Preventing the extinction of the Dinaric-SE Alpine lynx population through reinforcement and long-term conservation

LIFE16 NAT/SI/000634

COMMON GUIDELINES FOR

DINARIC – SE ALPINE POPULATION - LEVEL LYNX MANAGEMENT

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Editor: Sindičić Magda

May 2022

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DINARIC - SE-ALPINE LYNX POPULATION

BASIC HISTORICAL OVERVIEW

The Eurasian lynx (*Lynx lynx*) is a species with wide ecological tolerance. This has manifested itself in the past in a vast distribution inhabiting all types of forests, including some of Europe's non-forested environments, from Scandinavia to the Mediterranean and the Black Sea (Kratochvil, 1968; Matjushkin, 1978). Lynx inhabited most areas of the Western and Central Europe until the early 19th century (Kratochvil, 1968).

In 20th century, lynx started to disappear from the continental Europe with the most important causes being changes in the environment and persecution by humans (Kratochvil and Vala, 1968). While lynx persecution started in the early 15th century, the consequences became grave only at the beginning of the 20th century. Moreover, the widespread persecution of lynx in Europe was coupled with the loss of habitat and decrease in prey availability during the World Wars I and II. The number of large ungulates, primarily roe deer, dropped dramatically in many areas of Europe (Breitenmoser 1998), with some seeing a complete extinction of roe deer and wild boar. The lynx distribution in central Europe became fragmented and distances between individual populations increased, leading to shrinking of the persisting populations and rendering lynx more vulnerable to the unfavourable environmental and demographic factors. In the early 20th century, lynx disappeared from all over Western and Central Europe, with the exception of the Carpathians. The lynx population of the Balkan Peninsula survived only in the Šarsko - Pindsko Mountains. Where it persisted, lynx survived primarily in mountainous and scarcely inhabited regions.

The last specimens of the indigenous Balkan lynx (*Lynx lynx balcanicus*) were recorded in Croatia in 1903 (KORITNIK, 1974), Slovenia (Kos, 1928) and Serbia in 1908, Bosnia and

Herzegovina in 1911, and Montenegro in 1913 (Majić, 2004) while it survived up to this day only in isolated areas of Albania, Macedonia, Kosovo and Montenegro (Von Arx et al., 2004).

In the late 20th century, lynx reintroduction programs were initiated in different areas in Europe, including Slovenia. Three male and three female lynx were reintroduced by hunters to Kočevje area in 1973 with the primary aim to bring back an autochthonous apex predator (Čop 1972, Čop 1994). Already in the first year, three females reproduced and the number of lynx continued to increase in subsequent years, spreading to Croatia, the western part of Bosnia and Herzegovina and Italian Julian Alps when first lynx were recorded in 1974 (Frković 1998), 1980 (Sindičić et al. 2009) and 1989 (Molinari 1998), respectively. In the Alps, the reappearing lynx could have also been originating from the reintroduction in Austria (Molinari 1998). A fast population expansion was evident after the reintroduction in the Slovenian Dinaric Mountains and lynx became a hunted species with yearly hunting quotas in Slovenia and Croatia (Čop and Frković 1998).

The positive trend in population development was noticed until 1990s (Staniša et al. 2001, Koren et al. 2006) when the trend reversed and a rapid decline was observed in Slovenia (Kos et al. 2012), Croatia (Sindičić et al. 2016) and Italy (Molinari-Jobin et al. 2018) in the new millennia. The hunting stopped and the lynx gained full protection in 1998 in Croatia, 2004 in Slovenia and 2009 in BiH (Fležar et al. 2021, see next chapter for details on legislation today). After 2009, when no lynx mortality was recorded in Slovenia and the records in Croatia drastically decreased (Sindičić et al. 2016), it became generally accepted that the lynx population in the Dinarics is far from stable. Apart from hunting bags however, there was only limited amount of opportunistic data available about the lynx occurrence in the Dinarics and the SE Alps, with a lack of coordinated national or international monitoring programme until the start of the LIFE Lynx project (Fležar et al. 2019, Slijepčević et al. 2019). The main causes for declining numbers were considered to be human-caused mortality and a loss of genetic diversity due to inbreeding (Sindičić et al., 2010, Sindičić et al. 2013). The need for genetic remedy for the Dinaric population was advocated since the poor genetic status was described in 2010, but before the start of the LIFE Lynx project, no actions were undertaken to prevent further inbreeding of the lynx in the Dinarics. In SE Alps however, a small scale reinforcement

project “ULyCA” aiming at saving the local population from extinction (Molinari-Jobin et al. 2018) was initiated in 2012, however managed to translocate only 2 out of 3 animals from the Jura Mountains before the project was halted due to political opposition (Molinari et al. 2021). Today, there is limited evidence that lynx still persists in the Italian SE Alps however, with a successful establishment of a population stepping stone in the Slovenian SE Alps we expect the situation to change.

INTERNATIONAL AND NATIONAL LEGISLATION

Eurasian lynx is protected under international nature conservation law; the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1979). The objective of the Convention is to conserve wild flora and fauna and their natural habitats. Eurasian Lynx is listed under Appendix III within which species are protected and their exploitation is regulated in accordance with the Convention. Any exploitation of wild fauna shall be regulated with different measures for example closed seasons, temporary or local prohibition of exploitation, sales regulations, in order to keep the populations out of danger.

