1. Introduction

Even though the Eurasian lynx is not endangered over its entire range, some local populations are, nevertheless, under threat. In Western and Central Europe, the Eurasian lynx is still occurring in several isolated populations with limited genetic exchange (Chapron et al. 2014). Therefore, future reintroduction or reinforcement projects are required to create viable lynx metapopulations. It is important that these projects are carried out in a coordinated manner and that the Eurasian lynx is managed in a metapopulation context. The following guidelines are meant for conservation practitioners planning reintroduction and reinforcement projects in Western and Central Europe and for ex situ managers involved in breeding lynx for translocations. They provide standards for capture, transport, quarantine, rehabilitation, captive breeding, genetic management and veterinary care and assessment. The guidelines consist of 4 sections:

- Section 1: Introduction
- Section 2: In-Situ Management of Eurasian lynx
- Section 3: Ex-situ Management of Eurasian lynx
- Section 4: Appendices

1.1 Biology

Author: Christine Breitenmoser-Würsten
Reviewer: Markus Port

This section provides a very brief overview of some of the biological characteristics of the species. A comprehensive monograph is available in German “Der Luchs. Ein Grossraubtier in der Kulturlandschaft” (Breitenmoser & Breitenmoser-Würsten 2008). A summary of lynx biology is included also in the report “50 years of lynx in Switzerland” (KORA Foundation 2021, also available in German). Moreover, the chapter on Eurasian lynx of the new “Handbook of the Mammals of Europe” will be available soon (Breitenmoser & Breitenmoser-Würsten, in press).

1.1.1 Habitat

Forests are the preferred habitat for Eurasian lynx, and the species is often seen as a symbol for the conservation of large, contiguous forest areas. However, in recent decades it has become clear that the lynx can also adapt very well to cultural landscapes of Central Europe, using both highly fragmented forests and more open areas (Filla et al. 2017, Nagl et al. 2022). In Switzerland, for instance, lynx are now found not only in the Alps and the Jura, but also increasingly on the Swiss Plateau, which is densely settled and heavily influenced by human activities (Zimmermann & von Arx 2021). It is quite surprising that these animals live, almost completely unnoticed, in our vicinity. Various studies have shown that lynx use heavily human-dominated landscapes mainly at night and retreat to undisturbed places during the day (Filla et al. 2017, Gehr et al. 2017).

Male lynx can disperse considerable distances in their second year of life and cross unsuitable habitats or barriers such as large rivers or traffic infrastructure (rail roads, highways), whereas female lynx tend to remain in their population of origin (female philopatry) and rarely cross strong barriers. Therefore, lynx population expansion is much more conservative than expected from the potential dispersal capacity and compared to other large carnivores such as the wolf (*Canis lupus*). An

explanation may be that lynx population expansion generally happens along the edges of the resident population. This is one of the reasons why the reintroduced populations in Europe are still isolated as only males settle new areas.

1.1.2. Social system and behaviour

Lynx are solitary and resident (permanently established) animals defend their territories against other individuals of the same sex, so that their home ranges overlap only at the periphery. In contrast, home ranges of males and females overlap considerably, with the male's territory usually encompassing those of one to three females (Breitenmoser & Breitenmoser-Würsten 2008). The size of a lynx home range depends mainly on the availability of prey (Herfindal et al. 2005). In the Alps, it averages 169–363 km^2 for males and 100–165 km^2 for females, depending on the time period (Breitenmoser et al. 2016). In the Jura, males occupy on average 283 km^2 and females 185 km^2 (Breitenmoser-Würsten et al. 2007a). As lynx rarely meet, they communicate mainly by scent marks, which they leave by rubbing their heads and urinating on conspicuous objects (e.g., stumps, rocks, or woodpiles). These scent marks allow them to signal their claim over a territory, but also to communicate with opposite sex individuals in their vicinity (Vogt et al. 2014). The mating season of the lynx takes place from mid-February to mid-April. During this time, both sexes leave urine marks more frequently than during the rest of the year, and attract attention at night with loud calls (a high-pitched "aooh" similar to that of the fox). Most females breed for the first time at the age of two, males at the age of three years. After a gestation period of 67 to 72 days, a litter of 1 to 4 young (two on average) is born between mid-May and early June (Breitenmoser-Würsten et al. 2001, Breitenmoser-Würsten et al. 2007b). The young lynx remain with their mothers until the breeding season in March/April of the following year, when their mothers leave them. They usually continue to stay for some time in their mother's home range before moving out to find their own territory (Zimmermann et al. 2005).

