ISSN 1027-2992

# Special Issue

N° 14 | Autumn 2021

CAT NEWS

## The Eurasian lynx in Continental Europe

KORA
RAUBTIERÖKOLOGIE UND WILDTIERMANAGEMENT

HIT
UMWELT- UND NATURSCHUTZ STIFTUNGS-GMBH

CONVENTION DE BERNE
BERN CONVENTION

Life

NATURA 2000

Stiftung Natur und Umwelt Rheinland-Pfalz

SPECIES SURVIVAL COMMISSION
CAT SPECIALIST GROUP

**CATnews** is the newsletter of the Cat Specialist Group, a component of the Species Survival Commission SSC of the International Union for Conservation of Nature (IUCN). It is published twice a year, and is available to members and the Friends of the Cat Group.

**For joining the Friends of the Cat Group please contact Christine Breitenmoser at ch.breitenmoser@kora.ch**

Original contributions and short notes about wild cats are welcome
**Send contributions and observations to ch.breitenmoser@kora.ch.**

**Guidelines** for authors are available at www.catsg.org/catnews

This **Special Issue of CATnews** has been produced with support from the Stiftung Natur und Umwelt Rheinland-Pfalz, HIT Umwelt- und Naturschutz Stiftung, and Foundation KORA.

Design: barbara surber, werk'sdesign gmbh
Layout: Christine Breitenmoser
Print: Stämpfli AG, Bern, Switzerland

**ISSN 1027-2992** 

**Editors:** Christine & Urs Breitenmoser
Co-chairs IUCN/SSC
Cat Specialist Group
KORA, Thunstrasse 31, 3074 Muri, Switzerland
Tel ++41(31) 951 70 40
<u.breitenmoser@kora.ch>
<ch.breitenmoser@kora.ch>

**Cover Photo**: Camera trap picture of two Eurasian lynx kittens in north-eastern Switzerland. 11 December 2014 (Photo KORA).

BONN LYNX EXPERT GROUP[1]

# Recommendations for the conservation of the Eurasian lynx in Western and Central Europe

Conclusions from the workshop of the "Bonn Lynx Expert Group" in Bonn, Germany, 16–19 June 2019

The first assessment of the Eurasian lynx *Lynx lynx* across Europe was initiated by IUCN and WWF International in 1962, when the two organisations asked the Czech zoologist Josef Kratochvíl to review the status of the species across the continent (Kratochvíl et al. 1968a, b). A wider audience however became only aware of the fate of this elusive species when in the early 1970s, the reintroduction programmes started in Western and Central Europe (overview in Breitenmoser & Breitenmoser-Würsten 2008). In 1990, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) of the Council of Europe, commissioned a review of the status and the conservation needs of the lynx in Europe (Breitenmoser & Breitenmoser-Würsten 1990). Since then, a number of pan-European or transboundary conservation assessments and strategies were produced:

- Action Plan for the Conservation of Eurasian lynx (*Lynx lynx*) in Europe (Breitenmoser et al. 2000);
- The Pan-Alpine Conservation Strategy for the Lynx (Molinari-Jobin et al. 2003);
- Status and conservation of the Eurasian lynx (*Lynx lynx*) in Europe in 2001 (von Arx et al. 2004)
- Conservation Strategy and National Action Plans for the conservation of the Critically Endangered Balkan Lynx (Council of Europe 2011);
- Key actions for Large Carnivore populations in Europe (Boitani et al. 2015);
- Lynx in the Alps: Recommendations for an internationally coordinated management (Schnidrig et al. 2016);
- *Lynx lynx*: European regional assessment in the IUCN Red List of Threatened Species (von Arx 2018).
-

Although the situation of the lynx has improved since the population minimum in the middle of the 20th century, the above listed conservation plans have revealed that there is a considerable need for more focused conservation efforts in all autochthonous and reintroduced populations in Western and Central Europe. The past years have seen a marked increase of lynx projects in Continental Europe (see individual chapters of the proceedings of the Bonn conference in this Special Issue). This development is most welcome, but it calls for more cooperation and a common understanding and approach on the conservation and management of the lynx in the Western and Central European countries. Lynx as apex predators are rare animals, and their distribution is so far restricted to forested areas. Except for the major mountain ranges such as the Alps, the Carpathians or the Dinaric Range, none of the Western and Central European secondary mountain ranges or low-land forests could host a (genetically) viable lynx population in the long run as long as they are isolated. Therefore, the recovery and maintenance of demographically and genetically viable lynx populations entail a metapopulation-approach and transboundary cooperation. Activities such as "assisted dispersal" (translocations), reintroductions or genetic remedy (reinforcement) furthermore require standards and common protocols, because activities in one population in one country will ultimately affect those of neighbouring countries.

At the conference in Bonn, 16–19 June 2019, a group of 53 experts from across Europe gathered to review the situation of the Eurasian lynx in Western and Central Europe, to enunciate recommendations for the conservation and management of lynx, and to stipulate a number of standards and protocols.

The following recommendations should provide practical guidance for ongoing and future conservation projects in Western and Central Europe and for the cooperation between projects and countries. They are based on the best presently available information and science and are meant to set the standard for lynx conservation projects for the years to come. They are addressed to scientists as well as conservation practitioners, but also to decision makers in governmental institutions and to potential donors of lynx conservation projects.

## Strategic preamble

The Eurasian lynx is protected under the Bern Convention (Appendix III with the exception of the Balkan lynx *Lynx lynx balcanicus*, which is listed under Appendix II) and the EU Habitats Directive (Annexes II and IV, except for Estonia, Finland and Latvia, where it has an exception from Annex II; von Arx 2018). According to the Convention on Biological Diversity, "the fundamental requirement for the conservation of biological diversity is the in situ conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings". The lynx is an apex predator of European forested habitats, preying mainly on roe deer, but also on other small ungulates and a number of medium-sized mammals. The presence of lynx contributes to the ecological functionality of these ecosystems and preserves their evolutionary potential. Threats to lynx have been reviewed in all above-mentioned documents. The latest population-based review was done for the period 2012–2016 by von Arx (2018) in the frame of the IUCN Red List assessment for Lynx lynx in Europe (see "Threats in Detail"). Threats in Continental Europe are mainly anthropogenic, either human-induced mortality or intrinsic threats due to the limited size and isolation of the population in the modern cultural landscape. But all these threats can be mitigated though adequate measures.

The strategies and action plans for the Eurasian lynx in Europe listed above have all expressed the intention to maintain or recover viable lynx populations within the species' historic range wherever the ecological and anthropogenic environments allow it.

## Strategic framework

The participants at the Bonn workshop have reviewed the goals and objectives of the above-mentioned documents and synthesised the following strategic framework for the long-term conservation of the Eurasian lynx in Western and Central Europe.