The Habitats Directive (Council Directive No. 92/43/EEC. 1992) protects a wide range of endangered, vulnerable, threatened rare or endemic species. Lynx is covered by annex II (establishment of special areas of conservations known as Natura 2000 sites which are managed with the ecological needs of the species) and Annex IV (strict protection regime covers the entire natural range of species within and outside Natura 2000 sites).

The Eurasian lynx is classified as *Least Concern* on the IUCN red list of Threatened species due to its wide range and stable populations in north and east Europe, although recent assessment revealed that some isolated subpopulations remain *Critically Endangered* such as Lynx lynx ssp. balcanicus.

The Convention on Biological Diversity (CBD), known also as the Biodiversity Convention, is a multilateral treaty established as a response to biodiversity loss. It contains

three main objectives such as the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Eurasian lynx is listed in Appendix II of Convention on International Trade in Threatened Species of Wild Fauna and Flora (CITES - The Washington Convention) among species that are not necessarily now threatened with extinction but that may become so, if trade is not highly regulated and controlled. International trade with species listed on Appendix II is allowed under strict rules (permits, certificates). With Council Regulation (EC) No 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by regulating trade therein the European Union has put forward even stricter measures. Within the European Union Eurasian lynx is considered as Annex II and IV species, which list species that are either threatened with extinction or so rare that any level of trade would imperil the survival of the species or listing in the Annex is essential for the effective protection of those taxa. Although in the case of translocations and releases of specimens for reintroduction or reinforcements of small populations within the EU, CITES permissions are not needed.

The Large Carnivore Initiative for Europe (LCIE) is a working group of the IUCN Commission on the Conservation of Species. Main objective is to maintain and restore viable populations of large carnivores and coexistence with humans. The Pan-Alpine Conservation Strategy for the Lynx (PACS, Molinari-Jobin et al. 2003) has the very important goal to connect isolated populations from Switzerland and Slovenia with translocations in Austria, Germany, Italy, and Liechtenstein, and later on, establish a connection to the Dinaric, Bohemian-Bavarian-Austrian and Jura Mountains populations. The International treaty between Alpine Arc countries, also known as the Alpine Convention (1995), established the WISO platform (Wildlife and Society), which deals with large carnivores and wild ungulates. Among other issues, WISO has an initiative to counteract inbreeding in Alpine lynx subpopulation and to establish reinforcement. Recommendations for an internationally coordinated management for lynx in the Alps were prepared by WISO platform and KORA in 2016 (Schnidrig et al., 2016).

Lynx in Slovenia, Croatia and Italy are fully protected under the Habitat Directive and national legislation. In Slovenia, lynx is protected under different legislation including Nature

Conservation Act (ZON, 2004), Environment Protection Act (ZVO-1 2004), Hunting Act (ZDLov-1, 2004), Forest Act (ZG, 1993), Decree on special protection areas - Natura 2000 areas (2004) and Natura 2000 Management programme (2015), Decree on protected wild animal species (2004), Rules on the inclusion of endangered plant and animal species in the Red List (2002). In 2016, a Strategy of conservation and sustainable management was adopted. The last legally shot lynx in Slovenia was harvested in 2003. A quota was allowed in 2004, but was not realized. Since 2004, no culling of lynx has been allowed in Slovenia due to the endangered status and low number of animals.

In Italy, lynx is protected by hunting law (157/1992). In addition, there are the laws with which international regulations and conventions are implemented: the Law of 5 August 1981, n. 503 which acknowledges the Bern Convention, and the D.P.R. 8 September 1997 n. 357, transposing the Habitats Directive. Finally, the IUCN national red lists and the implementation of CITES are also adopted and operational.

In Croatia, lynx has been listed as strictly protected since 1995 Rulebook on the Protection of Certain Mammal Species (Mammalia), afterwards no hunting quotas were issued. The Nature Protection Law (2005, 2008, 2011, 2013) implements the obligations of Croatia arising from adopted international conventions and EU law. Based on the Population status report for 2011 and 2012, in 2013 national IUCN Red List category for lynx was changed from near threatened - NT to critically endangered - CR (D). A Lynx management plan for the Republic of Croatia has been implemented since 2004, and the last edition was for the 2010 - 2015 period.

CURRENT POPULATION STATUS - DISTRIBUTION AND SIZE

The lynx in the project area formally belong to two distinct subpopulations - the larger Dinaric and the smaller south-eastern Alpine subpopulation, however they are considered as one population since the SE Alps have been colonised by the reintroduced lynx (see chapter “Historical background” for details).