1.1.3. Activity

Lynx show an activity peak around dawn and dusk (Heurich et al. 2014), but can be found active throughout the day. They rest mainly around midday and midnight using rock ledges, roots of fallen trees or low branches as well as hollow tree stumps (Breitenmoser & Breitenmoser-Wuersten 2008).

1.1.4. Hunting and preferred prey

Lynx are ambush hunters, they stalk and approach their prey to within a few metres without pursuing it over long distances. If the lynx manages to jump on an ungulate and grab it with its front paws, it kills its victim with a targeted bite to the throat. Contrary to popular belief, lynx do not jump from trees, but benefits from the cover provided by dense undergrowth, rocks, or mounds. When hunting, lynx rely on the element of surprise - if they are spotted by the prey too early, the hunting effort will be in vain (Vogt & Ryser 2017).

In most parts of Europe where the two species co-exist, roe deer are the preferred prey of lynx (Herfindal et al. 2005). Depending on the area, other ungulates (e.g., red deer, reindeer, Alpine chamois or domestic sheep; Jobin et al. 2000, Mattisson et al. 2013, Odden et al. 2013, Belotti et al. 2014) or smaller mammals (e.g., foxes, hares, marmots or dormice; Krofel et al. 2011, Vogt & Ryser 2017) may also be predated.

After killing its prey, the lynx feeds on it until all the meat is consumed. If it is a large ungulate, it may

take three to seven nights to consume (Jobin et al. 2000, Vimercati 2014). During the day, the lynx typically stays in the immediate vicinity of its kill and only moves a few hundred metres away. A typical lynx kill can be recognised by the targeted throat bite, with heavy hematomas under the skin but little injuries visible from the outside. A lynx kill can also be recognised by the way it is consumed: lynx usually start feeding at the hind legs, the bones are cleaned and the skin turned inside-out to reach the last pieces of meat. The digestive tract and large bones are usually not consumed. Carcasses are often covered with grass, leaves or snow to protect them from scavenging birds, mammals, and insects (Teurlings et al. 2020). Lynx also usually leave the carcass in one piece and do not separate body parts (Molinari et al. 2022, Vogt & Ryser 2017). When the lynx has finished with its prey, scavengers such as foxes or corvids eat what is left; foxes in particular often take parts of the carcass and bring it to another location, so that only hair and stomach contents remain at the original site (Molinari et al. 2022).

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1.2. Perspective of the metapopulation of Carpathian lynx

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Reviewers: Markus Port, Kristina Vogt

Europe is home to three genetically well-defined subspecies of Eurasian lynx recognised by the International Union for Conservation of Nature Species Survival Commission (IUCN SSC) Cat Specialist Group:

- *L. l. lynx* in the northern Europe
- *L. l. carpathicus* in East and Central Europe, inhabiting the Carpathian Mountains
- *L. l. balcanicus* in the south-western Balkans (Figure 1.2.1).

All subspecies are protected under the Bern Convention and the EU Habitats Directive, except for *L. l. lynx* in Estonia, Finland and Latvia (Bonn Lynx Expert Group 2021a). The first assessment of the Eurasian lynx *Lynx lynx* across Europe was initiated by IUCN and WWF International in 1962 (Kratochvíl et al. 1968a, b, Bonn Lynx Expert Group 2021a). In the early 1970s, reintroduction programmes started in Western and Central Europe. 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). Later on, a number of pan-European and transboundary conservation assessments and strategies were developed:

- 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).

These conservation plans showed that there is a need for further conservation efforts in all autochthonous and reintroduced populations in Western and Central Europe (Bonn Lynx Expert Group 2021a; Fig. 1.2.1). In June 2019, 53 lynx experts met in Bonn to review and discuss the present status and the future of the Eurasian lynx in Continental Europe (Bonn Lynx Expert Group 2021b). The Bonn lynx expert group formulated recommendations to help coordinate the conservation of the Eurasian lynx in Western and Central Europe. These recommendations were adopted by the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) of the Council of Europe in 2019 (Bonn Lynx Expert Group 2021a).