**Goal:**
Maintain and restore, in coexistence with people, viable populations and metapopulations of Eurasian lynx in a favourable conservation status as an integral part of ecosystems and landscapes across Continental Europe.

The general Goal will be reached by striving for the following six Objectives:

**Objective 1.** To conserve all autochthonous populations, to enable their natural spread and recovery and to safeguard distinct evolutionary significant units (ESUs) of the Eurasian lynx in Continental Europe, and to take all measures needed to prevent local extinction.

**Objective 2.** To conserve all reintroduced populations of Eurasian lynx and to promote in accordance with IUCN guidelines further reintroductions in patches of suitable habitat apt for hosting viable populations or relevant subpopulations or "stepping stones" contributing to the functioning of a larger metapopulation.

**Objective 3.** To foster the natural or assisted connectivity between populations of the same phylogenetic units (e.g. subspecies[1] or ESUs) in order to secure the long-term maintenance of large viable metapopulations.

**Objective 4.** To develop and implement management measures addressing the interactions concerning lynx in the cultural multi-purpose landscapes of Europe (e.g. with regard to forestry or hunting).

**Objective 5.** To generate and provide objective information through monitoring and research to continuously observe the conservation status of each population and to propose the appropriate conservation measures.

**Objective 6.** To reduce human-induced mortality of lynx, esp. by illegal killing and vehicle collisions.

These Objectives will, among others, be achieved by accomplishing the following seven concrete Results:

**Result 1.** Agreement on "evolutionary significant units[1]" of Eurasian lynx in Continental Europe, their geographic delineation and the use of ESUs/subspecies for further translocations.

**Result 2.** A preliminary spatial metapopulation concept for Continental Europe to guide the improvement of functional connectivity between now isolated subpopulations[2] and implement respective practical measures.

**Result 3.** Recommendations on common approaches shared protocols for surveys and monitoring, and pooling data and information from surveys of lynx populations (including demographic, health and genetic status).

**Result 4.** Recommendations on genetic surveillance, management and remedy of inbred populations: why, when, how?

**Result 5.** Recommendations on the use of suited source populations for reintroductions, reinforcements or "assisted dispersal" (metapopulation management).

**Result 6.** Recommendations on best-practice protocols for health considerations and the practical execution of translocations, including quarantine and (transboundary) transport.

**Result 7.** Outlook on the long-term cooperation for the conservation of the lynx in Western and Central Europe: (1) engagement with international conventions and national conservation institutions, (2) involvement of stakeholders at international level (and subsequently at national and local level), (3) need for developing common transboundary management approaches, and (4) need for strengthened cooperation/coordination at regional or metapopulation level.

## Recommendations

The following Recommendations are the joint work of the participants of the Bonn Lynx Expert Group (Appendix I). The Recommendations were prepared in Working Groups, discussed in the Plenary, formulated by a drafting group and finally adopted by all participants.

### 1. Delineation of phylogenetic lines of lynx in Continental Europe

Three subspecies of *Lynx lynx* were described for Europe (Kitchener et al. 2017): the Northern lynx *L. l. lynx* (Linnaeus, 1758), the Carpathian lynx *L. l. carpathicus* (Heptner, 1972), and the Balkan lynx *L. l. balcanicus* (Bureš, 1941). The phylogenetic subdivision of the species is still under discussion. For instance, the Scandinavian population (von Arx et al. 2021) is genetically distinct from the Karelian and the Baltic populations (e.g. Hellborg et al. 2002), or *L. l. balcanicus* might be part of *L. l. dinniki* (the Caucasian lynx; Kitchener et al. 2017). Nevertheless, the present state of research indicates the presence of three extant phylogenetic lines in Continental Europe, which we recommend to treat as distinct "evolutionary significant units" (ESU): the Baltic, the Carpathian and the Balkan ESU.

The most threatened of these ESUs is the Balkan lynx, which is considered to be Critically Endangered according to the IUCN Red List of Threatened Species (Melovski et al. 2015). The Balkan lynx is subject of an ongoing recovery programme based on a conservation strategy (Council of Europe 2011); its conservation is hence not further elaborated in these recommendations. The general approach is to strengthen the remnant population in its present distribution area and help it expanding across the assumed historic range on the southern Balkan Peninsula. A viable Balkan population will be able to resist the competition with immigrating *L. l. carpathicus* from either the autochthonous Carpathian population or the reintroduced Dinaric population, as it has done for thousands of years in the past. An alternative conservation strategy would have to be developed if further monitoring reveals that the extremely small Balkan lynx population is (genetically) no longer viable.

Similar to the Balkan lynx, the conservation of the autochthonous populations of the Carpathian and Baltic lynx must have high priority. Both populations stretch over several countries (von Arx et al. 2021; Fig. 1) and would highly profit from common population-level conservation and management plans jointly developed by the countries sharing these populations and subsequently implemented through national action plans. The Baltic population is part of the large north-eastern European lynx (e.g. the Karelian) population, but it is severely fragmented in its south-western area. The Carpathian population is apparently divided into a northern and a southern part,

[1] For the Eurasian lynx, a number of distinct subspecies have generally been accepted, although not all of them are based on sufficient scientific evidence (Kitchener et al. 2017). Wherever sensible, we consider subspecies to be the ESUs.
[2] A subpopulation is a subset of a larger metapopulation; several subpopulations together form a metapopulation. Subpopulations are separated by barriers or less suited habitat, which are however permeable enough to allow a migration of individuals sufficient to maintain the demographic and genetic viability of the subpopulations.

