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# Conserving the north-eastern European lowland population of Eurasian lynx

**The north-eastern European lowland population of the lynx is commonly attributed to the “Baltic population” and believed to belong to the nominative subspecies *Lynx lynx lynx*. Geographically, its range extends from eastern Poland throughout the Baltic states north to Fennoscandia and east to central Asia. Within its range across north-eastern Europe the status of the species differs among the countries from fully protected year-round to a hunted species. The population is exposed to a varying degree of fragmentation with most severe habitat fragmentation in the south-western part of its range and well connected forest habitats in the north-east. The population is genetically structured, most likely as a result of habitat fragmentation. The genetically poorest subpopulation occurs in north-eastern Poland, which is most isolated from the remaining part, and the highest genetic diversity characterises the Latvian and Estonian lynx. The genomic data, however, confirm that lynx within the north-eastern European lowland population harbours a mitochondrial phylogeographic sublineage differentiated from the remaining central (Carpathian) and south-European populations, though its taxonomic value is still unclear. The lynx are facing various types of threats in different countries. Legal protection is not a sufficient measure to warrant the population’s demographic security, as it is exposed either to the lack of suitable and well connected habitat, forest logging, poaching or illegal amber mining. Hunted populations may be subject to excessive quotas. The challenges of lynx conservation include restoration of the suitability and connectivity of the habitat, reintroductions, reconsideration of hunting quotas, establishing non-invasive robust population monitoring, and increasing public awareness about the lynx conservation needs.**

## Distribution and population differentiation

The population of Eurasian lynx inhabiting north-eastern European lowlands extending from eastern Poland through Belarus, northern Ukraine, to the Baltic states is commonly attributed to the “Baltic population” (Von Arx et al. 2004, Boitani et al. 2015). The range of this population, however, is not clearly delimited due to lack of data from the Russian territory (Boitani et al. 2015). It should be assumed that it extends towards the east including large areas of continuous forest covering western Russia. On the other hand, the “Baltic population” of lynx probably should not include animals from the area of Karelia and Finland, because the Gulf of Finland plays some role as a barrier for gene flow (Ratkiewicz et al. 2014). They are believed to belong to the nominative subspecies *Lynx lynx lynx* (Kitchener et al. 2017).

The population distribution is very irregular because it consists of a severely fragmented section in the south-western part of the range (on

the territory of Poland, Belarus, Ukraine, the Kaliningrad Oblast and Lithuania) and a large, continuous part of the range in the north-east (Latvia, Estonia and Russia). The distribution of lynx largely coincides with the extent of fragmentation of forest habitat, and the most isolated populations are disseminated across the most fragmented habitat at the south-western edge of the species range (Fig. 1).

The population is clearly genetically structured, most likely as a result of long-term habitat fragmentation and isolation. Diversity of both, microsatellite and mitochondrial markers showed highest differentiation between the lynx from north-eastern Poland (particularly the Białowieża Forest) and all remaining subpopulations within the “Baltic population” (Ratkiewicz et al. 2014). The most isolated population of north-eastern Poland is also genetically the poorest, whereas the Latvian and Estonian lynx harbour highest genetic diversity. There is a very limited gene flow between the lynx of north-eastern Poland and the remaining “Baltic population”. Most

effective gene flow was detected between Finnish and Russian (Kirov Oblast) lynx and least between the Russian and Estonian animals (Ratkiewicz et al. 2014), indicating that the Finnish population should not be included within the “Baltic population” of this felid. There was also very weak (unidirectional) gene flow from Baltic (Estonia) to Finnish lynx, which suggests that the Baltic population should receive most gene flow from unsampled Russian lynx or only occasionally indirectly from Finland. The genomic (nuclear intergenic autosomal and mitogenomic) data confirmed that lynx within the north-eastern European lowland population cluster with Russian lynx up to the Ural Mountains, but also harbour a mitochondrial phylogeographic sublineage differentiated from the northern (Scandinavian) and south-European (Balkan) populations (Lucena-Perez et al., 2020). However, the taxonomic value of this finding is still unclear.