According to the IUCN Guidelines for Reintroductions and other Conservation Translocations (IUCN/SSC 2013), and also according to EU and/or national legislation, reintroduction and reinforcement projects require the identification of an adequate source population, and veterinary health precautions to prevent the transmission of pathogens when conducting translocations of animals (Breitenmoser et al. 2021). At the international lynx expert conference in Bonn, to help define those source populations, reintroduction and conservation regions of the three subspecies of continental Europe (corresponding to Evolutionarily Significant Units) have been delineated (Fig. 1.2.1):

- Northern lynx *L. l. lynx*: northern and north-eastern Europe, Baltic States and lowlands of northern continental Europe
- Carpathian lynx *L. l. carpathicus*: Carpathians, continental European low mountain ranges, Alps and northern Dinarides
- Balkan lynx *L. l. balcanicus*: Southern Dinarides and mountain ranges of the Southern Balkan Peninsula.

This geographical division is not intended to limit natural mixing through migration, it rather ensures that optimal starting conditions for a well-connected metapopulation are provided and possible outbreeding depression is prevented by using suitable lynx individuals for reintroduction and reinforcement projects in the corresponding region (Bonn Lynx Expert Group 2021a). The following guidelines are about the development of a conservation strategy and coordination of conservation efforts for the Carpathian lynx within the region designated in figure 1.2.1.

In 2021, three small to medium-sized autochthonous and eleven tiny to small reintroduced Carpathian lynx populations existed across Western and Central Europe (von Arx et al. 2021; Fig. 1.2.1). In recent years, efforts to connect these distinct populations were made and the number of ongoing and planned reintroduction and (genetic) reinforcement projects have increased (Bonn Lynx Expert Group 2021a, Breitenmoser et al. 2021).

For the most recent reintroductions, mainly animals from the autochthonous source population in the Carpathian Mountains (Slovakia, Romania) and from Switzerland have been used. While serving as sources, these populations have their own conservation issues. Population numbers in the Carpathian Mountains have been strongly overestimated leading to conflicts with human interests and ultimately to illegal killings. Further concerns are related to habitat quality and connectivity (Kubala et al. 2021). The lynx populations in Switzerland are themselves still too small and isolated for long-term viability and are in need of genetic remedy and better connectivity (Drouet-Hoguet et al. 2021, Molinari-Jobin et al. 2021). If taking animals from free-ranging populations, the removal of

these animals should not be detrimental to the source population (Bonn Lynx Expert Group 2021a). In this regard, conservation issues of (autochthonous) source populations need to be addressed in translocation and reintroduction programs to ensure that lynx can still be taken from source populations without harming them. Given the high demand from reintroduction projects expected for the near future, the possibility to include suitable (in terms of both genetics and behaviour) lynx individuals from the EAZA Ex situ Programme (EEP) and rehabilitated orphaned lynx into reintroduction and reinforcement projects should also be considered (see section *1.4 Lynx for reintroductions*; Lengger et al. 2021).