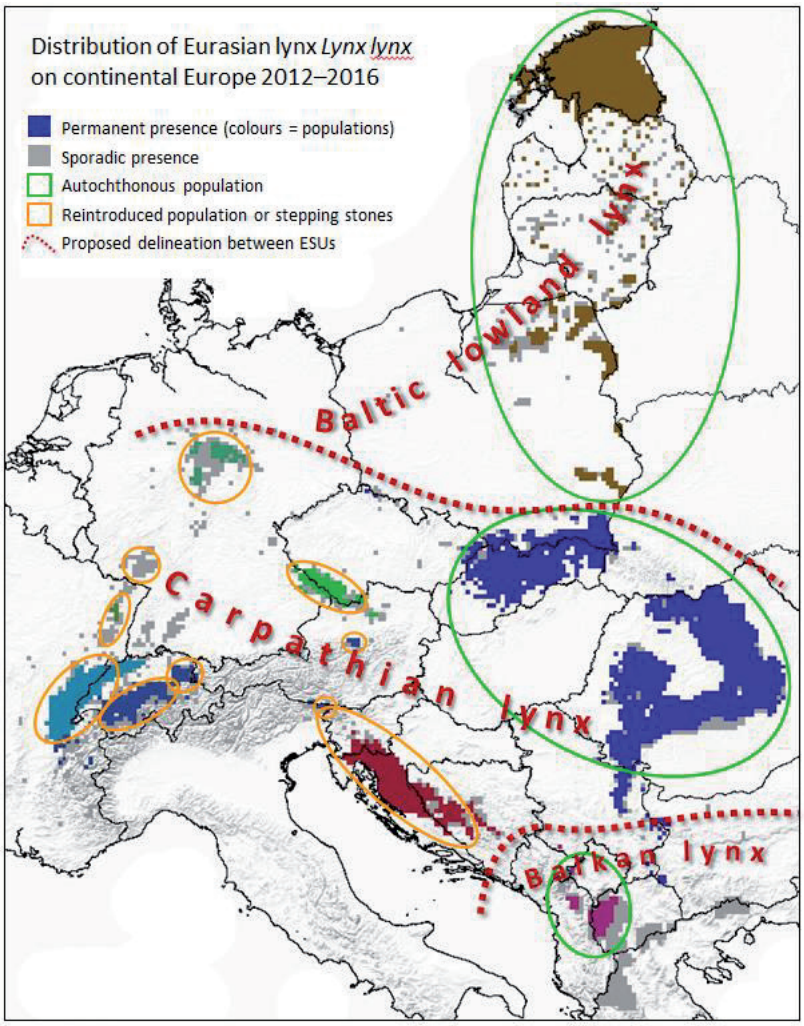


**Fig. 1.** Distribution of *Lynx lynx* in Continental Europe 2012–2016 according to a LCIE survey (von Arx 2018). The autochthonous populations (green circles) represent three different phylogenetic lines, which should be conserved as such. The dashed lines (dark red) represent the proposed delineation of the ESU's distribution range for recovery and reintroduction projects, respectively.



as the lynx in the Ukrainian Carpathian Mountains seems to be practically extinct (Fig. 1).

For the reintroduction of lynx in Western and Central Europe, which started almost 50 years ago, Carpathian lynx were generally used, with the exception of the reintroductions in the Kampinos National Park (Poland) and the Harz Mountains (Germany), where generic lynx from zoos were released (Breitenmoser & Breitenmoser-Würsten 2008). Today 87.5% of the Harz animals show haplotype 4 (Mueller et al. 2020), which is the only one found in the Carpathian lynx population. Although this haplotype is not exclusive, as it also occurs in the Baltic population, we can assume that most of the haplotypes 4 came from the Carpathian population (T. Reiners, pers. comm.).

To use Carpathian lynx in the early reintroductions in the 1970/80s was an arbitrary decision based on the geographic proximity and the habitat similarities of the Carpathian Mountains. Today, we know that the lynx historically living e.g. in the Alps were genetically not identical to the Carpathian lynx (Gugolz et al. 2008), but the lynx historically inhabiting these ranges are lost forever, so it was justifiable to use the nearest ecotype. The participants of a workshop on the genetic status and conservation management of reintroduced lynx populations in 2011 recommended continuing using *L. l. carpathicus* for the entire region where this phylogenetic line was used before (Breitenmoser 2011). So we distinguish three "lynx regions" in Continental Europe (Fig. 1): (1) the area of the Balkan lynx in the south-east, including the southern part of the Dinaric Range (extant area), and the Balkan and Rhodope Mountains as historic and potential expansion range. (2) The region between the central Dinaric Range and the southern rim of the Carpathians north to the Harz Mountains as extant or future distribution range of *L. l. carpathicus*. This would include large ranges such as the Alps, but also all secondary mountain chains in Western and Central Europe where Carpathian lynx have been reintroduced since the 1970s. (3) The lowland of the north-Continental plain should be considered the extant or future range of the Baltic lynx.

*Recommendations:*

- Distinguish three areas of distinct phylogenetic lines in Continental Europe (Fig. 1): *L. l. balcanicus* in the south-east (southern Dinarides or Hellenides, Balkan Range and Rhodope Mountains); *L. l. carpathicus* from the southern Carpathians and the central Dinaric Range north to the Harz Mountains, including the Alps and all secondary mountain ranges of Western and Central Europe; (3) the "north-eastern European lowland lynx" in the plains of north-Continental Europe north-east to the Baltic countries (see 3.5 for recommendations on source populations).
- Dispersal across the delineation line of the ESUs (Fig. 1) is a natural process that was occurring for thousands of years. It should neither be prevented nor furthered, but weak indigenous populations such as the Balkan lynx should be strengthened through sensible conservation measures.
- Within the designated distribution range of an ESU, the genetic diversity of each population should be optimised, monitored and maintained high (see 3.2 and 3.4).

**2. Metapopulations of lynx in Continental Europe and connectivity**

Both, habitat (forest cover and in large areas tree diversity) and prey base (e.g. roe deer) have considerably improved in Western and Central Europe since the historic lynx populations went extinct in the 19th century (Breitenmoser & Breitenmoser-Würsten 2008). Besides the large ranges such as the Carpathians, Alps or Dinaric Range, many of the secondary mountain ranges of Continental Europe nowadays provide well suited habitat for lynx, but their spatial extent may not be sufficient to host a genetically viable population. In the long term, the ultimate distribution range of each of the ESUs should be considered and managed as one genetic metapopulation. Some of the connections between subpopulations are obvious and have been demonstrated (e.g. Herdtfelder et al. 2021); some are speculative and anticipated only (as presented in Fig. 2 for the Carpathian lynx). Some populations are separated by distance and suboptimal habitat, others are close together, but separated by severe barriers like large rivers, agglomerations or major traffic axes. Lynx show a sex-biased dispersal: Male lynx go further and pass considerable barriers such as the main ridge of the Alps or the Rhine River. The potential of individual lynx to move across the cultivated and human-dominated landscapes of Western and Central Europe is considerable, but demonstrated cases of migration between populations with successful integration (reproduction) of the immigrant, are so far very rare. Success of migration depends on the distance and corridor quality between neighbouring populations, but also on the status of the source and target population. Connectivity and exchange of individuals can be predicted by means of models (Premier et al. 2021), but its effect on genetic diversity will ultimately have to be evaluated by means of genetic monitoring (see 3.4).

Several large "potential populations" or "metapopulations" have been proposed: The "Alpine population" (A in Fig. 2), has been considered as a potential population in the frame of the SCALP (Status and Conservation of the Alpine Lynx Population) concept (e.g. Molinari-Jobin et al. 2003, Schnidrig et al. 2016, Molinari-Jobin et al. 2021). The secondary mountain ranges of the Jura, the Vosges-Palatinate Forest, and the Black Forest are proposed as the "upper Rhine metapopulation" (B in Fig. 2; Krebühl et al. 2021). The well-forested mountain ranges surrounding the Czech Republic, with the Bavarian Forest in the west and the Carpathians in the east were proposed as potential metapopulation (C in Fig. 2; called "CELTIC" metapopulation by Wölfl et al. 2001; see also Wölfl et al. 2021). Last but not least, the Carpathian population (D in Fig. 2), always considered a stronghold of lynx in Central Europe, is today severely fragmented and may be functionally a metapopulation. Although the metapopulation concept presented here is not fully consistent and may have to be adapted in the future, it is a useful concept to plan the merging of fragmented populations or isolated occurrences. Connectivity between neighbouring populations must be maintained or restored through habitat amelioration, the creation of corridors, the mitigation of barriers such as traffic axes wherever feasible, or targeted stepping-stone releases (Molinari et al. 2021).

