livestock. In guarding scheme C, the dogs were engaged in guarding activities, they alerted by barking more frequently and no killed sheep were found inside the fenced area. Hence, Method C probably had the best preventive effect in the study (Hansen and Smith 1999).

In other projects conducted between 1996 and 2002, different livestock guarding dog breeds in combination with different guarding schemes were tested - livestock guarding dogs (LGDs) in combination with herding and use of night corrals as guarding scheme 1; LGDs on fenced pastures as guarding scheme 2; LGDs alone with sheep on open range as guarding scheme 3; and LGDs loose on patrol together with a shepherd as guarding scheme 4. Guarding scheme 1 was significantly the most successful livestock loss-reducing method, but also the most expensive due to the need for continuous herding. Moreover, the limitation placed on grazing patterns resulted in reduced lamb growth. Guarding scheme 2 was the least expensive method and proved successful with the second-best preventive effect. Losses were reduced by close to 100%, dependent upon pasture size. This scheme and the intended use of livestock guarding dogs posed not very time consuming, because the dogs could guard during day and night without people being present.

Guarding scheme 3 required dogs that were strongly socialized with sheep. This scheme was not to be recommended under Norwegian conditions, because dog keeping could be too uncontrolled and widely scattered, which make free-ranging sheep guarding difficult. Guarding scheme 3 showed, if a shepherd patrolled the grazing area together with a loose LGD in a systematic way, the area is covered during a certain time.

Cooperation

The Ministry of the Environment's Norwegian Directorate for Nature Management and the Swedish EPA coordinate the management and monitoring methods, with the ministry of environment of both countries taking part in the process. There is frequent dialogue between these national wildlife management agencies. Finland is included in these meetings at government level, as well.

No formal transboundary management plan exists with Sweden, with whom Norway shares the Scandinavian lynx population.

A common research project, Scandlynx, coordinates Norwegian and Swedish lynx research activity (see above). Since 2013, all applied methods and reporting of lynx status is coordinated with Sweden.

If a regional population is at or above its regional goal then quota setting is delegated down to a committee (appointed by the Ministry of the Environment) drawn from elected politicians in the county parliaments. These committees are assisted by employees of the relevant county administration.

In 2012, a working group delivered a report designed to harmonize monitoring methods, interpretation criteria, and reporting in both Norway and Sweden (Kaczensky et al. 2013).

Additionally, a Swedish carnivore policy document issued in 2012, stated that the collaboration, especially between Sweden and Norway but also with Finland, should be improved and there should be regular meetings at the state secretary of the ministry of environment level (Blanco 2012).

Joint barriers/conflicts

A major conflict is public acceptance due to conflicts with sheep and semi-domestic reindeer herders over killed individuals (with around 10.000 sheep and reindeer killed annually), as well as hunters, who see lynx as hunting competition and responsible for diminishing hunting trophies, mainly roe deer. Research has shown that, in marginal areas, lynx can have an impact on the potential roe deer harvest (Andersen et al. 2007). Because of these conflicts there are several groups campaigning for a reduction in the size of the lynx population placing constant pressure on parliament to reduce the goals. People in Norway want to have a traditional local management system and don't trust the superordinate management on a national level. This approach for large wide-ranging carnivores as the lynx is considered as inadequate and impractical. Therefore, the Norwegian government has divided the country into eight management zones. The zones are managed locally but have to follow guideline that applies at the national level (see Goals of lynx management and monitoring in Norway).

Driver assessment / threats

There are few threats to lynx in Norway, as there are clear objectives, good monitoring practices and an adaptive management, which adjust hunting quotas to match observed changes in population size. Due to the fact that Norwegian lynx are part of a large unfragmented Scandinavian population, there are few risks associated with this annual population control by harvesting a certain number of individuals. Illegal killing occurs but does not threaten the population; although it does introduce additional uncertainty into the quota setting process (Kaczensky et al. 2013).

Sweden

Existing approaches (monitoring and management, participation/stakeholder involvement)

The County Board Administrations in Sweden are responsible for the yearly lynx surveys, which are performed by rangers from these boards together with relevant stakeholders (reindeer herders, hunters and other volunteers). The surveys take place from January to February using snow tracking and identification of family groups. Subsequently, the County Board Administrations evaluate the surveys, and the Wildlife Damage Center compiles the data; distribution maps are then based on identified reproduction events, family groups (permanent), observations of lynx, dead found individuals and other collected signs of presence, which are plotted afterwards and function as the basis for lynx management planning, consideration and application for the next year.

Telemetry

Between 1994 - 2014, in Sarek were 240 lynxes captured and 93 VHF-collared and 22 with GPS collars; in Southern Sweden (1996-2016) were 105 lynx with VHF-collars equipped and another 47 individuals with GPS collars. In management studies conducted between 2005-2007 (in Norrbotten, Västerbotten and Jämtland) were 16 lynxes with GPS collars equipped. These studies concentrated on spatial and social ecology of lynx in Sweden and its consequences for population dynamics, as well as habitat and demography of the lynx population (mechanisms explaining spatial variation in population density, population dynamics) and consequences of applied management actions. Another focus was laid on the interspecific interactions between lynx - reindeer - wolverine, as well as lynx - other predators (wolf, wolverine, bear) and roe deer (Hemmingmoore 2018).

Management plan

Sweden is divided into three large carnivore management regions (North, Central, South), each with its own management goal. If the management goals for a region are fulfilled, the County Board Administrations within that region are responsible for the management decisions (like decree of annual harvest quotas). On national level, the Swedish Environmental Protection Agency is responsible for superordinate management decisions in lynx management.

An important management issue in northern Sweden is that the current lynx population is above the management goal, and therefore the harvest quotas are set quite high in order to reduce the population.

Especially in the regions where Sami are living, the lynx population and the cull was above all intended metrics for several years in order to reduce the number of lynxes in the area to protect the reindeer. According to Sweden's estimation in 2016/17, the lynx population totalled 1,220, a decrease from the previous year but an increase compared to 2013/14, when officials registered around 840 lynxes. The minimum for a healthy lynx population is considered to be at least 870 individual animals (<http://www.swedishepa.se>)

According to Kaczensky et al. (2013), the Swedish Environmental Protection Agency was working on a new management plan to replace an old action plan from 2003. However, no information on a revised document or planned action was obtained during research for the present compendium.

Genetic monitoring

Population genomic analysis presents another critical aspect to understand genetic variation and population structure within the Scandinavian population. Thereby, the monitoring is based on population-relevant aspects (e.g. structure, linkage disequilibrium, relatedness/isolation by distance, founder effects), as well as individual relatedness (parentage analysis and pedigree, inbreeding, implications to dispersal barriers/connectivity) and establishment drivers (multi-generational dispersal pathways, dispersal within and outside Sweden). Previous studies on connectivity of lynx populations in Fennoscandia indicate a low connectivity between the Scandinavian and Karelian population. For potential further analysis, next-generation sequencing (NGS) methods are used by the Swedish University of Agricultural Sciences (SLU) to answer questions concerning population structure and relatedness. Therefore, SNP genotyping is in development for individual identification and monitoring. The SLU has therefore already 96 individuals from across Sweden and Norway and another 500+ individuals in southern Sweden sequenced (Hemmingmoore 2018).