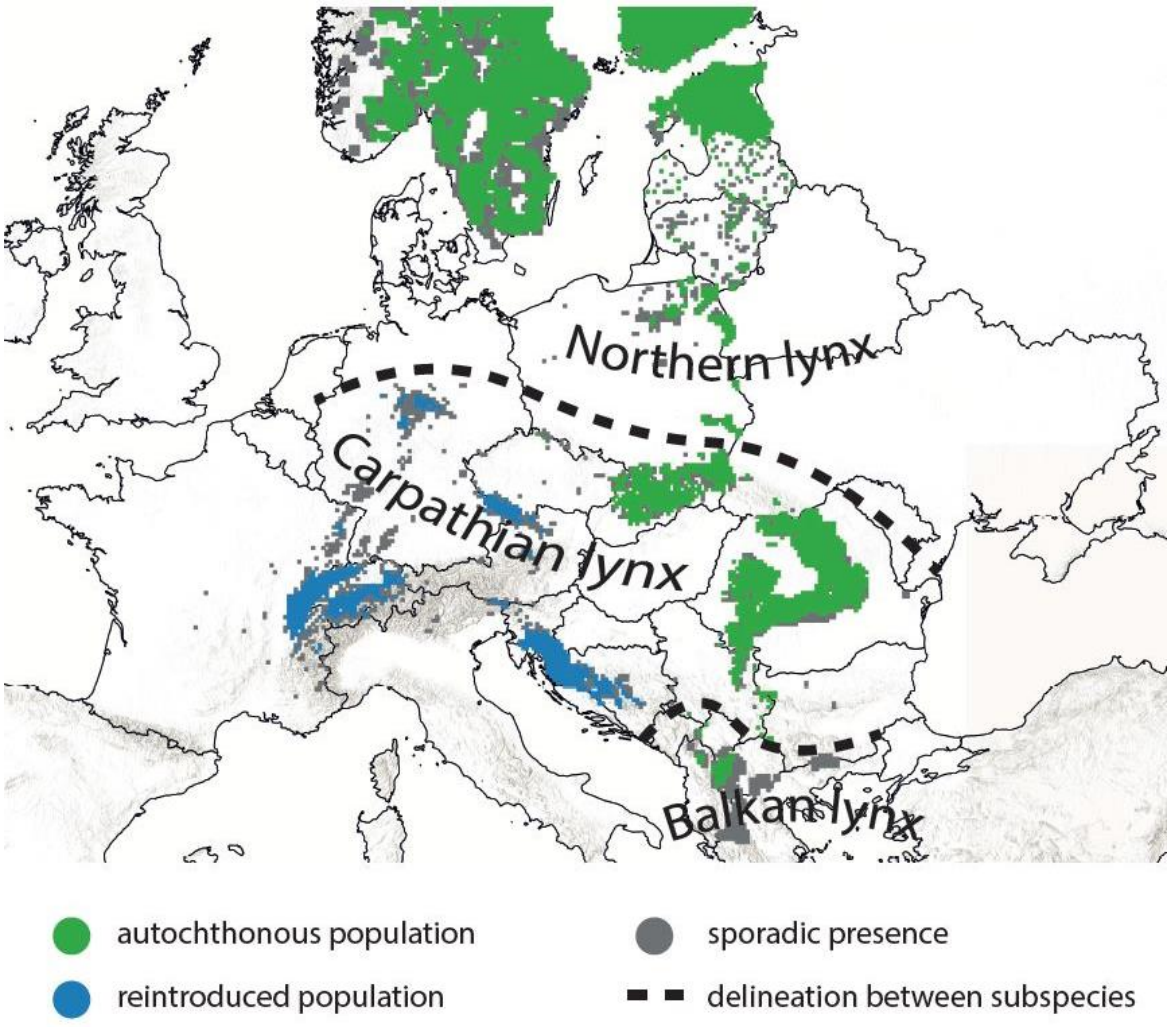

Fig. 1.2.1. Distribution of Eurasian lynx *Lynx lynx* in Europe 2012–2016 according to a LCIE survey (von Arx 2018). The dashed black lines represent the proposed delineation across Continental Europe for the conservation and reintroduction of the three Eurasian lynx subspecies (according to Bonn Lynx Expert Group 2021a).

Several challenges arise regarding the conservation of a Carpathian lynx metapopulation in Western and Central Europe. Most lynx populations across Europe are currently small and isolated, mainly caused by habitat fragmentation due to natural and artificial barriers and the fact that lynx are bad colonizers (philopatric females). Another challenge is the current high inbreeding in many of the

Carpathian lynx subpopulations due to the use of few founder animals for previous reintroductions, the effects of genetic drift (slow population growth) and low connectivity between neighbouring populations (Fig. 1.2.2).

Only the populations inhabiting the major mountain ranges (e.g., Carpathians, Alps or Dinarides) are considered to be (or have the potential to become) viable over the long term but none of the other populations, as long as they remain isolated (Bonn Lynx Expert Group 2021a). Therefore, and due to the increasing number of conservation projects for the Carpathian lynx, there is a need for:

- more cooperation and coordination on the conservation and management of the Carpathian lynx, including common guidelines and protocols (e.g., for breeding, husbandry, and assessment of zoo-born lynx, for the rehabilitation of orphaned lynx, for genetic and health monitoring, for captures, clinical examination, quarantine and transport etc.);
- a metapopulation-approach, including an assisted metapopulation management, a system for assessing and exchanging animals between reintroduced and other genetically deprived (sub)populations and
- a transboundary cooperation to maintain demographically and genetically viable lynx populations (Bonn Lynx Expert Group 2021a).