*Recommendations:*

- Each transboundary population or designated metapopulation should be cooperatively monitored and transboundary conservation and management plans should be developed based on the principles proposed by Linnell et al. (2008). A common conservation strategy is especially recommended for the autochthonous Carpathians and Baltic populations.
- The knowledge on lynx movements between populations must be refined. This includes common monitoring of the population (genetic status) and movement of individuals (dispersal of both sexes), but also understanding of habitat, corridors, and obstacles to lynx movements.



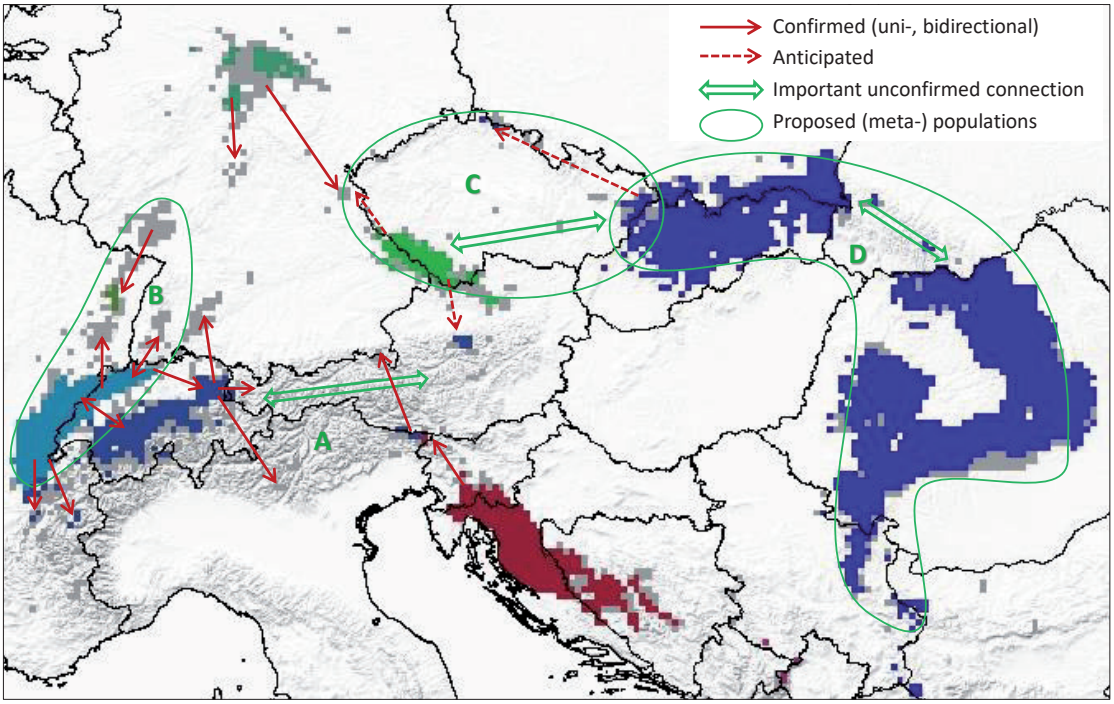


**Fig.2.** Distribution of the Carpathian lynx *L. l. carpathicus* in Continental Europe 2012–2016 (colours = populations), confirmed (radio-telemetry, camera trapping, or genetics), or anticipated movements of lynx between populations (arrows), unconfirmed, but potentially important connections, and proposed (meta-) populations (polygons A–D, see text) to be conserved and managed as larger units.

- Wherever considered insufficient (e.g. based on genetic monitoring), functional connectivity should be improved (e.g. restoring corridors, green bridges, mitigation of human-induced mortality, etc.). Where the enhancement of natural migration is not possible or too expensive, assisted dispersal by means of translocations must be considered. Local populations should not be allowed to drop below functional (demographic) viability.

**3. Concepts for monitoring of the conservation status of lynx populations**

The pan-European review of the conservation status of the European lynx populations was coordinated by the Large Carnivore Initiative for Europe (LCIE). A comprehensive assessment is preformed every six years based on the IUCN Red List assessment procedures (von Arx 2018; von Arx et al. 2021). The pan-European assessment is a compilation of population and country oriented information ranging from expert opinion to robust quantitative estimations of abundance. A number of countries have adopted specific protocols for the monitoring of lynx (e.g. Breitenmoser et al. 2006; Reinhardt et al. 2015; Gimenez et al. 2019; Zimmermann 2019), and for several populations, a transboundary coordinated monitoring scheme or at least a procedure for the common interpretation and release of monitoring reports have been established (e.g. the Norwegian-Swedish Instructions for lynx monitoring; Alps, Molinari-Jobin et al. 2021; Bohemian-Bavarian-Austrian population, Wölfl et al. 2021). Monitoring the conservation status of a species includes information on distribution, population size, population dynamics (demography), health, genetic status, threats and conflicts. The following recommendations address the (technical) monitoring of the ecological and biological parameters of lynx, although we are aware that monitoring of conflicts with human activities (hunting, livestock breeding) and peoples' attitudes are as important for the successful implementation of conservation programmes.

*Distribution* is generally the first aim of repeated monitoring. At a European scale, distribution is presented by means of the 10 x 10 km EEA (European Environment Agency) reference grid, with some specification per cell, such as permanent (with/without reproduction), sporadic or uncertain presence (Kaczensky 2018) based on reported records per country differentiated according to the SCALP Criteria from the standardised monitoring for the Alps (Molinari-Jobin et al. 2012). The result is a naïve occupancy map, mostly based on chance and opportunistic observations, for certain populations or countries including information on reproduction. For some countries, distribution information is however still based on expert opinion or a rather randomly collected set of observations.

*Population size (population indices, minimum count, robust capture-recapture estimates)* in Continental Europe bases today mainly on camera trapping (different to more northern countries, snow tracking is nowhere systematically used) and partly on radio-telemetry (mostly combined with research projects). The most reliable abundance or density estimations are achieved with capture-recapture analyses of camera-trapping data (e.g. Zimmermann & Foresti 2016; Gimenez et al. 2019). Camera-trapping sessions in reference areas should be repeated about every two to three years to gain a sufficient resolution of population trends and to get reliable demographic parameter estimates (e.g. survival, recruitment).