Compensatory measures

Performance payment scheme

To alleviate carnivore-livestock conflicts in Sweden, a performance payment scheme was developed and implemented. In 1996, the Swedish government implemented this new performance payment strategy as a policy measure to attain and maintain stable populations of large carnivores, including Eurasian lynx, within the country.

Performance payments are monetary or in-kind payments made by a paying agency to individuals or groups conditional on specific conservation outcomes. Performance payments are made on a strict “quid pro quo” basis depending on the level of conservation outcome. Their focus is entirely on the outcome, the actions that led to the conservation outcome are not relevant.

This conditionality concept gives the paying agency the possibility to pay exactly and solely for the conservation goal that it strives for (Zabel and Holm-Müller 2007). The performance payments are made by the Swedish state to Sami villages based on the number of carnivore reproductions that are certified on the villages’ reindeer grazing grounds.

The payments are made irrespective of actual predation incidents. Applied incentives are not distorting protective measures for livestock and therefore the applied scheme does not cause any moral hazard. Furthermore, there are no problems with time lags, since payments are made for carnivore offspring, i.e. while the animals are too young to cause damage. The size of the payment is determined according to the monetary damage that the offspring are expected to cause throughout their lifetime. The transaction costs connected to counting and verifying the number of carnivore reproductions may, however, be substantial.

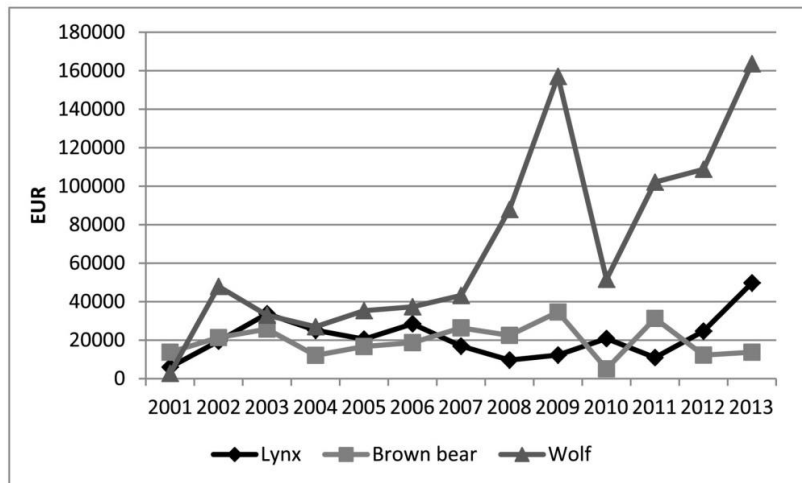


Figure 18. Total compensation for brown bears, lynxes and wolves 2001-2013, in EUR in 2015 value (taken from Widman and Elofsson 2018)

In Sweden, once the money is paid, the Sami villages have the authority to decide on the use and internal distribution of the money. Theoretically, a village needs to solve two problems: (i) determine the number of carnivores that will optimize its overall welfare (dependent on the amount of payment per reproduction) and (ii) make sure that no village member has a reason to deviate from this scheme (e.g. by being insufficiently compensated by the payment for projected losses of reindeer), which could lead to cases of illegal killings.

If payments are set high enough to assure full conservation, the internal distribution scheme should create a situation in which each individual carnivore's value is higher if conserved compared to a situation in which these individuals are killed. Otherwise, incentives to reduce the number of carnivores that causes damage may arise (Zabel and Holm-Müller 2007). In 2013, the costs for compensatory payments in Sweden accounted to 3 - 3.5 Mio. € per year for reindeer and 10.000 - 25.000 € per year for sheep (Kaczensky et al. 2013).

Preventive measures

In Sweden there persists no modern knowledge of working with livestock guarding dogs to protect livestock from lynx and other large carnivore attacks and there are no special breeds of livestock guarding dogs (Yilmaz et al. 2015). Since 1997, the Wildlife Damage Centre has worked intensively with electrical fences to protect domestic livestock from attacks by large carnivores. Consequently, most livestock in Sweden is fenced, either with electrical fences, traditional sheep wire-netting fences or sheep wire-netting fences supplemented with two electrical wires. A minority of farmers let their livestock range freely during the summer. While the confirmed number of free ranging animals being killed or injured by large carnivores was not high, there was a widespread anxiety that damages to livestock will occur. Some farmers were convinced, that the actual presence of large carnivores in the immediate surroundings of their herd will induce stress and cause indirect damage, like failed ovulation, abortions, decreasing milk production etc. The Wildlife Damage Centre encouraged farmers to purchase pups of reliable guarding dog breeds and also recommended, county councils subsidising the purchase of these dogs (Yilmaz et al. 2015).

Cooperation

There is no formal common population level management plan for Sweden and Norway. But the national agencies (the Swedish Environmental Protection Agency (EPA) and the Norwegian Directorate for Nature Management (DN) meet regularly. The new Swedish carnivore policy has acknowledged the idea of population management, and civil servants at the national political level meet to discuss large carnivore management questions. At the moment, there is a working group led by the national agencies to develop a common survey methodology and common status reports for Sweden and Norway.

SCANDLYNX

In 2005, the developing collaboration between NINA and Grimsö Wildlife Research Station was formalized under the name SCANDLYNX in order to initialize a long-term research project on lynx in northern Sweden and Norway. This research project has a tight cooperation with the aforementioned Norwegian Institute for Nature Research (NINA), Grimsö Wildlife Research Station (the Swedish University of Agricultural Science, SLU), as well as The Norwegian University of Life Science (UMB), The Norwegian University of Science and Technology (NTNU) and Hedmark University College (HIHM). It focuses on collecting basic ecological data on lynx, studying the impact of lynx on semi-domestic reindeer and lynx-roe deer interaction, exploring the potential interactions of lynx-wolverine and lynx-wolf, assessing lynx population dynamics and exploring social organization, lynx dispersal, colonization and establishment of lynx in southern Sweden.

SCANDLYNX contributes to knowledge-based management models that are accepted by different interest groups and that assist in decision-making and management of the Scandinavian lynx population as well as the Karelian population.

Joint barriers/conflicts

The main human-lynx conflict is lynx depredation on semi-domestic reindeer (see above) and to a smaller extent depredation on domestic sheep. Another conflict is the competition for roe deer between lynx and hunters.