## Population status and threats

The status of the species varies dramatically among the countries harbouring the Baltic lynx population. It is fully protected year-round in Poland, Lithuania, Belarus and Ukraine with high fines imposed for killing individuals, but in contrast, it constitutes a legally hunted species in Estonia, Latvia and large parts of Russia. Legal protection, however, is not a sufficient measure to warrant the population’s demographic security. The lynx are facing various types of threats within their range across north-eastern Europe. Factors contributing to population threats in countries ensuring the species full legal protection include the lack of suitable and well-connected habitat, small population size, low prey availability, forest logging, poaching or even illegal amber mining. Hunted populations may be subject to the risk of unsustainable quotas.

## Poland

Conservation status of the species is least favourable in Poland. Despite being a large, relatively well forested country (30% of the area), the area occupied by lynx accounts for only 3.5% of the entire territory (Schmidt 2011). Although the lynx has been fully protected since 1995, its range has not increased and numbers remain at a level of 200 individuals (Mystajek et al. 2019). Habitat suitability modelling showed that the current distribution of lynx largely overlaps with the major patches of best quality habitat – localised in north and south-eastern Poland – in terms of

structure and diversity of forests (Schmidt & Górny, in prep.). However, considering the general availability of sufficiently large patches of forest cover, there would be a potential to expand the population range of this felid nearly three-fold so that it could occur in 10% of the country's area. It is thus likely that habitat fragmentation along with its poor quality (simplified structure of forest monocultures) is obstructing the lynx population expansion within Poland. Another issue that may negatively affect the development potential of the lynx population is low availability of the main species of lynx prey – the roe deer, a fact that has been established within the framework of a large-scale monitoring of ungulates in Poland (Borkowski 2019).

Within the Polish part of the lynx range there are thus five major conservation challenges, which include: (1) restoring and improving the connectivity between large forest complexes; (2) improving the habitat quality in the forests; (3) improving the availability of the food resources for lynx; (4) strengthening and increasing the existing population through reintroductions or reinforcements; and (5) implementing the state-wide monitoring of large carnivores.

#### *Lithuania*

The lynx population in Lithuania has been fully protected since 1975, though during recent decades, it has experienced a decline from 200 to 30–40 individuals in 2010 (Balčiauskas 2021). The population is currently distributed throughout the country, although it is severely fragmented due to the very sparse distribution of forest habitats. However, as an effect of a successful reintroduction programme conducted in 2011–2017, as well as implementation of measures directed at improving breeding habitats and prey availability, the lynx population has started to increase since 2015. A higher frequency of recorded family groups has been observed (Balčiauskas et al. 2017). The population size is currently estimated at approximately 150 individuals (L. Balčiauskas, pers. comm.). Habitat fragmentation and lack of primary habitats suitable for lynx breeding are being considered as important challenges for effective conservation of the species. Competitive interactions with wolves are also regarded as an interfering factor.

#### *Latvia*

The population of lynx in Latvia has a favourable status. Therefore, based on the detailed conservation strategy, a limited use of the

species for hunting purposes is allowed in accordance with Article 16 of the EC Directive 92/43/EEC (Habitats Directive) on the Conservation of Natural Habitats and of Wild Fauna and Flora. Hunting however is banned in the middle part of the country. The population has been growing steadily since the late 1960s and early 1970s. Its distribution covers the whole area of the country and recent estimations suggest a population size of 600–1600 individuals, depending on the survey method applied (Ozoliņš et al. 2017). Some 100–160 lynx are harvested annually, half of the killed animals being used for research purposes such as population demography, genetics and parasitology. Although the lynx status is monitored and the harvest of the population seems to be well controlled, there is concern that a lack of coordination in management action plans (including its dual supervision by two Ministries – Environment and Agriculture) may cause future conservation problems for the species. As the replacement of traditional agriculture with new land uses, such as deer farming or free-ranging sheep husbandry, has recently been promoted, there are claims rising for lynx depredation on livestock. Establishing ecological corridors to mitigate the effects of developing road infrastructure and restrictions on hunting to ensure that conservation status is maintained are among the major challenges in lynx conservation in Latvia.