*Demographic data (natality, mortality, age structure and sex ratio)* are important and should at least be systematically collected as chance observations throughout the distribution range. Further demographical parameters such as growth rate, survival, or recruitment can be estimated by means of capture-recapture models.

*Population trend* describes temporal change of parameters such as distribution, population indices, abundance and density. Monitoring and interpreting trend information is fundamental to draw the right conclusion with regard to conservation or management interventions.

*Health monitoring* is of growing importance especially for the small populations in Continental Europe, as health issues may be linked to population size and genetic status and may become more important with climate change (emerging pathogens). Furthermore, a health screening following agreed veterinary protocols are required for any translocation of lynx between populations or countries. Health concerns include harmonised screening of the populations (e.g. protocol for necropsy), handling of live caught animals (anaesthesia, health check-up) and veterinary requirements for translocations (transport, quarantine, health reporting; Ryser-Degiorgis et al. 2021). Veterinary protocols should be coordinated with the genetic monitoring (see below).

*Recommendations:*

- The compilation, analysis, interpretation and presentation of distribution records (systematically compiled, georeferenced, dated and categorised chance observations) needs to be standardised for all countries sharing a population, and harmonised distribution maps for the entire population should be updated regularly
- Occupancy models should be computed besides presenting the naïve occupancy to compensate for incomplete detection (e.g. Molinari-Jobin et al. 2018).
- A standardised protocol for camera-trapping for abundance/density estimations for Western and Central Europe needs to be developed (reference area, size and camera-trap spacing, duration, season, data analysis and interpretation).
- A series of standardised veterinary and health protocols (capture and anaesthesia, health screening, necropsy, quarantine, transport, reporting) need to be developed (or adapted/translated where they already exist ), made available and regularly reviewed and updated (see also Online Supporting Material to this issue).
- To tackle the above-mentioned tasks and to develop/harmonise the proposed protocols, permanent expert working groups on (1) monitoring and (2) health issues should be established.

**4. Principles for the genetic monitoring and management of lynx populations**

Genetic monitoring is important for all small, reintroduced, isolated, and fragmented populations, and for those that went through a serious historic bottleneck. In other words: for all European lynx populations. The reintroduced populations will not be (genetically) viable in the foreseeable future, so they need short- to long-term genetic management. All reintroduced lynx populations in Central and Western Europe with exception of those in Poland are considered part of the Carpathian lynx ESU.

Small and isolated populations should be genetically managed to minimise loss of genetic diversity (heterozygosity, allelic richness) and to keep the inbreeding coefficient $F_{IT}$ below 0.15. If the inbreeding coefficient exceeds 0.25 (equivalent to full sibling mating) immediate action is needed to restore the genetic variability of the populations

and decrease the inbreeding coefficient. Gene flow should be established within a local metapopulation to reach these goals. If this is not possible or not sufficient through natural migration, assisted gene flow (assisted dispersal) has to be implemented. If local metapopulation dynamics (within an extant, but fragmented population or between neighbouring reintroduced populations) is functioning either through natural gene flow or assisted dispersal, the effective population size of the population/metapopulation (Fig. 2) should not drop below an effective population size of 100 mature individuals as recently proposed by Frankham et al. (2014). Consequently, releasing related animals in newly founded or very small population nuclei should be avoided. Related animals and animals from inbred populations should not count fully, but e.g. 2 siblings as 1.75. Genotyping of each animal to be released is mandatory.

The sampling of material for genetic analyses needs to be included in monitoring protocols: Opportunistic sampling (e.g. from dead or captured lynx) has to be permanently implemented across the range. If a sample-size goal of 30 animals per generation (5 years) per population is not reached, sampling needs to be intensified. A common panel of 15 microsatellites should be used across the range by all laboratories involved in genetic monitoring of lynx. Calibration samples need to be exchanged between participating laboratories and a calibration table should be shared. New marker systems should be tested as they become available.

*Recommendations:*

- Genetic monitoring needs to be established where it does not already exist and must become mandatory for all lynx populations in Continental Europe. This includes the tracking of genetic diversity and inbreeding over time, allowing assessing the effective population size (Ne) and the detection of gene flow between neighbouring populations.
- To establish an assisted metapopulation management, a system for assessing and exchanging animals (e.g. orphaned lynx) between reintroduced and other genetically deprived populations/subpopulations needs to be developed.
- A permanent lynx genetics working group including experts from the laboratories involved in genetic monitoring and research should be established. This group should develop a more detailed protocol for genetic monitoring and conservation (genetic remedy of inbred populations, long-term genetic management of the metapopulations). Regular exchange of information between participating laboratories and with the in situ projects needs to be secured. Any new laboratory starting to work in lynx genetics is encouraged to join the working group.

**5. Source populations for reintroductions or reinforcement**

Reintroduction projects, reinforcement (including stepping-stone nuclei; Molinari et al. 2021), genetic remedy of inbred populations and continued genetic management (assisted dispersal/translocation) need suited lynx to be translocated and released. Until recently, the dominating source was the autochthonous population of Slovakia, which however has some conservation concerns itself (Kubala et al. 2021). The LIFE Lynx Project aiming at mitigating the inbreeding of the Dinaric population has now established Romania as a source for providing lynx (Fležar et al. 2021). However, although the autochthonous populations will remain an important source for reintroductions and reinforcements, capturing and translocating wild animals is increasingly complicated because of partly conflicting welfare, health and genetic considerations (see 3.6).

Alternative sources are the Eurasian lynx breeding programmes of the European Association of Zoos and Aquariums (EAZA). The EAZA today maintains two European Studbooks (ESB) for Eurasian lynx, one for *L. l. lynx* and another one for *L. l. carpathicus* (Lengger et al. 2021). After the genetic status and relatedness of the ESBs have been tested, these breeding programmes will be ready to provide animals for releases – provided that lynx designated for being released are bred, managed, trained and tested according to a rigorous protocol. The Carpathian lynx ESB is basically ready to provide animals (Lengger et al. 2021) for being released in the respective range (Fig. 1). With the Northern lynx ESB, there is however an important phylogenetic question to be answered: Are the Scandinavian and Fenno-Baltic lynx phylogenetically close enough to be considered an ESU? Until this question is answered, we recommend using only wild lynx from the Baltic population or captive-bred lynx demonstrated to belong to the Baltic or the Karelian populations for any reintroduction or reinforcement in the region of the Baltic lowland lynx (Fig. 1).

A third "source" are orphaned lynx, which come up almost yearly in any of the populations. Such lynx often show up in human vicinity and then taken into an enclosure in late fall and may be released in spring when they are about one year old, hence in their dispersal age. Provided that they are physically and mentally healthy and genetically fit (e.g. come from a population that is recommended as a source for translocation), such subadult animals are ideally suited to be translocated. Experience with regard to the survival of rehabilitated orphans is mixed. However, they do not seem to have a lower survival rate compared to naturally dispersing yearlings. A pan-European compilation and review is presently under way to review the survival of rehabilitated orphans and their potential to be used for reintroduction projects or genetic remedy (A. Molinari-Jobin, pers. comm.).