Drivers assessment / threats

A chronic threat is the low population goals set because of conflict with semi-domestic reindeer herding. The reindeer husbandry system has advocated certain tolerance levels for the total losses of reindeer to all predators based on economically acceptable losses. These “acceptable” losses are much lower than the estimated losses today (Kaczensky et al. 2013). Thus, if the politicians decide to follow these tolerance levels, then the management goals, in regard to population numbers for all predators, including lynx, would have to be much lower than at present.

In the past, the main threats were over-harvesting and poaching. Today, poaching persists. The risk of over-harvest is currently much lower, as the harvest quotas are set in relation to actual family group numbers and management goals, with effects of applied management schemes and population development being evaluated by annual surveys. The management system is now closer to an adaptive management approach, which means that any undesired reductions in population size can be addressed immediately by reducing annually harvest quotas (Kaczensky et al. 2013).

Research carried out between 1996 and 2002 on 245 radio-collared lynx in Sweden and Norway revealed that 46% of adult mortality was attributable to probable or certain illegal poaching. Great caution must be taken into account, not to reflexively and indiscriminately accuse herders of illegal poaching, as they represent a very heterogeneous group. Although most not have any connection to poaching activities, a review of recent verdicts on illegal poaching found that reindeer herders were among those proven culpable (Zabel and Holm-Müller 2007).

7 Conclusion

Existing and persisting conflicts and barriers for lynx conservation

For the present compendium, derived from the information collected on conflicts/barriers occurring in different lynx management and monitoring schemes applied in EU member states, two main types of conflicts, causing a negative human attitude for the different Eurasian lynx populations were identified, which were stated already in 2013 by Kaczensky et al.

Hunters claiming that Eurasian lynx reduce game abundance/availability and the depredation of (semi-)domestic livestock, causing losses to livestock herders/owner (Kaczensky et al. 2013; Breitenmoser and Breitenmoser-Würsten 2016). Thereby, an additional and important barrier, that plays a key role adding to an incorrect perception of the impact of the species (as described within the present compendium), a general lack of public awareness, knowledge and training, how to deal with lynx within many countries, as well as a lack in legal enforcement of protection and conservation measures especially in Eastern and Southern Europe (e.g. Bego 2007; Rigg & Kubala 2015).

However, many research studies show, in most areas, where Eurasian lynx exist as large carnivorous species exclusively, respectively in scenarios seeing several large carnivore species coexisting with humans, that lynx are causing a minor impact to livestock (in regard of depredation rate and compensation costs), especially in comparison to other large carnivores such as bear and wolf (Widman and Elofsson 2016, 2018).

Thus, according to research related to lynx depredation on livestock, it is low for most of the Eurasian Lynx populations, with a depredation rate (taken from a study in Switzerland) below 0.5% of available livestock (Angst & Breitenmoser 2003). Only within lynx populations exposed to large scale livestock herding of (semi-)domestic animals, such as practiced with sheep and reindeer in Finland, Norway and Sweden, depredation and compensation rates show a significant increase (if no proper protection and mitigation measures are taken). Leading to approximately 7.000-10.000 sheep and 7.000-8.000 semi-domestic reindeer attributed to be killed by lynx and compensated in Norway every year, summing up to 5 Mio. € in total/per year. In 2009, Sweden paid approximately €18.000 for depredation on sheep and an additional 3.5 Mio. € as an economic incentive to reindeer herders for accepting the presence of lynx within their husbandry boundaries. In 2011, Finland paid approximately 16.000 € for 25 attacked domestic animals and another 827.000 € for 554 reindeer (Boitani et al. 2015).

Competition with hunters over prey

But the main perceived and persisting conflict found during research for the present compendium, which is associated with the presence of the species all over the Eurasian lynx distribution range, competition with recreational hunting of ungulates, mainly roe deer (*Capreolus capreolus*) and chamois (*Rupicapra rupicapra*) (Boitani et al. 2015).

While a range of practical prevention measures (e.g. electric fencing, guarding dogs) exists to facilitate and decrease livestock depredation, effective methods and management measures to address and mitigate conflicts with hunters are still not available (Lüchtrath and Schraml 2015).

Ongoing research and practical experiences within the compendium shows, conflicts with hunters are more severe and of greater concern for ongoing conservation efforts than conflicts arising from losses (except for the Karelian and Scandinavian population) caused by depredation on livestock. Consequently, hunters oppose lynx reintroduction programs skeptically and biased, perceiving the predator as a direct competitor for prey animals and trophies, with the status quo of the protected species secured and promoted by federal legislation and nature conservation institutions at a high level, while hunters understand their concerns as insufficiently protected (Lüchtrath and Schraml 2015). Thus, illegal killings within all populations are occurring, which influence and hamper the survival of small, fragmented populations on a medium- to long-term base. This conflict scenario has impact, especially in countries where the lynx has been reintroduced in the past without public consent and outside of protected areas (Breitenmoser and Breitenmoser-Würsten 2016). This leaves sites of special protection, such as National Parks still as most important source areas to ensure a long-term survival of Eurasian lynx in Western Europe (Müller et al. 2014).

Lethal control

Set out research projects in countries where the species is subject to lethal control (hunting and/or culling of problem individuals) in order to reduce conflicts and who are considering population and species recovery as ecological functionality goals, showed that there is no evidence to support the effectiveness of such actions as e.g. a last resort to meet and solve conflicts caused by livestock depredation (Stahl et al. 2001). Lynx hunting only reduces losses by depredation of livestock when it significantly reduces the size of the present lynx population. Within the member states of the European Union, whatsoever, this is not acceptable from a conservation and legislative point of view (a.o. due to the requirements of the Habitats Directive of the EU).

Compensation systems

In the present compendium, different compensation and mitigation schemes for depredation on livestock for the Alpine Population (Switzerland/France), Scandinavian Population (Norway/Sweden), as well as the Karelian Population (Finland) were more precisely explained and depicted. While in many other countries the establishment or implementation of such a scheme is hindered by absence or insufficient assessment of losses, a general weakness of legal enforcement of compensation payments, respectively a general absence of existing compensation schemes (Trajce et al. 2008, Rigg and Kubala 2015)

Existing compensation schemes differ as follows: incentive payments, e.g. to reindeer herders (see Karelian, respectively Scandinavian population chapter - Compensation schemes for further information), whose husbandry areas are located in regions with lynx occurrence, which allows compensation to meet occurring damages to semi-domestic livestock before the damage is done and post facto compensation systems, that usually involves a trained expert, which examines the killed livestock, if the death was most likely caused by a large carnivore or not. These compensation systems can lead to social tensions. In fact, livestock owners often claim that only a small fraction of the compensated livestock losses are documented through a formal examination of the carcass by an expert (Mattisson et al. 2014).