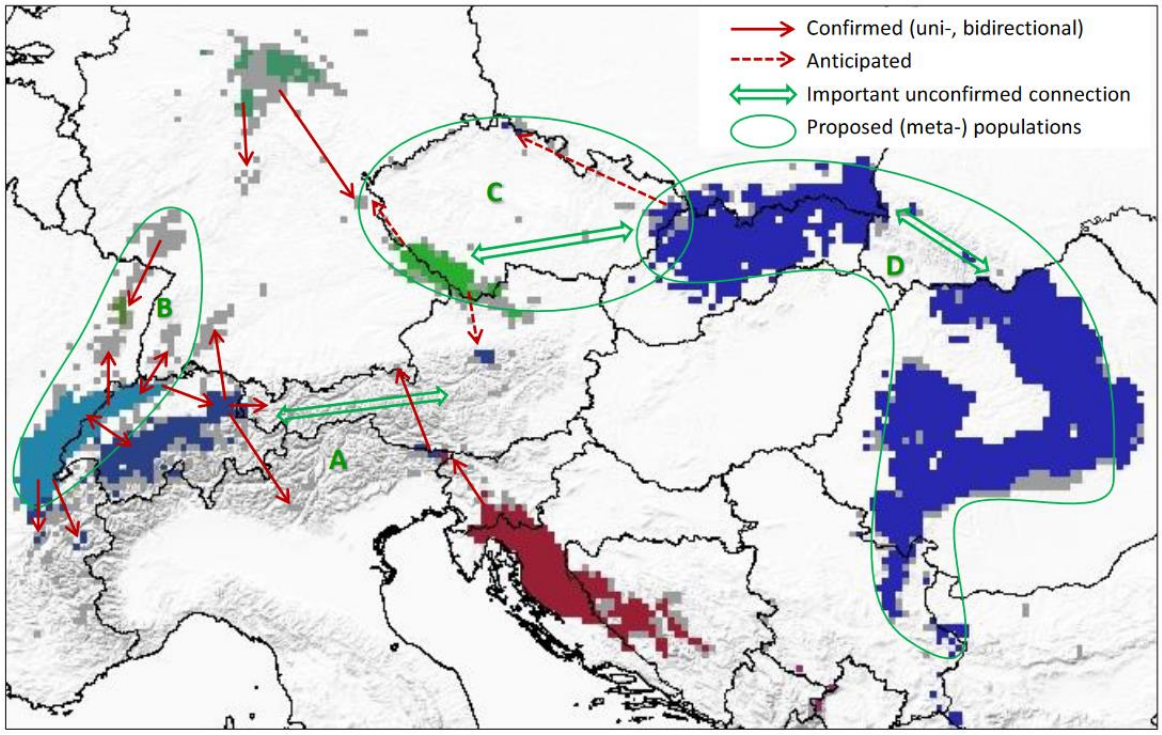

Fig. 1.2.2. Distribution of the Carpathian lynx *L. l. carpathicus* in Continental Europe 2012–2016 (colours = populations), confirmed (radio-telemetry, camera trapping, or genetics), or anticipated movements of lynx between populations (arrows), unconfirmed, but potentially important connections, and proposed (meta-) populations (polygons A–D) to be conserved and managed as larger units. Adapted from Bonn Lynx Expert Group (2021a). Note that the Harz population is largely of non-Carpathian origin.

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1.3. Background on Linking Lynx

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During the lynx conservation meeting in Bonn 2019, it was agreed that regular follow-up meetings should take place and that several working groups covering different conservation topics should be established, namely:

1) the **Sourcing Working Group** aiming to coordinate the use of lynx from different sources (wild captures, orphaned lynx, ex-situ bred lynx) for translocation projects;

2) the **Genetics Working Group** working on transboundary genetic monitoring and genetic assessment of lynx from all sources;

3) the **Health Working Group** collaborating on veterinary aspects of sourcing lynx and on wildlife disease;

4) the **Monitoring Working Group** aiming to produce a harmonized distribution map for the realm of the Carpathian lynx and to discuss technical and methodological standards;

5) the **Policy Working Group** serving as the link between the expert network and policy makers;

and 6) the **Engaging with People Working Group** aiming to foster exchange of best practice examples and formulate guidelines for public engagement.