*Recommendations:*

- Sources for reintroductions and reinforcement (genetic remedy) in the designated distribution area of the Carpathian lynx (Fig. 2) are (1) the autochthonous population in Slovakia and Romania, (2) lynx (including orphans) taken from any population that meets the genetic requirements (see 3.4), and (3) properly managed specimens from the EAZA Carpathian lynx ESB.
- Sources for the reintroduction in the "Baltic lowland lynx" area (Fig. 2) are suited wild animals form the Baltic or Karelian populations or specimens from the EAZA Northern lynx ESB if it is demonstrated that they belong to the Fenno-Baltic line.
- If animals are taken from free-ranging populations, the removing of individuals must not be detrimental to the source population. This must be demonstrated by an adequate monitoring/assessment before and after the captures.
- Specific protocols must be developed for (1) breeding, husbandry, training and assessment of zoo-born lynx designated to be released, and (2) for the rehabilitation, husbandry, training (if needed) and evaluation of orphaned lynx to be released. These protocols must be jointly developed by lynx experts, the EAZA Felid TAG and ESB, and relevant IUCN SSC institutions (e.g. Cat Specialist Group, Conservation Translocation Specialist Group (formerly Reintroduction SG), and LCIE).

**6. Protocols for translocation of lynx**

Reintroduction and reinforcement including genetic management require the translocation of lynx from its place of origin to the release site. This process requires a number of legal obligations and practical precautions with regard to the safety of the animal, the people, and the ecosystem at the capture and release sites. General guidance for the planning of translocations is provided e.g. by the IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC 2013) or the Guidelines for the management of confiscated, live organisms (IUCN 2019). Wild-to-wild translocations generally include the following practical components:

*Capture*: Choice of adequate trapping system, surveillance system, competent handling of the animal including anaesthesia, examination, and decision on the suitability of the individual.

*Quarantine*: Preparation of quarantine station (to minimise risks of injuries and stress and to meet legal requirements where required), examinations and assessments during the quarantine time (diseases, genetics, signs of stress), duration (as short as possible, as long as needed; duration of the quarantine often requires a compromise between welfare and veterinary requirements), re-capture and preparation for transport/release (e.g. collaring).

*Transport*: Appropriate transport box and vehicle (both need to be well ventilated), timing (e.g. if border formalities are needed), transport team (driver(s), veterinary attendant). For long journeys, animal care-takers and transport vehicles have to be certified by the EU TRACES (Trade Control and Expert System) system.

Many of these considerations concern the translocation of zoo-born lynx, too, but zoo born lynx have the advantage that the suited individual can be selected in advance and that its genetic constellation, its behaviour, and to a certain extent its health status is known before the capture. Recent experiences with translocation of lynx are available from the reintroduction projects in north-eastern Switzerland (taken into account in Breitenmoser et al. 2014), in the Palatinate Forest (Idelberger et al. 2021) and reinforcement project in the northern Dinaric Range (Fležar et al. 2021). The joint experiences from these projects allow producing specific and detailed guidelines and protocols for the translocation of Eurasian lynx.

*Recommendation:*

- A working group should be established to draft detailed protocols for capturing, treating/examining, quarantining and transporting of Eurasian lynx for translocations (see 3.).

**7. Cooperation in lynx conservation in Europe**

The recovery and long-term maintenance of viable metapopulations of Eurasian lynx in Europe requires the involvement of many institutions and interest groups. The Bonn symposium and workshop was a meeting of wildlife researchers and conservationists. The plenary discussion revealed that there is a demand for exchange beyond scientific publications and a need for a more coordinated and institutional cooperation beyond the "Bonn expert group". The following topics were addressed:

Sharing of information: For the continuous assessment and conservation of the European lynx metapopulations, data on the status of the populations (abundance, trend, demography, genetics, and health) and ecological information need to be shared. Development of sensible conservation programmes furthermore requires information on (1) laws, policies, strategies and action plans, (2) threats to the lynx and coexistence with people, (3) economic aspects (prevention and compensation of depredation, impact on hunting, ecotourism), and (4) communication and awareness. For the practical implementation of conservation and management measures, information should be shared on (1) approaches (concepts, tools, protocols) and experiences (results), (2) upcoming research and conservation projects, and (3) lessons learnt and best practices. This combined experience should be compiled into recommendations and guidelines, which are to be regularly updated.

Scientific and popular publications are the basic way of sharing information, but they should be supplemented through (1) regular multinational and interdisciplinary meetings, (2) information and data sharing platforms (e.g. EUROLYNX; Heurich et al. 2021), (3) targeted information to over-arching conservation institutions and authorities in charge (e.g. IUCN SSC groups, conventions and national governmental institutions, interest groups at international, national and local level).

Outreach to other institutions and interest groups: The group of experts, which met in Bonn, needs to engage more with international conventions, national governments and stakeholders groups, and needs to advance the development of transboundary conservation strategies or management plans and strengthen the cooperation at regional and metapopulation level.

International conventions to be involved in long-term lynx conservation are the Bern Convention (Council of Europe; see 4. Concluding remarks), the EU Commission (Habitats Directive), the Alpine Convention's Platform Wildlife and Society, the Carpathian Convention, and IUCN SSC and its specialist groups. These bodies should regularly be informed and invited to participate in further meetings on lynx conservation in Europe.

National authorities concerned with the conservation and management of lynx should be continuously informed "bottom up" through project holders and wildlife experts, by the "Bonn expert group" as needed, but also by international institutions (EU Habitats Directive, Bern Convention) if the matter concerns transboundary cooperation or international obligations. The relevant national authorities should be made aware of status reports and recommendations (e.g. this publication).

Stakeholders and interest groups must be involved in lynx conservation and management at all levels, but the "Bonn expert group" should engage with them at international level. Obvious partner groups are the IUCN SSC Cat Specialist Group and the LCIE, and the EAZA Felid TAG. Regular contact should furthermore be established with the Federation of Associations for Hunting and Conservation of the EU (FACE), the International Council for Game and Wildlife Conservation (CIC), the World Wide Fund for Nature (WWF), Landowners' Association, Europarc/Alparc, Euronatur, Greenpeace, and others. These institutions should (1) be regularly informed about the conservation status of lynx, (2) attend international/Continental meetings, and (3) be invited to provide expertise and support.

The scientific cooperation between lynx researchers at European level is well functioning based on personal communication and cooperation at project level. Networks such as EUROLYNX (Heurich et al. 2021) are further facilitating cooperation. There are however two obvious requirements with regard to science and lynx conservation: (1) Social scientists must be involved in the lynx conservation group in the future. Although social and legal science research on large carnivore conservation has considerably increased over the past two

decades, most papers relevant to lynx conservation are still from the natural science point of view. (2) Conclusions from research projects must be more directly considered in lynx conservation and management approaches. This requires first that policy and decision makers (and relevant interest groups) are informed about the scientific findings (see above).