Fencing & Livestock guarding dogs (LGD)

Comparative studies from France, Sweden, Slovenia, Croatia and Slovakia (see respective population chapters and overview tables within the Appendix), which were examined for the present compendium, have shown that confining livestock such as sheep in fenced structures and using guarding dogs, dramatically reduces attacks by large carnivores and depredation losses by lynx (Linnell and Lescureux 2015; Rigg et al. 2011; Rigg and Gorman 2005; Rigg 2001).

Wild prey availability

Another factor that was discussed in the compendium and that is a matter of discussion is wild prey availability. In Norway, a research project focused on assessing the role of wild prey availability in order to reduce lynx depredation on free-ranging domestic sheep (Odden et al. 2013). The results showed a negative correlation between the depredation of sheep and wild prey availability. The authors highlighted and stressed the importance of using ecological modelling to calculate available wild prey and predict livestock depredation rates as well as to identify areas where mitigation measures in case of low prey availability are most likely to be required.

Depredation rates determine individual compensation schemes

Exactly calculated depredation rates can be used together with an accurate lynx population monitoring to assess and evaluate compensation payment levels based on collected, empirical data, instead of simply estimating losses by experts, as it is currently handled within many populations (besides Finland, Norway, Sweden and Switzerland who uses the calculation of depredation rates on livestock, respectively an annual per capita losses of livestock (ACLL)).

Consequently, the results are used to create a compensation system based on objective, accurate data within other countries and populations, too. This would promote a transition to a risk-based incentive system, which encourages prevention measures against depredation rather than anchoring a “compensate and act when the damage is done” policy by documentation and ex post payments schemes, that are currently for many populations in use. The resulting compensation schemes should include spatially explicit risk models of livestock depredation in order to get a more accurate estimate of loss rates. Initially, this approach requires the collection of a large amount of ecological data and eventually opens the way to an improved fairness coexistence model that tolerates the presence of large predators as the Eurasian lynx within (semi-)domestic livestock husbandry areas in the future.

Outcomes and outlooks from scientific research on lynx management and conflict mitigation concerning damages caused by depredation of livestock

Within the research for the compendium, different scientific research studies showed the urgent need to adopt an adaptive and stratified lynx management (that for some populations such as the Alpine and Scandinavian populations is already established). As well as including a multi-species approach, when addressing the management of multiple large carnivore species in an area, which needs to include the establishment of a functioning conflict assessment, mediation and compensation scheme for losses caused by depredation (i.a. Linnell et al. 2007). Thus, researchers studied the interactions between lynx and reindeer and sheep depredation in Sweden and suggested improvements of management practices and tools to mitigate depredation conflict schemes in the near future (Widman and Elofsson 2016, 2018).

Amongst other, results indicated that a reduction of the lynx population (lethal control - see above) would not necessarily affect the viability of the lynx population as the lynx is also abundant outside the reindeer husbandry area with individuals from outside taking over territories of individuals destroyed by lethal control measures (Mattisson et al. 2011a).

Furthermore, a study by Mattisson et al. (2011b) showed, total predation pressure on prey, in this case reindeer, could be reduced in areas with both lynx and wolverines (as well as in areas with different intermediate predator species), if enhanced scavenging opportunities led to a significant decrease in wolverine predation without increasing lynx predation. Another factor persists, that apex predators such as the lynx play an important role in shaping ecosystem structures by subsidizing smaller scavengers and predatory species such as wolverines via carrion (or other intermediate predators), thus providing them a benefit from lynx presence in a given area (Hussein et al. 2014). These outcomes highlight the importance of understanding the role of the species in coexistence dynamics to improve lynx conservation and management schemes in functioning multi-predator systems in the future.

Multi-use semi-natural forest habitat scenario

An outcome that many projects and research studies shared: nowadays, a majority of the lynx populations need to be conserved in a multi-use semi-natural forest habitat scenario (with many primeval forested areas converted into “production forests”), that many large forested areas in Europe are composed of today. This leads automatically, to conflicts with certain forms of human land use (mainly with hunters and forestry) and drives habitat fragmentation and-quality for the Eurasian lynx, whose known for preferring mostly undisturbed/minor impact forest areas, while occupying rather large territories.

With the installment of sufficient and functioning management and monitoring schemes - which include an efficient toolbox consisting of monitoring, management (participation), conflict mitigation and compensation measures and schemes, e.g. including educational programs for relevant stakeholder groups - arising and persisting conflicts and barriers can be negated and met in the course of time. To solve conflicts between different group of people (such as hunters, nature conservationists, ecologists, foresters), it is a necessity to cooperate, discuss and present solutions on mutual consent, while ensuring a transparent process along the way to allow for an efficient long-term protection of the species.

An essential factor is met with the involvement and participation of all stakeholder groups in planned and ongoing management and monitoring efforts, allowing and discussing conflicting views. Another critical factor, the cooperation with official authorities and bodies, such as police, border guards and customs in cases of illegal killings and/or trafficking of animals, respectively their products in order to allow an effective persecution of person responsible violating applicable law, when killing a strictly protected species in countries with no designated open season, respectively at closed season.

Eventually, this will lead to efficient and far-reaching elucidation and persecution of illegal killings supporting effective lynx conservation efforts, which allows a favourable conservation status of the Eurasian lynx in more than five EU member states in the near future (Müller et al. 2014).

EU-funded projects and pilot programs for lynx conservation

Since the year 2000, many EU-funded and pilot projects have been implemented to improve the conservation of the Eurasian lynx (*Lynx lynx*) and Balkan lynx (*Lynx lynx balcanicus/martinoi*), some of them only focusing on lynx and others in combination with other large carnivores, such as European Brown Bear (*Ursus arctos arctos*) and Eurasian Wolf (*Canis lupus lupus*).

Thus, in the last decade, in many countries action and management plans were agreed on and implemented by local NGOs in collaboration with EU partner organisations and institutions, as well as involved, resident scientists, federal bodies and the participation of local stakeholders (e.g. in the form of baseline surveys, workshops etc.) as for example in Albania and Macedonia within the Balkan Lynx Recovery Program (2006 - 2018 - see Balkan population).

These programs, action and management plans on the way include preventive measures to reduce cases of depredation containing livestock herding management techniques, such as the use of electric fences and changes in grazing management. So, shepherds were taught how to correctly use electric fences and move livestock to night resting places.

Like in many other projects, the Balkan Lynx Recovery Programme's main objective aimed to conserve, manage and restore viable populations of the critically endangered Balkan lynx in Albania and Macedonia. Which include the lobby for the declaration of new protected areas, involving locals in protection, research, education and the establishment of monitoring activities and routines for the species in the Southwest Balkans. In 2018, the project can be considered to be successful in assisting and contributing towards the conservation of the extremely small (20-39 individuals) and fragile population roaming within the countries of the former Yugoslav Republic (Melovski et al. 2015).