Currently the majority of Dinaric-SE Alpine lynx population is distributed throughout the NW Dinaric Mountains (Slovenia and Croatia), where several territories are occupied by lynx of both sexes and regular reproduction is observed. In the survey year 2020–21, a minimum of 24 adult lynx were present in Slovenian part of the Dinaric Mountains (Kočevska and Notranjska) and a minimum of 74 in Croatia (Gorski Kotar, Lika and northern Dalmatia), including animals recently translocated from the Carpathian population as part of the reinforcement efforts (Fležar et al. 2022). In Bosnia and Herzegovina, lynx are mainly distributed in the central and western part of the country however, no reliable estimate of population size is currently available (SCALP report 2018). Number of lynx in the Alpine and pre-Alpine part of the population is extremely low and lynx apparently disappeared from most of their formal distribution in this region. The presence of lynx was only confirmed in the pre-Alpine region (Hrušica and Trnovski gozd), where at least one animal was present (Fležar et al. 2022) while no confirmed records of presence of remnant lynx are currently available in the SE Alps, although some unconfirmed sightings were reported. In 2021, one of the translocated males from Romania briefly crossed the pre-Alpine and Alpine area, but afterwards returned to the Dinaric Mountains. In scope of LIFE Lynx project, we translocated five animals (3 females, 2 males) from Romania and Slovakia to the Slovenian Julian Alps in spring of 2021.

CURRENT POPULATION GENETIC STATUS

The Dinaric lynx population was founded by six reintroduced animals, some of which were related. The population remained isolated from other European populations which rapidly led to animals having to mate with relatives. The first genetic survey of the Dinaric lynx population (Sindičić et al. 2013) showed that the Dinaric SE Alpine lynx population had the lowest genetic diversity of all lynx populations studied so far. The average inbreeding coefficient exceeded 0.25, which is expected in a brother-sister mating.

After the reintroduction in 1973 the population had a relatively high effective population size, indicating population expansion however, it lost a considerable proportion of genetic diversity already through the reintroduction bottleneck. High genetic drift caused by

the small effective population size and limited number of unrelated mates immediately after the reintroduction caused rapid inbreeding, followed in-step by the related drop in heterozygosity. While it seems that the population was still doing well in the 1980s when inbreeding coefficient is estimated at Fe = 0.176, this parameter reached Fe = 0.192 by the 1990s. At this level of inbreeding, we can already expect a 68% drop in fitness (δ = 0.684) at the population level, relative to the source population in Slovak Carpathians. Although not yet evident from the field data, we suspect that inbreeding depression may have already started to have a pronounced effect on demography. By the 2000s, when field reports started indicating a decreasing lynx population, inbreeding already reached Fe = 0.26, meaning the Dinaric lynx were more inbred than offspring of a brother and a sister. The expected drop in fitness in this case is 80% and with inbreeding reaching F = 0.316 just before 2019, the expected drop in fitness was even higher (85%) (Skrbinšek et al., 2019).

The field data indicate that the Dinaric SE Alpine lynx population was going into the "extinction vortex" (Frankham et al. 2002) when it's difficult to predict when the population would go extinct without intervention. Therefore, we started with the population reinforcement project (LIFE Lynx) in 2019 and translocated 8 lynx from the Carpathians to the Dinarics until 2021. We also confirmed the first offspring of translocated and resident lynx (Fležar et al. 2022). The genetic status of the population under reinforcement was re-evaluated in 2020 to help us understand how the population is expected to develop if the translocated animals manage to successfully reproduce and include their genes into the population (Krofel et al. 2021). If the introduced animals and offspring formed 15% of the total population (Figure 1), the inbreeding coefficient would drop to 0.21. While this is still high, it is closer to the range we observed in the 1980s (around 0.18) when population still seemed viable (Skrbinšek et al. 2019).

In the next few years, a lot will depend on the reproductive performance of the translocated animals, so we have to continue monitoring the situation closely over the following years.

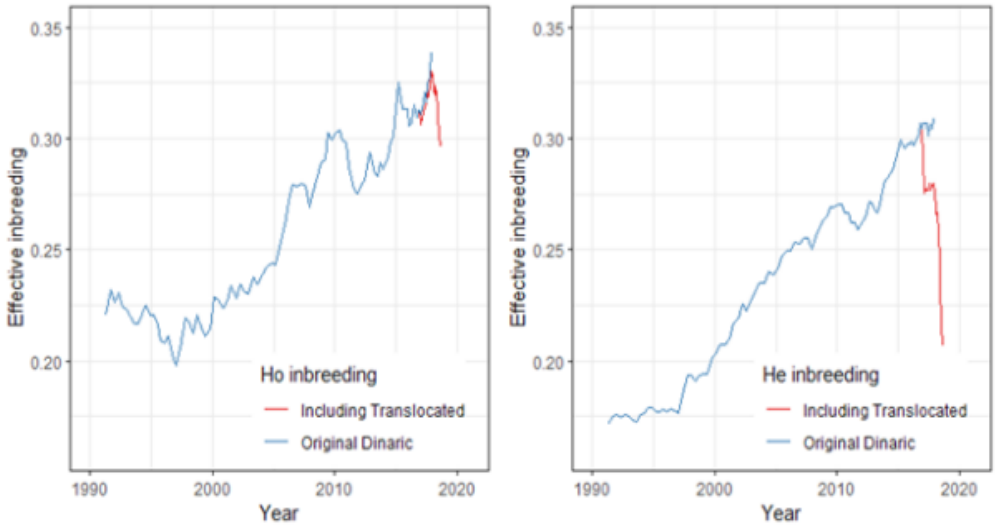

Figure 1. Effective inbreeding of Dinaric lynx relative to the source population in Slovak Carpathians, calculated from observed (left) or expected (right) heterozygosity, with and without including translocated animals and their offspring, calculated with 60-sample travelling window. Source: Skrbinšek et al. (2019)