#### *Estonia*

Estonia is the only EU country where the lynx is a species derogated to the Annex V of the Habitats Directive. It is a species hunted from December to February with a strictly quoted bag. According to the Large Carnivore Action Plan, the population size of lynx is expected to be 100–130 reproducing females (Männil & Kont 2013). The current population status is, however, unfavourable with 50–65 reproductive females recorded in 2013–2018. Several factors could have contributed to the population decline, including the crash of roe deer numbers due to extremely harsh winters in 2010/2011, too high harvest quotas from 2012–2015, illegal hunting, sarcoptic mange and emigration (in search for areas with better prey base; Veeroja & Männil 2019). Contrary to demographic model predictions, the lynx population has not improved by 2018, although the roe deer population has recovered well. In response to the population decline, hunting quotas have been suspended from 2016 to 2019.

#### *Ukraine*

The Baltic population of lynx occurs only along the northern border of the country in the Polesie region and it is estimated at 60–80 individuals (M. Shkvyrja, unpubl. data). It is likely a continuous population with lynx in Belarus and the Russian Federation. The species is fully protected in the country and included in the Red Book of Ukraine. Main conservation challenges for the species include establishing a conservation action plan and state-wide monitoring. The lynx is threatened by massive forest logging, poaching, illegal capture for captive breeding as pets, and illegal amber mining.

#### *Belarus*

The species has been protected since 1981 and it was included in the Red Book of Belarus in 1993. Its distribution is fragmented throughout the country and the official estimation of lynx numbers varied from 250 to 830 individuals during the period 2000 to 2018 (A. Kozorez, pers. comm.). However, these numbers have never been achieved by rigorous state-wide monitoring. In 2011, the Lynx Population Management Plan was approved for a period of 10 years. Measures have been initiated to update the status of the lynx, as well as attempts to estimate its population size. Although the removal of the lynx from the Red Book has recently been suggested, this seems unlikely at the moment, but instead, some licensed hunting might be considered (A. Kozorez, pers. comm.). Currently, the main threat to the lynx in Belarus is poaching due to widespread belief that it has harmful effects on the populations of ungulates.

#### *Russian Federation*

The Eurasian lynx is considered a widely distributed and common species in the Russian Federation. Therefore, it is hunted in the majority of the Russian territory. However, within the European part of Russia its status has recently shifted from hunted to protected in 23 out of 46 regions (Lissovsky et al. 2019). Programmes of reintroduction have been also recently proposed (A. P. Saveljev, pers. comm.).

### **Common challenges for the north-eastern populations**

The status and distribution of lynx in particular countries across the Baltic population are highly diverse from strictly protected and threatened by anthropogenic factors to hunted populations that are increasing in numbers. Moreover, there is a significant genetic diffe-

rentiation and differences in genetic variability among the sub-populations resulting from recent anthropogenic impacts. Considering the whole range of the north-eastern European lowland population of Eurasian lynx, the major common challenges of species conservation include restoration of the suitability and connectivity of the habitat, improving prey availability, establishing a unified monitoring system and improving public awareness about lynx ecology and conservation needs. The individual sub-populations require additional specific conservation measures, such as re-consideration of hunting quotas, mitigation of conflicts caused by livestock depredation, or improvement of habitat quality.