These working groups started to form in the years following the Bonn meeting. The first to start operating in 2021 were the Genetics (CElynx consortium) and the Sourcing Working Group. The founders of the Sourcing Working Group agreed on a Memorandum of Understanding for sourcing ex-situ lynx for reintroductions (Appendix I).

The recommendations formulated by the Bonn Lynx Expert Group in 2019 were subsequently adopted by the Standing Committee of the Bern Convention as recommendation No. 204 (Council of Europe 2019). Recommendation No. 204 asks for the creation of a permanent Eurasian Lynx Working Group. During the next follow-up meeting in the Harz Mountains in 2023, lynx experts working on Carpathian lynx conservation met again and formed the “Linking Lynx - Carpathian Lynx Working Group”. It was agreed during the Harz meeting that the Linking Lynx group will take on the role of a permanent working group within the realm of the Carpathian lynx (Fig. 1.2.1) as foreseen by recommendation No. 204. The working groups 3) – 6) were formed during the Harz meeting and Linking Lynx now unites all working groups outlined above, as well as planned and ongoing reintroduction and reinforcement projects. A steering committee – consisting of the coordinators of each working group and an overall Linking Lynx coordinator – is responsible for the organisation of regular meetings and the establishment of a common website and information platform. The following guidelines have been developed by the Sourcing Working Group in cooperation with the Genetics and Health Working Groups.

1.3.1. Aim and Objectives of Linking Lynx

The long-term goal of the Linking Lynx network is to achieve a functionally, demographically and genetically viable metapopulation of Carpathian lynx spanning from the Carpathian Mountains to the Jura and Western Alps, including the German low mountain ranges. In order to achieve this long-term goal, a transboundary conservation strategy for the lynx in the Carpathian Mountains, further reintroductions to create stepping-stone populations between already existing populations and (genetic) reinforcement of genetically impoverished populations are needed. To meet the demand for lynx needed for these activities in the next decade, while avoiding over-exploitation of the wild source populations, cooperation between the ex-situ breeding program and the in-situ projects is crucial.

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1.4. Lynx for reintroductions: three sources

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Reviewer: Christian Stauffer

Lynx individuals for reintroduction or reinforcement projects can originate from three different sources: 1) translocations from wild source populations; 2) release of suitable animals from the captive breeding program; 3) rehabilitation of orphaned lynx. Each of these sources have advantages and disadvantages. Wild-caught adult lynx are animals who have proven their capacity to successfully survive in nature and may already have reproduced. However, wild captures come with a large field effort, planning uncertainty and, depending on the choice of trapping system (see chapter *2.4 Capture and transport*), can be male-biased. They have to be accompanied with monitoring programs to evaluate the impact on source populations (IUCN/SSC 2013).

Ex-situ lynx can adapt to living in the wild and have been successfully used for reintroductions in the past (e.g., Mueller et al. 2020). The Bonn Lynx Expert Group (2021) has, therefore, considered captive-born individuals, particularly those listed in the EAZA Ex situ Programme (EEP) for the Carpathian lynx, as a source for reintroductions and reinforcement (Lengger et al. 2021). Their use provides more certainty for planning without the risk of harming wild source populations. However, the genetic and behavioural suitability of captive-bred lynx has not always been properly evaluated in previous reintroduction projects. Releasing zoo-born lynx to the wild can also cause a certain scepticism and safety concerns among stakeholders or local communities who may question the suitability of these animals for a life in the wild. Therefore, a thorough evaluation of each individual is crucial.

The rehabilitation of orphaned lynx who have lost their mother and are still too young to survive on their own ideally combines animal welfare with conservation objectives. Orphaned lynx have been successfully used for reintroduction projects (e.g., Idelberger et al. 2021) and their translocation has a lower impact on the source population than the removal of adult reproductive individuals. However, a thorough health assessment is necessary for these individuals, since many of them are in bad condition and a certain proportion of them is not viable. Combining lynx from different sources can be the optimal strategy for reintroduction and reinforcement projects. The Linking Lynx Sourcing Working Group aims to coordinate the demand from in-situ projects with the availability of lynx from all three different sources.

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