HABITAT FRAGMENTATION AND CONNECTIVITY

Habitat loss and fragmentation as well as restoring and maintaining sufficient habitat connectivity is an important issue of modern conservation management of Eurasian lynx populations in human dominated landscapes of Europe. This is because habitat fragmentation can lead to population isolation, disrupting genetic and demographic connection in lynx populations, decrease the population's viability and make it more sensitive to demographic stochasticity and genetic deterioration. Habitat fragmentation also obstructs lynx movements, slowing population expansion and communication between local occurrences, thus decreasing the possibility of long-term survival of the species in the region and establishment of well-connected meta-populations.

One of the most radical anthropogenic changes to the landscape of Europe over the past centuries has been the creation of large scale urban and agricultural areas and subsequent extension of infrastructure networks. After more than 5000 years of intense human activities only 2% of original prime forest remains (Iuell et al. 2003).

Human influenced landscape changes through deforestation and expansion of cultivated land were one of the most important reasons why Eurasian lynx, once widespread throughout Europe, disappeared from Central and Southern Europe and many other parts of the continent during the 18th and 19th centuries (Breitenmoser 1998, Schadt et al. 2002, Zimmermann 2003, Potočnik et al. 2009). Eurasian lynx survived in isolated populations in the most remote mountainous part of the continent. After the Industrial revolution and associated socioeconomic changes at the end of the nineteenth century, abandoning of cultivated lands in many mountainous regions of Europe started the process of reforestation of these areas (Breitenmoser 1998, Zimmermann 2004). The improvement of habitats as well as protective legislation led to the increase of the remaining lynx populations, as well as other large carnivores and prey species (Apollonio et al. 2010). However natural recolonization of new habitats for lynx was importantly hindered by still existing barriers for lynx movement. Nowadays the most important barriers for lynx movement include densely continuously populated (urban) areas, intensive agricultural lands and transport infrastructure. Fenced highways are an especially important barrier, as many researches show that the majority of lynx individuals, especially females, have difficulties crossing them (Zimmermann et al. 2007, Potočnik et al. 2020). Most of today's existing lynx populations are therefore a result of successful reintroduction and translocation projects (Zimmermann et al. 2007, Potočnik et al. 2020).

HUMAN DIMENSIONS

The range of large carnivores mostly extends beyond protected areas, or they represent only a small part of the range of large carnivores (Linnell et al. 2001; Santini et al. 2016). Therefore, their persistence depends on successful coexistence with humans

(Reinhardt et al. 2019), but involving the public or various interest groups in the management of large carnivores has been a rarity in Europe in the past. Decisions were usually made at the level of management bodies or with the help of experts, including decisions on resettlement in areas where these species had previously been exterminated. With the development of the sociological sciences, various interest groups began to be systematically involved in the management of protected species in a participatory manner.

An interest group is a group of people or an organization that has an interest or concern in lynx management. Interest groups can influence or be influenced by lynx management decisions, objectives and policies. Some examples of key interest groups in lynx management are local public, livestock breeders, hunters, environmentalists, experts, forest workers, recreationalists, tourists, urban public, etc. Since low acceptance by individual stakeholder groups significantly influence the conservation of large carnivores (Boitani et al. 2015), not all interest groups are equally important. Urban inhabitants express more favourable attitudes towards large carnivores, also lynx, than rural, which may be due to the lack of direct or indirect negative experiences with the species (e.g. perceived or actual conflicts). Since local people face the issues regarding large carnivores on a daily basis, the importance of this interest group should not be neglected or equated with the aforementioned urban public. However, direct experiences with the species or indirectly by observing and experiencing their habitat, can foster a positive attitude towards lynx. Due to the species tendency to avoid humans, it is very difficult to observe lynx in nature, even in areas where their density is higher. A smaller number of interactions also means less opportunities for the local population to gain positive experience with the species. Attitudes toward lynx may not vary just among stakeholder groups, but also among different countries. So far implemented public opinion surveys among randomly selected residents of Croatia, Italy and Slovenia, including also the stakeholder groups of hunters and livestock breeders, highlighted the favourable attitudes to lynx and support of its conservation in all three countries (Bele et al. 2022, Majić Skrbinšek et al. 2020). Additionally, prevalent support for increasing the lynx abundance was documented among respondents from the general public and stakeholder group of hunters (but not livestock breeders) in all three countries. Besides, the opposition to hunting lynx was also detected among all the respondents.

The surveys' results (Bele at al. 2022, Majić Skrbinšek et al. 2020) also showed that livestock breeders and especially hunters seem to be much more familiar with the causes of lynx population deterioration than the general public. General public respondents identified overharvesting and poaching as the main cause, while hunters and livestock breeders primarily ranked inbreeding as the main cause for the recent deterioration of the lynx population.

For successful lynx translocations and long-term conservation, positive attitudes towards the species are crucial. In accordance with the surveys' (Bele et al. 2022, Majić Skrbinšek et al. 2020), the general public in all three countries supports population reinforcement. Opposition to bringing new lynx to this cross-national area (Slovenia/Croatia/Italy) was documented primarily among livestock breeders.