A Balkan Lynx Field Handbook (2005) and an action plan for Albania (2007) was produced and provided an informed framework of actions that are required to promote and establish conservation schemes for the population of the species in the Balkan countries. Areas were selected which were known as potential lynx distribution areas and baseline survey and camera trap pilot studies were planned and executed to allow for a census and to receive information concerning habitat requirements, potentially inhabited territory and concerning the socio-economic needs of the local population and land owners.

Within the programme, amongst other methods (see: Albania, respectively Macedonia for further details) electric fences were installed to further discourage carnivores such as lynx from preying on livestock. Additionally, awareness building measures with the participation of the local community proved useful for helping to achieve the project's main objectives.

Several other EU-projects, in East, Western European, as well as Alpine countries, as with the present 3Lynx- and LIFE Lynx project form part of a European strategy for the conservation of Eurasian lynx and its subspecies. As a general objective, they seek to maintain the regained habitat of lynx, that were reintroduced in the 1970s and 1980s as well as of individuals, that originate from these schemes and which are now migrating and establishing new territories in neighboring states and countries (e.g. such as lynx in Hungary deriving from the Carpathian population in Slovakia), as well as encourage the return to habitats originally known to be colonized by lynx in order to maintain or restore populations and thrive towards a favourable state of conservation.

A significant part of the programs and projects discussed in the present compendium consisted of extensive awareness campaigns, mainly directed at affected stakeholder groups in areas inhabited or which are potentially suitable for the species. Thus, workshops concerning damage prevention, compensation and general education about the ecology of the species were held, in order to allow for an increase in public awareness among stakeholders as immanent action and fundamental task in the projects, which included the active involvement and participation of relevant local stakeholder groups obtaining often good perception and results. A positive effect of the schemes applied in these projects, local authorities learnt how to better manage conflict scenarios with large carnivores and mitigate them with the efficient application of subsequent compensation and mitigation schemes. Consequently, applied measures, methods and schemes reduced often incidences of poaching and helped to avoid conflicts between the species and the local population after implementation.

Future recommendations

The conflict between humans and the Eurasian Lynx relates not only to the natural recovery and local reintroduction of the species, but mainly to a lack of public awareness, a wrong perception of the ecological impact and the abandonment of traditional husbandry techniques and methods that assisted in the prevention or mitigation of depredation scenarios in the past. For the present compendium, this conclusion is confirmed by lessons learned during research of available scientific literature and the recent history of distribution, abundance and conflicts within the lynx populations in the EU member states.

Therefore, in terms of the current and potential future of the European lynx's distribution and conservation, suitable ecological conditions (e.g. adequate wild prey availability) and preventive measures (traditional and innovative herding and fencing techniques in connection with livestock guarding dogs) have to be fully provided, implemented and financially supported. Additionally, hunters as stakeholders need to be specifically targeted by awareness raising activities focusing on their perceived competition with the lynx.

Finally, the author suggests an alternative preventative measure model that incorporates a priori payments to livestock owners within the lynx distribution's range. Many of the cited authors and publications within the present compendium strongly recommend that ecological findings and scientific results within this topic have to be extensively applied in lynx species conservation and management to further improve dealing with large carnivores such as the Eurasian lynx in Europe.

8 Appendix

Table 3 Applied monitoring methods within the different populations and countries

Population	Country	Monitoring methods		Literature / References
		National/Population	Regional	
Alpine	France - Alps	Confirmed presence signs and chance finds (SCALP C1 & C2); opportunistic and systematic camera-trapping; collection and analysis of genetic samples	CMR camera trapping in reference areas	Vandel et al. 2004
	Switzerland - Alps	Confirmed presence signs and chance finds (SCALP C1 & C2); yearly inquiry of game wardens; known livestock losses /killed livestock number compensated as lynx kills, opportunistic and systematic camera-trapping; collection and analysis of genetic samples of captured or dead lynx; examination of dead lynx - Vetsuisse Bern	CMR camera trapping in reference areas, telemetry in reference areas; genetics	BAFU 2004,2016: Konzept Luchs Schweiz“ - Implementation assistance of the Federal office for environment for lynx management in Switzerland
Balkan	Albania	Questionnaire baseline surveys; collection of chance finds and observations	Snow tracking, camera trapping (intensive 2014/15; extensive 2014-2016), telemetry	Balkan Lynx Conservation Compendium; ; Balkan Lynx Recovery Programme" (BLRP); Bego 2007; Keçi et al. 2008; Breitenmoser et al. 2008; Trajçe et al. 2008; Trajçe et al. 2009; Trajçe 2010; Melovski 2012; Trajçe et al. 2016; Ibrahim 2017
	Kosovo	Questionnaires using SCALP-criteria		Balkan Lynx Recovery Programme" (BLRP); Breitenmoser et al. 2008; Spangenberg et al. 2011; Melovski 2012
	Macedonia	Questionnaire baseline survey (2007-2009); density extrapolation by means of camera-trapping (capture-recapture); confirmed presence signs (SCALP C1 & C2)	Snow tracking; genetics; intensive camera trap studies (Mavrovo NP - 2008-2010; 2013; 2015-2018 and Galichica NP, 2009, 2018; Pelister NP 2014, 2018; Jasen PA 2010/11, 2014); radio telemetry	Breitenmoser et al. 2008; Keçi et al. 2008; Trajçe et al. 2009; Melovski et al. 2009; Melovski 2012

Population	Country	Monitoring methods		Literature / References
		National/Population	Regional	
Balkan	Montenegro	Questionnaire baseline survey (2000; 2013)	Camera trapping (2013-2014; 2014-2015 – Prokletije NP and its surroundings)	Paunović & Milenković 2004; Melovski 2012; Đurović & Perović 2013; Đurović & Perović 2015
Baltic	Estonia	Snow tracking; unique annual reproductions (based on track and direct observations); data of harvested/dead individuals; permanent winter-track count transects; damage surveys	Independent snow track observations in certain areas; telemetry	Valdmann et al. 2005; Balčiauskas et al. 2010; Männil 2017
	Latvia	Cohort analysis of hunting bags (all legally shot lynx and dead found individuals reported and 40-50% analysed on lab scale regarding age and female fecundity); sum of hunting ground "counts"; guesstimate; long term trend in harvest composition; diet studies/assessment of lynx impact on prey populations; hunter surveys; DNA analyses for kinship structure and genetic heterogeneity; parasites	telemetry	http://www.csb.gov.lv/en/statistikas-temas/ ; Valdmann et al. 2005; Bagrađe et al. 2016; Ozolins et al. 2017
	Lithuania	Questionnaire baseline surveys; snow tracking; citizen science project - counting direct observations (and chance finds) as well as photo/video evidences of large carnivores, including lynx	Snow tracking	Bukelskis et al. 2004; Balčiauskas et al. 2010; Balčiauskas et al. 2018
	Poland - NE	Questionnaire baseline surveys; confirmed signs of presence (chance finds and observations); snow tracking; guesstimate	snow tracking; year-round registration of direct and indirect observations (tracks, scats etc.); direct observations of number of females with kittens; genetics; camera trapping; regularly monitored in areas of occurrence in Augustów, Knyszyn and Białowieża	Borowik et al., n.d.; Balčiauskas et al. 2010; CSO 2012