## References

- Balčiauskas, L. 2021: Lūšis. *Lynx lynx* (Linnaeus, 1758) – In: Rašomavičius, V., (Ed.). Red Data Book of Lithuania. Animals, plants, fungi. – Vilnius, 305 pp.
- Balčiauskas L., Balčiauskienė L., Litvaitis J. A. & Tijušas E. 2017. Preliminary impressions of a citizen-scientist effort to monitor large carnivores in Lithuania. *Beiträge zur Jagd- und Wildforschung* 42, 37–41.
- Boitani L., Alvarez F., Anders O., Andren H., Avanzinelli E., Balys V., ... & Zlatanov D. 2015. Key actions for large carnivore populations in Europe. Institute of Applied Ecology (Rome, Italy). Report to DG Environment, European Commission, Bruxelles. Contract no. 07.0307/2013/654446/SER/B3. 120 pp.
- Borkowski J. 2019. Określenie bazy pokarmowej wilka i rysia na stanowiskach monitoringu. [Determining the food base of wolf and lynx at monitoring plots]. Conference: "Pilot monitoring of wolf and lynx in Poland implemented as part of the State Environmental Monitoring - preliminary results of the project POIS.02.04.00-00-0040/16". Ministry of Environment, Warsaw, 15.10.2019. [in Polish]
- Kitchener A. C., Breitenmoser-Würsten C., Eizirik E., Gentry A., Werdelin, L., Wilting, A., ... & Tobe, S. 2017. A revised taxonomy of the Felidae. The final report of the Cat Classification Task Force of the IUCN/SSC Cat Specialist Group. *Cat News Special Issue* 11, 80 pp.
- Lisovsky A. A., Sheftel B. I., Saveljev A. P., Ermakov O. A., Kozlov Yu. A., Smirnov D. G., Stakheev V.V. & Glazov D.M. 2019. Mammals of Russia. Species list and applied issues. KMK Scientific Press, Moscow. 191 pp.
- Lucena-Perez M., Marmesat E., Kleinman-Ruiz D., Martínez-Cruz B., Węcek K., Saveljev A.P., ... & Godoy J.A. 2020. Genomic patterns in the widespread Eurasian lynx shaped by Late Quaternary climatic fluctuations and anthropogenic impacts. *Molecular Ecology* 29, 812–828.
- Männil P. & Kont R. (Eds) 2013. Action Plan for Conservation and Management of Large Carnivores in Estonia in 2012–2021. Estonian Game No. 12. Estonian Theriological Society, 120 pp.
- Mystajek R., Kwiatkowska I., Diserens T. A., Haidt A. & Nowak S. 2019. Occurrence of the Eurasian lynx in western Poland after two decades of strict protection. *Cat News* 69, 12–14.
- Ozoliņš J., Bagrade G., Ornicāns A., Žunna A., Done G., Stepanova A., Pilāte D., Šuba J., Lūkins M. & Howlett S.J. 2017. Action Plan for Eurasian lynx *Lynx lynx* Conservation and Management. LSFRI Silava, Salaspils, 78 pp.
- Ratkiewicz M., Matosiuk M., Saveljev A. P., Sidovich V., Ozoliņš J., Männil P., ... & Schmidt K. 2014. Long-range gene flow and the effects of climatic and ecological factors on genetic structuring in a large, solitary carnivore: the Eurasian lynx. *PLoS ONE* 9(12): e115160.
- Schmidt K. 2011. Strategia ochrony rysia (*Lynx lynx*) warunkująca trwałość populacji gatunku w Polsce – projekt. [Strategy of lynx (*Lynx lynx*) conservation ensuring stability of its population in Poland – proposal]. Instytut Biologii Ssaków PAN, Białowieża/Szkoła Główna Gospodarstwa Wiejskiego, Warszawa. [in Polish]
- Veeroja R. & Männil P. (Eds) 2019. Status of Game populations in Estonia and proposal for hunting in 2019. Estonian Environment Agency, Tartu, 132 pp.
- von Arx M., Breitenmoser-Würsten C., Zimmermann F. & Breitenmoser U. 2004. Status and conservation of the Eurasian lynx (*Lynx lynx*) in 2001. Muri: KORA Bericht no 19, 330 pp.



**Fig. 1.** Distribution of the Eurasian lynx (grey) in central and north-central Europe. Modified from von Arx et al. (2004); forest cover=green, dashed line=reintroduced populations..