Despite the fact that lynx belongs to the least damage-causing large carnivore species (Breitenmoser et al. 2000), there are concerns that increased lynx abundance, increased local densities and species' spatial expansion could result in more damages. Damages caused by lynx in all three countries have been close to non-existing over the last decade (see the chapter Livestock protection). General public and hunters seem to be aware of this, while close to 30% of livestock breeders thought that lynx causes unacceptable damage to domestic animals in their respective country (Bele et al. 2022, Majić Skrbinšek et al. 2020). This indicates a tendency of generalising the experiences with other far more conflicting large carnivores – wolves and bears - or in other words, to the farmer, it is not important which large carnivore species is causing the damage.

The fact that lynx prey primarily on roe deer is often mentioned as a cause of lynx being disliked by hunters in Europe (Breitenmoser et al., 2010). According to the results of the surveys' carried out in Dinaric-SE Alpine region (Bele et al. 2022, Majić Skrbinšek et al. 2020), a large majority of hunters acknowledged the role of lynx in regulating roe deer numbers. In addition, close to 30% of hunters thought that the presence of lynx reduces their opportunities to hunt ungulates, confirming the existence of the concerns.

To better inform the public, especially local residents and stakeholder groups about the species, increase their knowledge and foster favourable attitudes remains one of the key missions to maintain public support for population reinforcement and species long-term conservation.

THREATS AND CONFLICTS

INBREEDING DEPRESSION

Inbreeding depression is a decline in reproductive fitness of populations and is caused by mating of individuals related by ancestry. In small isolated populations inbreeding depression represents a considerable threat to long term population survival and has consequences on all aspects of reproduction and survival of an inbred population (Frankham et al. 2002). According to the population development modelling, without the translocations done in the LIFE Lynx project, the Dinaric - SE Alpine population could go completely extinct in approximately 28 years from the year 2017 when genetic monitoring was conducted (Pazhenkova, Skrbinšek, 2021). Even though genetic rescue of Dinaric - SE Alpine population is one of the main purposes of the LIFE Lynx project, the success of this undertaking will depend on the reproductive performance of the translocated animals and their offspring. Furthermore, inbreeding depression can be aggravated by increasingly fragmented habitats along with the lynx' poor dispersal capacity. The same could happen to the proposed "stepping stone" if they become disconnected from the main population in the Dinaric or they fail to establish connection to other European lynx populations.

Even if none of the above mentioned threats materialise the population might remain small and isolated, and might as such continue to inbreed. The population development model produced in the scope of the LIFE Lynx project, shows that translocations significantly delayed the fatal decrease of population genetic diversity and inbreeding. For 28 years after translocations the inbreeding level stayed below the 0.15 threshold. However, after 45 years the inbreeding level exceeded 0.25 threshold, which is equal to the full-sib mating and considered a critical threshold for immediate action (Pazhenkova, Skrbinšek, 2021).

HABITAT FRAGMENTATION AND CONNECTIVITY

One of the biggest threats to the Dinaric - SE Alpine lynx population is the lack of sufficient landscape connectivity between Dinarics and southeastern Alps. Almost five decades after the reintroduction of the Dinaric - SE Alpine lynx population, it is evident that the lynx dispersal and recolonization was more successful towards southeast, along the Dinaric Mountains in Croatia and Bosnia and Herzegovina (BiH), than toward northwest, into the southeastern Alps in Slovenia, Austria and Italy. For example, the maximum distance of recorded area of presence of lynx in BiH from the release site in Slovenia is around 390 km, while from the northwest (NE Italy) is around 140 km. This is mainly because of the Ljubljana – Trieste highway in Slovenia, which is the most important barrier for lynx movement between Dinarics and southeastern Alps. This is supported with considerable evidences from telemetry studies, proving its negative effect on the connectivity between Dinaric and Alpine parts of the population.

Another threat for the long-term survival of the Dinaric - SE Alpine lynx population is also its current isolation from other neighbouring populations. Currently the limits of the range of Dinaric-SE Alpine population are still approximately 200-400 km from the closest lynx populations (i.e. small population in the Kalkalpen in Austria, larger Swiss Alpine population in Switzerland, and critically endangered Balkan lynx population in North Macedonia/Albania) (Linnell et al. 2020; Molinari-Jobin et al. 2020; Krofel et al. 2021).

Besides the negative effects of habitat fragmentation on the population, traffic infrastructure, including highways, also has a high impact on individual survival. Since legal protection of lynx, traffic accidents were between the most frequent causes of mortality among cases recorded in Croatia (Sindičić et al. 2016).

The lately ongoing refugee crisis in Europe has seen many countries rush to construct border security fencing to divert or control the flow of immigration (Linnel et al. 2016). The process of Slovenia and Croatia border fencing is representing an important additional threat

to the existing Dinaric - SE Alpine lynx population because it can cause additional fragmentation of habitat, reducing its connectivity and lower effective population size.