Transboundary management plans as proposed by Linnell et al. (2008) are considered a useful tool to develop and coordinate transboundary cooperation. While the technical/scientific cooperation at international level works rather well, and monitoring is increasingly coordinated at metapopulation level (Molinari-Jobin et a. 2021), there are still very few transboundary conservation and management projects where the respective national institutions are engaged. Technical cooperation and international funding (e.g. EU LIFE or InterReg projects) for transnational projects is often a good start. The lynx expert group (e.g. in cooperation with NGOs) should engage more in the development of transboundary population management/conservation strategies and the related national action plans as implementation tools. It is important to define measurable goals/objectives at population level. However, national authorities are often scared by binding concrete international obligations that they need to enforce at the national level. In this respect, the "freedom within frames" principle (Linnell et al. 2008) should be applied allowing adopting population-level goals to national requirements.

*Recommendations:*

- In order to give the participants of the Bonn lynx symposium and workshop a face and a voice, it should be continued as a permanent lynx working group, e.g. affiliated with IUCN SSC specialist groups such as the Cat Specialist Group and the LCIE.
- This group should develop and maintain a number of practical protocols for lynx conservation and management as outlined under "Recommendations" above.
- Besides technical recommendations, the group should engage with other experts to develop concepts for a wider outreach and communication in order to reach the institution and interest groups mentioned above, but also the general public.

## Concluding remarks

The final discussion at the Bonn lynx symposium and workshop revealed that the participants considered this review of the situation of lynx (see Proceedings in this issue) most useful and the conclusion and outlook (these Recommendations) a starting point for more targeted and coordinated work on lynx conservation. It is relatively easy to reach consensus within a group of like-minded experts, but it is much more challenging to engage with the relevant authorities, the interest groups and the civil society. This requires a long-term commitment and continuous dialogue between all parts of our society interested and concerned. These Proceedings summarise the present status of the Eurasian lynx in Continental Europe, and the Recommendations outline the strategic approach and provide guidance for practical cooperation. A report summarising the Bonn symposium and workshop was submitted to the Berne Convention, and on 6 December 2019, the Standing Committee has adopted the Recommendation No. 204 (2019) on the Conservation of the Eurasian lynx (*Lynx lynx*) in Continental Europe (https://rm.coe.int/2019-rec-204e-lynx/1680993e0b; see also Online Supporting Material Document D1). These Recommendations were hence reviewed, discussed and adopted by representatives of all countries considered in this report. These Proceedings and Recommendations will be used to inform and engage with the potential partners in lynx conservation as identified above. Reaching out to the public and national or local stakeholders requires messages adapted to the local situation, communicated in the respective languages and through the appropriate channels. This cannot be the task of an international group of specialists as the "Bonn Lynx Expert Group". However, these Recommendations may provide the basis for more targeted messages adapted to the situations in the countries of Western and Central Europe. Furthermore, the Recommendations also provide an agenda for the future work of the lynx experts that met at the Bonn lynx symposium and workshop.

Supporting Online Material SOM Document D1 is available at www.catsg.org

**References**


Boitani L., Alvarez F., Anders O., Andren H., Avanzinelli E., Balys V., ... & Zlatanova 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.

Breitenmoser U. 2011. Genetic status and conservation management of reintroduced and small autochthonous Eurasian lynx *Lynx lynx* populations in Europe. Final scientific report on an exploratory workshop in Saanen, Switzerland, 24–27.10.2011, 9 pp.

Breitenmoser U. & Breitenmoser-Würsten Ch. 1990. Status, conservation needs and reintroduction of the lynx (*Lynx lynx*) in Europe. Nature and Environment Series, No. 45, Strasbourg, France, 47 pp.

Breitenmoser U. & Breitenmoser-Würsten Ch. 2008. Der Luchs – ein Grossraubtier in der Kulturlandschaft. Salm Verlag, Wohlen/Bern, Switzerland, 537 pp.

Breitenmoser U., Breitenmoser-Würsten Ch., Okarma H., Kaphegyi T., Kaphegyi-Wallmann U. & Müller U. M. 2000. Action Plan for the conservation of the Eurasian Lynx (*Lynx lynx*) in Europe. Nature and Environment, No. 112. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Strasbourg, France, 70 pp.

Breitenmoser U., Breitenmoser-Würsten Ch., von Arx M., Zimmermann F., Ryser A., Angst C., ... & Weber J.-M. 2006. Guidelines for the Monitoring of Lynx. KORA Bericht Nr. 33e, Muri b. Bern, Switzerland, 31 pp.

Breitenmoser U., Ryser A. & Ryser-Degiorgis M.-P. 2014. Dokumentation Fang, Narkose und Markierung von Raubtieren. Bericht z.H. der Tierversuchskommission, 35 pp. (Unpublished report, available on request.)

Council of Europe. 2011. Conservation Strategy and National Action Plans for the conservation of the Critically Endangered Balkan Lynx. T-PVS/Inf (2011) 33. Council of Europe, Strasbourg, France, 30 pp.

Fležar U., Pičulin A., Bartol M., Stergar M., Sindičić M., Gomerčić T., Slijepčević V., Trbojević I., Trbojević T., Molinari-Jobin A., Molinari P., Krofel M. & S. Černe R. 2021. Eurasian lynx in the Dinaric Mountains and the south-eastern Alps, and the need for population reinforcement. Cat News Special Issue 14, 21–24.

Frankham R., Bradshaw C. J. A. & Brook B. W. 2014. Genetics in conservation management: Revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation 170, 56–63.

Gimenez O., Gatti S., Duchamp C., Germain E., Laurent A., Zimmermann F. & Marboutin E. 2019. Spatial density estimates of Eurasian lynx (*Lynx lynx*) in the French Jura and Vosges Mountains. Ecology and Evolution 9, 11707–11715.

Gugolz D., Bernasconi M. V., Breitenmoser-Würsten Ch. & Wandeler P. 2008. Historical DNA reveals the phylogenetic position of the extinct Alpine lynx. Journal of Zoology 275, 201–208.

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

Herdtfelder M., Schraml U. & Suchant R. 2021. Steps towards a lynx population in the Black Forest? Cat News Special Issue 14, 45–46.

Heurich M., Premier J., Oeser J., Streif S., Bastianelli M., Morelle K., Focardi S., De Groeve J., Urbano F. & Cagnacci F. 2021. EUROLYNX: Collaborative science for studying Eurasian lynx movement ecology at the range of its distribution. Cat News Special Issue 14, 60–63.

Idelberger S., Krebühl J., Back M., Ohm J., Prüssing A., Sandrini J., & Huckschlag & 2021. Reintroduction of Eurasian lynx in the Palatinate Forest, Germany. Cat News Special Issue 14, 38–42.