Population	Country	Monitoring methods		Literature / References
		National/Population	Regional	
Carpathian	Bulgaria	Questionnaires and follow up field investigations to confirm presence	Camera trapping; snow tracking	http://balkani.org ; Zlatanova and Genov 2001; Zlatanova et al. 2009
	Slovakia	Sum of hunting ground "counts"	Snow tracking; genetics; camera trapping; GPS telemetry in Slovakian Carpathians: Nizke Tatry NP; Lower Tatra and Tatra NP, Mala Fatra NP; PLA Beskydy; PLA Horna Orava, PLA Kysuce	Ondrus and Adamec 2009; Rigg and Kubala 2015; Kubala et al. 2017; Dul'a and Kutal 2018; Krojerová and Duľa 2018; Dubrulle, n.d.
Carpathian	Hungary	Tracks and signs assessment along transects; observations by qualified experts; snow tracking	Camera trapping	Szemethy and Markus 2004; Soldo and Lucic 2004; Szabó and Gadó in Rigg and Kubala 2015
	Poland	Confirmed presence signs; guesstimate	Snow tracking; genetics	Borowik et al., n.d.; Okarma et al. 2007; CSO 2012
	Romania	Nonsystematic population estimates using snow tracking (winter/spring) with particular focus on family groups; hunting ground counts	Snow tracking, genetics, camera trapping, telemetry, confirmed reproduction	Pop et al. 2013
	Serbia	Population guesstimates from own data (method not described) and statistical data from the government	Small-scale camera trapping	Paunovic 2002; Paunović and Milenković 2004; Paunovic et al. 2008; Ćirović and Paunović 2016
Dinaric	Croatia	Camera trapping; genetics; collection of dead lynx	Snow tracking, telemetry	Majić-Skrbinšek 2008; Sindičić et al. 2016
	Bosnia-Herzegovina	Population estimation from data collected by hunters, foresters/forestry offices; direct observations and chance finds; questionnaire baseline surveys using SCALP-criteria		Paunovic 2002; Soldo and Lucic 2004; Trbojević and Trbojević 2018

Population	Country	Monitoring methods		Literature / References
		National/Population	Regional	
Jura	Switzerland-Jura	Confirmed presence signs and chance finds (SCALP C1 & C2)	CMR camera trapping in reference areas; telemetry; genetics	
	France-Jura	Confirmed presence signs and chance finds (SCALP C1 & C2); yearly inquiry of game wardens; known livestock losses /killed livestock number compensated as lynx kills, opportunistic and systematic camera-trapping; collection and analysis of genetic samples of captured or dead lynx; examination of dead lynx - Vetsuisse Bern	CMR camera trapping in reference areas, telemetry in reference areas; genetics	BAFU 2004,2016: Konzept Luchs Schweiz“ - Implementation assistance of the Federal office for environment for lynx management in Switzerland
Karelian	Finland	Systematic snow tracking; direct observations & collection indirect presence signs	Telemetry	Holmala and Rintala 2012
Scandinavian	Norway	Systematic snow tracking (single lynx & confirmed family groups); lynx harvest data; lynx damage reports; census along fixed line transects; collection of all shot and dead found lynx	Additional presence data collected by camera-trapping; extensive telemetry	
	Sweden	Systematic snow tracking (single lynx & confirmed family groups); collection of indirect signs of presence; lynx harvest data; lynx damage reports	Genetics; telemetry	http://www.swedishepa.se ; Andren et al. 2002
Vosges-Palatinian	France - Vosges	Confirmed presence signs and chance finds (SCALP C1 & C2)		Vandel et al. 2004; Vandel et al. 2006
	Germany - Palatinian	Confirmed presence signs and chance finds (SCALP C1 & C2)		Bull et al. 2016; Germain and Charbonnel 2017

Table 4 Applied lynx action and management plans within the different countries & populations

Population	Country	Management methods		Literature / References
		National/Population	Cooperation	
Alpine	France - Alps			Molinari-Jobin et al. 2012; Schnidrig et al. 2016
	Switzerland - Alps			Molinari-Jobin et al. 2012; Schnidrig et al. 2016
Balkan	Albania	Lynx Action Plan– Albania; Conservation Strategy and National Action Plans for the conservation of the Critically Endangered Balkan Lynx - Balkan Lynx Recovery Programme	BLRP - Ministry of Environment of Macedonia and Albania; close cooperation among scientists of these countries	Bego 2007; Breitenmoser et al. 2008; KORA 2011
	Kosovo	Strategic planning for the conservation of the Balkan lynx - Balkan Lynx Recovery Programme	BLRP	Breitenmoser et al. 2008
	Macedonia	Conservation Strategy and National Action Plans for the conservation of the Critically Endangered Balkan Lynx - Balkan Lynx Recovery Programme	BLRP - Ministry of Environment of Macedonia and Albania; close cooperation among scientists of these countries	Breitenmoser et al. 2008; KORA 2011
	Montenegro	Strategic planning for the conservation of the Balkan lynx - Balkan Lynx Recovery Programme	BLRP	Breitenmoser et al. 2008
Baltic	Estonia	National Action Plan for Eurasian lynx Conservation and Management for the period of 2018 - 2028; Lynx population is regulated by hunting (01.12-28.02)	Close cooperation with Latvia and Poland: over lynx reproduction events near Estonian-Latvian Border; information on lynx management (census, hunting bags); Research with Poland and Latvia on genetics of Baltic lynx population; Cooperation translocating lynx of Estonia to NE PL	

Population	Country	Management methods		Literature / References
		National/Population	Cooperation	
Baltic	Latvia	National Action Plan for the Conservation of Lynx in Latvia; Lynx classified as specially protected species whose use is limited; hunting season open from 01.12 - 31.03 with hunting quotas set by state forest service; fines for poaching during closed season/ in protected areas	See Cooperation: Estonia; 1999: joint project between Estonian and Latvian Funds for Nature - "Conservation planning of large carnivores in Estonian-Latvian cross-border region; 2003-2007: research projects on the territorial behaviour of lynx using radio telemetry in cooperation with the Norwegian Institute for Nature Research (NINA), scientists from Estonia, Lithuania and Poland	Ozolins et al. 2008; Ozolins et al. 2017
	Lithuania	Fine for illegal killing of fully protected Eurasian lynx in Lithuania: 16.300 Litas (~4721 €); imprisonment is possible	Various agreements with neighbouring countries (e.g. Latvia, Russian Federation, Estonia) regarding cooperation in the field of environment, as well as a memorandum of understanding with Estonia regarding environmental protection; BLCI – Baltic Large Carnivore Initiative (includes Lithuania, Latvia and Estonia)	
	Poland - NE		see Cooperation: Estonia; private contacts established with experts of Latvia, Estonian, Lithuania and Belarus; cooperation between MRI and Belarussian State University in Minsk	Blanco 2012; Mysłajek and Nowak 2013