LACK OF COORDINATED MONITORING AT THE POPULATION LEVEL

Regular, systematic monitoring is key for a thorough understanding of changes in lynx population status, distribution, health issues and threats. To reach the goal of establishing an interconnected lynx population in the Dinaric-SE Alps, it is critical to collect reliable data which will enable us to assess the status of the lynx in all involved countries (Austria, Italy, Slovenia, Croatia, BiH). Only a rigorous monitoring program, combining assessment of demographic and genetic monitoring will enable us to adequately define further conservation and management measures for the Dinaric SE Alpine lynx population.

Since lynx became a protected species and hunting bags data were not available any more (Staniša et al. 2001, Koren et al. 2006), opportunistic data were the only source of data about lynx in the Dinaric SE Alpine region. Since 2012, "SCALP criteria" was used to classify opportunistically-collected data according to their validity and verification possibility (Molinari-Jobin et al. 2012). While these data are assumed to be collected in the long term, other methods need to be used for reliable estimation of population size or density.

Camera trapping is a standard method used for monitoring species with visual identity (e.g. individually distinct pelage pattern) and has been used to monitor lynx in Central Europe for more than a decade in some areas (e.g. Palmero et al. 2021). Implementation of camera trapping under a suitable field design and the choice of statistical models allows for calculation of population density (Rovero & Zimmermann 2016), which is a demographic parameter that enables a direct comparison of the status of different lynx populations. In Italy, Slovenia and Croatia, coordinated transboundary camera trapping has been initiated in 2018, with camera traps set up at 303 locations covering an area of approximately 10.000 km2 (Slijepčević et al. 2020). This approach enabled us to obtain the first reliable data about the minimum lynx

population size and determined the baseline status of the core of the Dinaric SE-Alpine lynx population. Even though the survey area expanded towards the Alps in Slovenia in the following years to follow the detected changes in the lynx distribution (Krofel et al. 2021, Fležar et al. 2022), the future adaptation of such a monitoring program is not assured. Moreover, the existing program does not representatively cover the entire presumed lynx distribution in the Dinarics, especially in the Southern part of Croatia and BiH.

A lack of genetic monitoring will not enable us to detect the effects of population reinforcement which was undertaken with the LIFE Lynx project on the levels of inbreeding. Non-invasive genetic samples are notoriously difficult to find and a high effort and manpower as well as specific knowledge is needed to obtain a sufficient amount of samples each survey season (Fležar et al. 2022). In addition, climate change has a noticeable impact on snow cover duration and quality which further hampers finding a sufficient amount of non-invasive genetic samples since most of them are collected during snow tracking. Therefore, new methods might be needed to efficiently collect non-invasive genetic samples in the future (Hočevar et al. 2020).

UNDERDEVELOPED PARTNERSHIPS WITH STAKEHOLDERS

A failure to address concerns of the most important parties that must be considered when planning conservation and management actions (typically hunters and livestock breeders, both at the level of representatives and local communities), may decrease overall public support for lynx conservation and subsequently possibly lead to poaching. Historically hunters played a contributory role in lynx reintroduction efforts in the Dinarics and generally value lynx as part of their wildlife heritage once native to the Dinaric-SE Alpine region.

The recent (Bele et al., 2022) and also previous surveys in the Dinaric-SE Alpine area highlighted that the hunters were not recognized as the most controversial interest group in lynx conservation, as it is generally believed. Therefore, their direct, participatory-based

involvement to maintain the support of the reinforcement process is vital for lynx recovery and successful conservation of the species in the future. The study of local public and stakeholder attitudes (Bele et al., 2022) showed high support for conservation activities and favourable attitudes toward the lynx among respondents from Slovenia, Italy and Croatia. As opposed to locals and hunters, the livestock breeders were slightly less in favour of the species, since they are more concerned about the potential of economic damage caused by lynx. Nevertheless, they were significantly opposed to the extermination or illegal killings of lynx. However, some hunters may still perceive lynx negatively and have low tolerance, especially if they believe that lynx are overly-reducing populations of ungulates. In extreme cases, poaching of lynx may occur due to the perception of lynx as a competitor.

In the frame of the LIFE Lynx project, there are considerable efforts to develop good partnerships with all stakeholders. The consortium of partners needs to find ways to maintain the mutual trust even after the project in order to keep the tolerance level high, all the more so when conditions change (e.g. increase of wolf abundance, change in brown bear management etc).

POACHING

There is a lack of population level data on poaching in the Dinaric – SE Alps. In Croatia, research on mortality causes of lynx by Sindičić et al. (2016) estimated that poaching accounted for 60% of all recorded fatalities from 1999 to 2013. In Slovenia in recent years, there was no confirmed poaching recorded, but should not be taken as non-existent. Some of the collared and non – collared lynxes that apparently disappeared could have been killed illegally.

Poaching, as a prohibited and unregulated activity, can have a serious negative impact on the population status of an individual animal species. This is especially pronounced in small populations, such as lynx, where each individual may be important for the long-term survival

of the population. It is therefore important that a lot of attention is paid to activities related to the prevention and detection of poaching.

In most countries, wildlife crimes are rarely solved due to limited experience and capacities of police units, emphasising the need for reinforcement of detection and rigorous prosecution of illegal killing of lynx and other wildlife. With limited experience of national police forces, the transfer of best practices between them should be encouraged. The Hunting Association of Slovenia has zero tolerance to illegal killings of any wildlife and as an active partner of the LIFE Lynx projects initiated a cooperation with the Slovenian police forces to fight wildlife crime.