IUCN. 2019. Guidelines for the management of confiscated, live organisms. Gland, Switzerland: IUCN. iv + 38 pp.

IUCN/SSC. 2013. Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission, viiii + 57 pp.

Kaczensky P. 2018. IUCN Red List Mapping for the regional assessment of the Eurasian Lynx (*Lynx lynx*) in Europe. Supplementary information to von Arx (2018). *Lynx lynx* (errata version published in 2019). The IUCN Red List of Threatened Species 2018: e.T12519A145266191.

Kitchener A. C., Breitenmoser-Würsten Ch., 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 Cat Specialist Group. Cat News Special Issue 11, 80 pp.

Kratochvil J. et al. 1968a. History of the distribution of the lynx in Europe. Acta sc. nat. Brno 2(4), 1–50.

Kratochvil J. et al. 1968b. Recent distribution of the lynx in Europe. Acta sc. nat. Brno, 2(5/6), 1–74.

Krebühl J., Idelberger S., Zimmermann F., Breitenmoser-Würsten Ch., Breitenmoser U., Herdtfelder M., Suchant S. & Drouet-Hoguet N. 2021. Transboundary cooperation in lynx conservation under the auspice of the Upper Rhine Conference. Cat News Special Issue 14, 55–56.

Kubala J., Ćirović D., Duľa M., Kutal M., Mysłajek R. W., Nowak S., … & Zlatanova D. 2021. Conservation needs of the Carpathian lynx population. Cat News Special Issue 14, 12–15.

Linnell J., Salvatori V. & Boitani L. 2008. Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070501/2005/424162/MAR/B2). 85 pp.

Melovski D., Breitenmoser U., von Arx M., Breitenmoser-Würsten Ch. & Lanz T. 2015. *Lynx lynx* ssp. *balcanicus*. The IUCN Red List of Threatened Species 2015: e.T68986842A68986849. Downloaded on 25 July 2020.

Molinari P., Breitenmoser U., Černe R., Fuxjäger C., Weingarth K., Ryser A. & Molinari-Jobin A. 2021. The contribution of stepping-stone releases for enhancing lynx distribution. Cat News Special Issue 14, 46–49.

Molinari-Jobin A., Molinari P., Breitenmoser-Würsten Ch., Wölfl M., Stanisa C., Fasel M. ... & Breitenmoser U. 2003. The Pan-Alpine Conservation Strategy for the Lynx. Nature and Environment, No. 130. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Strasbourg, France, 25 pp.

Molinari-Jobin A., Wölfl S., Marboutin E., Molinari P., Wölfl M., Kos I. ... & Breitenmoser U. 2012. Monitoring the Lynx in the Alps. Hystrix 23, 49–53.

Molinari-Jobin A., Kéry M., Marboutin E., Marucco F., Zimmermann F., Molinari P., ... & Breitenmoser U. 2018. Mapping range dynamics from opportunistic data: spatiotemporal modelling of the lynx distribution in the Alps over 21 years. Animal Conservation 21, 168–180.

Molinari-Jobin A., Breitenmoser U., Breitenmoser-Würsten Ch., Černe R., Drouet-Hoguet N., Fuxjäger C., … & Zimmermann F. 2021. SCALP: Monitoring the Eurasian lynx in the Alps and beyond. Cat News Special Issue 14, 50–52.

Mueller S. A., Riners T. E., Middelhoff T. L. Anders O., Kasperkiewicz A. & Nowak C. 2020. The rise of a large carnivore population in Central Europe: genetic evaluation of lynx reintroduction in the Harz Mountains. Conservation Genetics 21, 577–587. Published online 7 April 2020.

Premier J., Kramer-Schadt S., Fickel J. & Heurich M. 2021. Effects of fragmentation and connectivity of lynx habitats on population genetics in continental Europe and long-term management perspectives. Cat News Special Issue 14, 57–59.

Reinhardt I., Kaczensky P., Knauer F., Rauer G., Kluth G., Wölfl S., Huckschlag D. & Wotschikowsky U. 2015. Monitoring von Wolf, Luchs und Bär in Deutschland. 2., überarbeitete Version. BfN-Skripten 413. Bundesamt für Naturschutz, Bonn, Germany, 94 pp.

Ryser-Degiorgis M.-P., Meli M. L., Breitenmoser-Würsten Ch., Hofmann-Lehmann R., Marti I. A., Pisano S. R. R. & Breitenmoser U. 2021. Health surveillance as an important tool in wild felid conservation: experiences with the Eurasian lynx in Switzerland. Cat News Special Issue 14, 64–75.

Schnidrig R., Nienhuis C., Imhof R., Bürki R. & Breitenmoser U. (Eds) 2016. Lynx in the Alps: Recommendations for an internationally coordinated management. RowAlps Report Objective 3. KORA Bericht Nr. 71. KORA, Muri bei Bern, Switzerland, and BAFU, Ittigen, Switzerland, 70 pp.

von Arx M. 2018. *Lynx lynx* (errata version published in 2019). The IUCN Red List of Threatened Species 2018: https://www.iucnredlist.org/species/12519/145266191 (downloaded on 18 July 2019).

von Arx M., Breitenmoser-Würsten Ch., Zimmermann F. & Breitenmoser U. 2004. Status and conservation of the Eurasian lynx (*Lynx lynx*) in Europe in 2001. KORA Bericht Nr. 19, Muri b. Bern, Switzerland, 330 pp.

von Arx M., Kaczensky P., Linnell J., Lanz T., Breitenmoser-Würsten Ch., Breitenmoser U., Boitani L. & Contributors. 2021. Conservation Status of the Eurasian lynx in West and Central Europe. Cat News Special Issue 14, 5–8.

Wölfl M., Bufka L., Cerveny J., Koubek P., Heurich M., Habel H., Huber T. & Poost W. 2001. Distribution and status of lynx in the border region between Czech Republic, Germany and Austria. Acta theriologica 46, 181–194.

Wölfl M., Wölfl S., Mináriková T., Weingarth K., Gerngross P., Engleder T., … & Klose M. 2021. Favourable conservation status and population level management – the Bohemian-Bavarian-Austrian lynx population as a case study. Cat News Special Issue 14, 53–54.

Zimmermann F. 2019. Monitoring von grossen Beutegreifern. *In* Wolf, Luchs und Bär in der Kulturlandschaft. Heurich M. (Ed.). Ulmer, Stuttgart, Germany, pp. 165–200.

Zimmermann F. & Foresti D. 2016. Capture-recapture methods for density estimations. *In* Camera trapping for Wildlife Research. Rovero F. & Zimmermann F. (Eds). Pelagic Publishing, Exeter, UK, pp. 95–141.

[1] For the members of the Bonn lynx expert group see Appendix I