Population	Country	Management methods		Literature / References
		National/Population	Cooperation	
Carpathian	Bulgaria			
	Slovakia	Lynx conservation program in Slovak language available: "Program Starostlivosti o rysa ostrovida (lynx lynx) na slovensku" (Antal et al. 2017)	Living with Carpathian Spirits (2013 – 2015) - Swiss-Slovak Cooperation Programme; Coordination of conservation, monitoring and management of the western Carpathian population of Eurasian lynx and Grey wolf on the Czech-Slovak border (2018-2019)	Rigg and Kubala 2015; Kubala et al. 2017; Antal et al. 2017
	Hungary		Data collection by a network of experts with regular meetings to unify methods and discuss results and outcomes	Szabó and Gadó in Rigg and Kubala 2015
	Poland	-	-	Mysłajek and Nowak 2013
	Romania	Romania abandoned trophy hunting of lynx in 2012 (Commitment under the umbrella of the "Carpathian Convention", to a management scheme that support a "stable" Carpathian lynx population	
	Serbia			
Dinaric	Croatia	2008: Proposal for common Lynx management strategy for Slovenia and Croatia ("Prijedlog zajedničke strategije upravljanja risom u Sloveniji i Hrvatskoj"); Lynx management plan for the Republic of Croatia 2010 – 2015	Cooperation between researchers/universities of Slovenia and Croatia; 2005-2008: DinaRis-Project between Croatia and Slovenia; 2015-2018: cooperation of wildlife experts from the Faculty of Veterinary Medicine of the University of Zagreb and Karlovac University of Applied Sciences in research and monitoring of lynx in Gorski Kotar; 2017-2024: LIFE Lynx project cooperation (SI, IT, HR, AT, (BH)	Majić-Skrbinšek 2008; Sindičić et al. 2009; Sindičić et al. 2010; Sindičić et al. 2012; Sindičić et al. 2016; www.lifelynx.eu
	Bosnia-Herzegovina		No scientific cooperation with Slovenia and Croatia	

Population	Country	Management methods		Literature
		National/Population	Cooperation	
Jura	Switzerland-Jura		Some cooperation in terms of monitoring, research and management – both countries follow the methods established by the SCALP project; french experts cooperate with KORA for analysis of camera trap data	
	France-Jura		See: Switzerland	
Karelian	Finland	Mgmt. Plan for Lynx in Finland (2007); pop. regulated by hunting (01.12-28.02)	No cooperation for Karelian population between Finland and Russia	Ministry of Agriculture and Forestry 1b/2007
Scandinavian	Norway	Specific open hunting seasons (01.02-30.04); hunting quotas assigned on fine scale regional basis (adapted to population numbers and sex ratio); most areas include female sub-quotas to prevent over-harvest of this important demographic group	Close cooperation in research/monitoring (“SCANDLYNX”); no formal common population level management plan for Sweden and Norway; the Norwegian Directorate for Nature Management (DN) and the Swedish Environmental Protection Agency (EPA) coordinate management and monitoring methods	http://scandlynx.nina.no
	Sweden		See - Cooperation: Norway	
Vosges-Palatinian	France (Vosges)	2016-2018: “Programme Lynx Massif des Vosges” (PLMV)	Cooperation between France and Germany in LIFE Lynx Palatinate Forest	Fisher 2017; Germain and Charbonnel 2017
	Germany (Palatinian)			

Table 5 Conflicts, threats scenarios and compensation schemes within the different countries and populations

Population	Country	Conflicts/Threats	Compensatory measures	Literature / References
Alpine	France - Alps			
	Switzerland - Alps	Damages to livestock and domesticated animals caused by lynx are limited (less than one fifth of killed livestock caused by lynx); lynx seen as major competitor to hunters/predation on wild ungulates; illegal killing; traffic accidents; habitat fragmentation; inbreeding depression	Compensation system in action; assessment and investigation of each particular case by game wardens. Damage to livestock and agricultural crops by lynx are jointly compensated by federal and canton	Breitenmoser-Würsten and Obexer-Ruff, n.d.; Linnell and Lescureux 2015; BAFU 2016; Enzerink 2017
Balkan	Albania	illegal killings (not major source of conflict), loss of prey base, forest/habitat degradation	No form of compensation system in action; no prevention or mitigation measures undertaken by management authorities to address livestock depredation	Trajçe et. al. 2008; Keçi et. al. 2008; Ministry of Environment, Forests and Water Administration 2010; von Arx 2015; Linnell and Lescureux 2015
	Kosovo	no information	no information	-
	Macedonia	Few cases of livestock depredation; no central information on livestock depredation; general lack of knowledge about lynx presence and ecology; very small population size very fragile in the face of illegal killing; depletion of prey base; potential degradation and fragmentation of habitats caused by infrastructural projects; forest conversion -> traffic accidents	Compensation system in action: Damages on livestock compensated if caused by strictly protected species like lynx. Implementation is only executed for damages caused by bear (and few cases of damages caused by lynx) which are easily recognizable, also because bears are causing much more conflicts than lynx. projects where livestock guarding dogs were given to shepherds to reduce poisoning of lynx	Keci et al. 2008; Lescureux and Linnell 2010; Lescureux et al. 2011; Melovski 2012; Linnell and Lescureux 2015

Population	Country	Conflicts/Threats	Compensatory measures	Literature / References
Balkan	Montenegro	Political and economic instability have negative influence on conservation efforts; illegal killings; habitat degradation; decline in prey base	No compensation systems or prevention methods are applied in the country	Paunović 2002; Trajçe 2013
Baltic	Estonia	Major competitor to hunters/ predation on wild ungulates -> pressure to increase hunting quotas; rare depredation cases on livestock; insignificant decrease in prey abundance (but potentially increasing) risk factor for lynx); illegal killings (minor impact on lynx population)	Compensatory system in action; paid by the state (responsible body Environmental Board (EB)); cases inspected by trained experts of the EB; if proven 100 % of the market value paid as compensation	Lõhmus et al. 2002; Linnell and Lescureux 2015; Ozoliņš et al. 2017
	Latvia	(minor) damages caused to livestock; lynx seen as major competitor to hunters/predation on wild ungulates; hunting main factor limiting lynx population, but sustainable harvest schemes based on reproduction units	No damage compensation scheme; Goal within the current Action Plan 2018-2028: development of schemes for prevention and compensation in cases when a lynx has attacked/killed livestock	Valdmann et al. 2005; Ozoliņš et al. 2017
	Lithuania	Habitat fragmentation; land conversion; fencing of border region Lithuania / Belarus	No damage compensation scheme (no damages to livestock recorded until 2018 - Balčiauskas, pers. comm)	Saklaurs 2008; Balčiauskas et al. 2010, 2017; Balčiauskas 2018
	Poland - NE	Few cases of lynx attacking livestock; habitat fragmentation; loss of habitat diversity; loss of potential prey base by overhunting; human caused mortality (poaching, vehicle collisions)	Regional Directorates for Environmental Protection responsible for estimation and compensation of damage caused by lynx and for reporting of accidental mortality in every province. In national parks, park directors are responsible for damage compensation	Myslajek and Nowak 2013; Linnell and Lescureux 2015