PREY MANAGEMENT

Lynx, as a specialised predator of small ungulates, supplements its diet with a wide range of other predatory species (Kos I. in sod., 2005). As an opportunistic predator when hunting, it usually chooses the smallest species among the available ungulates (Krofel M., 2011). The relationship between the lynx and its prey has important effects on both the predator and the prey. Therefore, in the management of ungulates, it is necessary to ensure the existence of an adequate prey base, especially in roe deer - *Capreolus capreolus*, red deer - *Cervus elaphus*, chamois – *Rupicapra rupicapra* and mouflon – *Ovis amon musimon*.

Management of ungulates disregarding the impact of lynx predation, as well as excessive encroachment in game populations through culling, can lead to the long-term decline of healthy and viable game populations. The abundance and other population characteristics of prey species have an impact on the vitality of the lynx, as a permanently available food source is a prerequisite for its long-term survival.

Lynx predation can also affect hunters' tolerance to the predator, as lynx prey species are also important game species for hunters.

LIVESTOCK PROTECTION

Conflicts with protected species, in particular damages to human property caused especially by wolves and brown bears, are one of the major challenges for both the preservation of traditional agricultural practices and the conservation and management of these species. Successful damage prevention is essential to ensure the well-being of rural inhabitants, as it has wider economic and social impacts. In recent years, damages to human property (especially small livestock) have become more frequent in the Alpine and pre-Alpine areas of Slovenia. The trend is linked mainly to the spatial expansion of wolves and bears. Even though lynx attacks on livestock are far less common, measures to prevent or mitigate conflicts with farmers in certain areas are needed, also to address an important potential threat to lynx – the unfavourable attitudes of certain stakeholder groups that can be triggered by damages caused. In Slovenia, livestock depredations from lynx are documented occasionally (in the past 10-year period 1 per year). In neighbouring countries, Croatia and in Italy, there are no registered damages caused by lynx.

In areas where flocks of sheep and goats are left unattended, unprotected or inadequately protected, as well as game kept in enclosures (mainly fallow deer, red deer, mouflon), depredations may occur. With increasing lynx numbers, increased local densities and population expansion from the Dinaric population in the Alpine region (creation of the stepping stone), the damage may increase in the future.

DISEASES

Infectious diseases have not yet been thoroughly investigated in the Dinaric-SE Alpine population. Sindičić et al. (2016) hypothesize that the low number of performed necropsies probably masks the significance of other mortalities such as diseases. So far data is available for retroviruses (Gomerčić et al. 2021) and one case of rabies was reported within mortality study (Sindičić et al. 2016).

ORPHANED LYNX

An orphaned animal is defined as a young animal that was separated from its mother and is too young to survive on its own. Juvenile lynx may become orphans for various reasons. They may lose their mother (trauma, poaching, disease), they may fail to follow her due to injury or illness, they may be abandoned due to suboptimal health condition, a lack of experience (inadequate behaviour and care) of their mothers, or other external factors (Borel et al. 2022). Experiences throughout Europe have shown that orphan lynx that are released back to nature after appropriate rehabilitation have a similar survival probability as their counterparts that have never lost the mother (Molinari-Jobin et al. in prep). Based on these findings, the rehabilitation of orphans has a significant conservation value especially in small populations.

LYNX REMOVAL

Removal of individuals is always a difficult choice due to public acceptance of this management measure or due to the influence on the species especially in cases when the population is small and isolated. But removal sometimes can't be avoided. The primary objective is the well-being of a population, of a species. If the removal of a single individual can contribute to a decisive improvement of the situation, then it must be considered. The motivation for removing an animal should always be evaluated based on the overall picture, which is not the same for all regions and countries.

LEGISLATION

The conservation and management of the lynx is governed by national and international rules (see the chapter on International and national legislation). But the gap between the adopted documents and their implementation might lead to inconsistent

practices and weaken the protection of the species. To identify the potential gaps in national legislation and national management documents, an analysis should be carried out to ensure an appropriate legal basis for successful management of the lynx population.

VISION AND OBJECTIVES

Vision: Improving the conservation status by creating a viable lynx population in the Dinaric and SE Alps through international collaboration.

Objectives:

- Minimize threats.
- Restore and increase landscape connectivity within the population and enable connectivity to the neighbouring populations to facilitate creation of a Dinaric - Alpine meta-population.
- Acquire data and knowledge required for successful and efficient long-term lynx conservation.
- Promote public acceptance (provide general guidelines, since it is mostly site-specific).

Specific objectives are further elaborated in the next chapter. We recommend incorporating listed actions into national management documents.

MAINTAINING GENETIC DIVERSITY AND AVOIDING INBREEDING DEPRESSION

One-time reintroduction as executed in the LIFE Lynx project is not a panacea to the genetic rescue of the Dinaric - SE Alpine population. Population development and impact of the reintroduced animals on the genetic status of the population should be regularly monitored with special attention to the population genetic metrics, such as inbreeding coefficient (FIT), number of alleles per locus (A), observed heterozygosity (Ho) and effective population size (Ne). According to the recommendations for the conservation of the Eurasian lynx by the Bonn Lynx Expert Group, isolated populations should be managed to keep the inbreeding coefficient (FIT) below 0.15, and if the inbreeding coefficient rises above 0.25 immediate action is required (Bonn Lynx Expert Group, 2021).