Population	Country	Conflicts/Threats	Compensatory measures	Literature / References
Carpathian	Bulgaria	Conflict with hunters (as competitor for hunting ungulates); illegal killings; decrease in prey base due to over-harvesting of prey populations; habitat degradation; pest control (poisoning); lack of knowledge about species ecology; poor enforcement of legislation	No information on existing compensation schemes for damages caused to livestock/domestic animals	Zlatanova and Genov 2001; Spassov et al. 2006; Carpathian Environmental Outlook 2007; Linnell and Lescureux 2015
	Slovakia	minimal conflict by damages caused to livestock; habitat fragmentation by forestry activities and infrastructural development (roads etc.); infectious diseases, congenital malformations (genetic samples revealed high amount of cadmium), poaching	Damage compensations (after investigation) are mentioned, without describing specific terms and forms of application in cases of damages caused by Eurasian lynx	Rigg 2001; Rigg and Gorman 2005; Environmental Outlook 2007; Ondrus and Adamec 2009; Rigg et al. 2011; Rigg and Kubala 2015
	Hungary	Illegal killing caused by lacking public acceptance (important to address hunters' attitudes); habitat fragmentation & suitability; decline in prey base; small population size; human disturbance by increased tourism and recreational activities	No compensation system and no damage prevention methods are applied in the country	Szemethy and Markus 2004; Carpathian Environmental Outlook 2007; Szabó and Gadó in Rigg and Kubala 2015
	Poland	minimal conflict by damages caused to livestock; habitat fragmentation by forestry activities and infrastructural development (roads etc.); infectious diseases	Damage compensations (after investigation)	Linnell and Lescureux 2015; Myslajek and Nowak 2013
	Romania	Illegal killing; reduction of habitat connectivity; conflict with hunter (as competitor for hunting roe deer); traffic accidents	Compensation payments for damages on livestock/domestic animals; all kills have to be verified and documented by trained experts	Mertens and Promberger 2000; Carpathian Environmental Outlook 2007; Linnell and Lescureux 2015; Yilmaz et al. 2015; Papp et al. 2016

Population	Country	Conflicts/Threats	Compensatory measures	Literature / References
Carpathian	Serbia	Minor conflicts over damages caused to livestock; no central information on livestock depredation; illegal killings; conflict with hunters (as competitor for hunting ungulates)	Existing compensation scheme, but not working; damages caused by protected species and within protected areas are compensated by the government, have to be identified by experts	Carpathian Environmental Outlook 2007; Ćirović and Paunović 2016
Dinaric	Croatia	Low genetic diversity and inbreeding depression due to founder effect and isolation; Low acceptance of hunters, who believe lynx cause unacceptable damage to roe deer populations; illegal killings;	Population reinforcement in progress as a part of LIFE Lynx project, improved strategies for cooperation with hunters implemented as part of LIFE Lynx project, trained experts examine and evaluate each case of damage on livestock; evaluation serves as the basis for subsequent compensation payments for livestock owners,	Sindičić et al. 2009; Sindičić et al. 2012; Polanc et al. 2012; Linnell and Lescureux 2015; Sindičić et al. 2016; Skrbinišek et al., n.d.
	Bosnia-Herzegovina	Illegal killings; traffic accidents; lack in prey base (ungulates)	No information were obtained	
Jura	Switzerland-Jura	Damages to livestock and domesticated animals caused by lynx rather limited (less than one fifth of killed livestock caused by lynx); lynx seen as major competitor to hunters/predation on wild ungulates; illegal killing; traffic accidents; habitat fragmentation; inbreeding depression	Compensation system in action; assessment and investigation of each particular case by game wardens; Damages to livestock and agricultural crops caused by lynx are jointly compensated by federal and canton	Linnell and Lescureux 2015; BAFU 2016; Enzerink 2017
	France-Jura	Conflicts with sheep herding and husbandry; seen as major competitor to hunters/predation on wild ungulates; traffic accidents; illegal killings	Financial compensation of damage assessed by experts of the "réseau lynx" by the Ministry of Environment; removal of problem lynx (causing repeated damages to livestock) possible	Vandel et al. 2004

Population	Country	Conflicts/Threats	Compensatory measures	Literature / References
Karelian	Finland	Main conflict with herders over killed reindeer; hunters over predation on wild ungulates; traffic accidents; illegal killings; maintaining motivation of the voluntary carnivore contact persons	2009: Game Animal Damages Act - Large carnivore damages (e.g. to crops, domestic animals, property and reindeer) are fully compensated - maximum compensation current value of the attacked animal	Ministry of Agriculture and Forestry 2007; Liukkonen et al. 2009; Otstavel et al. 2009; Rassi et al. 2010; Linnell and Lescureux 2015; www.largecarnivores.fi
Scandinavian	Norway	Lynx depredation on domestic sheep; illegal killings	Compensation is paid for all domestic animals documented as killed by lynx and for others that are assumed to be killed by lynx	Hansen & Bakken 1999; Hansen and Smith 1999; Hansen 2005; Odden et al. 2008; Hansen, I. (n.d.); Norwegian Environment Agency - Norwegian Wildlife Damage Centre (n.d.)
	Sweden	Lynx depredation on semi-domestic reindeer (to a smaller extent on domestic sheep); competition for roe deer between lynx and hunters; illegal killings	Compensation scheme; performance payment scheme	Zabel and Holm-Müller 2007; Widman et al. 2017; Widman and Elofsson 2018
Vosges-Palatinian	France - Vosges	Illegal killings; small and vulnerable population -> low genetic diversity	Financial compensation of damage assessed by experts of the "réseau lynx" by the Ministry of Environment; removal of problem lynx (causing repeated damages to livestock) possible	
	Germany - Palatinian	Traffic; competition for roe deer between lynx and hunters; illegal killings	Compensation is paid for all domestic animals documented as killed by lynx; no further information	Idelsberger 2015; Fisher 2017

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