With regular genetic monitoring the threat that Dinaric - SE Alpine population would be sucked back in the "extinction vortex" without us knowing is minimised. Knowledge obtained through genetic monitoring can also help to address other threats such as further population isolation that could result from habitat fragmentation. So it is crucial that results provided by regular genetic monitoring form the basis for management decisions.

To prevent genetic erosion of the population and ensure its continued viability, a long-term strategy for genetic management of the population must be implemented. Such a strategy should be based on the results provided by genetic monitoring and population development models. It is recommended that such models are revised and the strategy updated when new data on the population development becomes available (for example: when genetic monitoring is concluded; at the end of the LIFE Lynx project when more empirical data on the effect of translocations is collected; when the stepping stone population is confirmed as established). Based on recent work on population development modelling, two scenarios would ensure long term population viability: (1) translocation of 3 animals every 5 years. (2) translocation of 7 animals every 15 years. The first scenario allows to minimise fluctuations in the inbreeding coefficient and translocation of fewer animals which is easier to organise. On the other hand, the second scenario provides the longest after – translocation

effect - the inbreeding coefficient is kept below 0.25 threshold for 34 years (Pazhenkova and Skrbinšek, 2021).

Apart from further reintroductions, the management goals must be directed towards connection of Dinaric - SE Alpine population with other lynx populations in Europe. Population "stepping stone" established in the Julian Alps within the LIFE Lynx project serves this purpose. The Julian Alps are within the average dispersal distance from the current lynx population in the Dinaric Mountains of Slovenia, but improving connectivity between these areas will be beneficial to maintain adequate gene flow between the stepping-stone nucleus and the core population, for which permeability of the Ljubljana-Trieste highway is especially important. Lynx expansion in this and other areas should be supported with activities that will increase lynx acceptance among the public and local interest groups.

After Julian Alps are re-colonized by the lynx, further stepping-stone nuclei should be created in the Koroška region in Slovenia, Italy and Austria with a final goal to connect Dinaric-SE Alpine population with other, currently isolated lynx populations in the Alps (Molinari-Jobin et al. 2003). This would create a functional meta-population across the NW Dinaric Mountains and the Alpine arch, and ensure gene flow, reducing the need for further translocations. Expansion should be promoted also towards the south with potential connection with the Carpathian and Balkan populations through Bosnia and Herzegovina, Serbia, Montenegro and Kosovo.

Title of the action	**Maintaining genetic diversity and avoiding inbreeding depression**
Objective(s)	Ensure that inbreeding in the Dinaric and SE Alpine lynx population remains at an acceptable level in the long term. Ensure connectivity of the Dinaric-SE Alpine population with other lynx populations in Europe, creating a functional meta-population across the Dinarics and the Alpine arch.

Description of the activities	Regular genetic monitoring of the population Lynx translocations according to the proposed optimal scenarios – 3 animals every 5 years or translocation of 7 animals every 15 years. Timely updates of the strategy using the monitoring data and new insights from forward-time population development simulations performed with the new data. Creation of new stepping-stone nuclei in the Koroška region in Slovenia, Italy and Austria.
Expected result(s)	The population inbreeding level is kept constantly below 0.15. Increased observed heterozygosity as an indicator of genetic variability compared to the baseline value. Improved long-term viability of the population. Connection of the Dinaric – SE Alpine population with other Alpine populations, Balkan and Carpathian populations.
Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Coordination of translocation planning with monitoring of the genetic status of the population. Implementation of the strategy for genetic management of the population
Means of assessing success	Genetic parameters of the lynx population estimated from empirical data.

HABITAT FRAGMENTATION AND CONNECTIVITY

Given the severe threat of population isolations, and subsequent inbreeding for the Dinaric-SE Alpine population, the visions and objectives are to increase and restore connectivity of the habitats 1.) within the Dinaric-SE Alpine population (population scale) and 2.) between the Dinaric-SE Alpine population and the neighbouring populations (meta-population scale).

Within these steps It is crucial to gain sufficient knowledge about the distribution of suitable lynx habitats and connectivity among them both on the population and meta-population levels. One of the prerequisite conservation management tools to deal with these issues is the creation of lynx habitat suitability and connectivity model over the entire population and meta-population range (Skrbinšek 2004, Potočnik et al. 2020). Ecoinformatic tools such as habitat suitability and dispersal models are useful to pinpoint critical connectivity areas (i.e. corridors and barriers) and provide background and justification for improvement of habitat parameters. Moreover, bio-logging data such as GPS telemetry data, together with data on lynx presence, should be used to support and improve statistical models. For instance, such models for lynx habitat suitability already exist (Skrbinšek 2004, Potočnik et al. 2020) (Fig. 2). The model indicates 16.300 km2 of population area as high-quality habitat and additional 20.900 km2 as still suitable habitat. Dinaric Mountains and SE Alps represent 11.400 km2 and 9.500 km2 of suitable habitat, respectively.

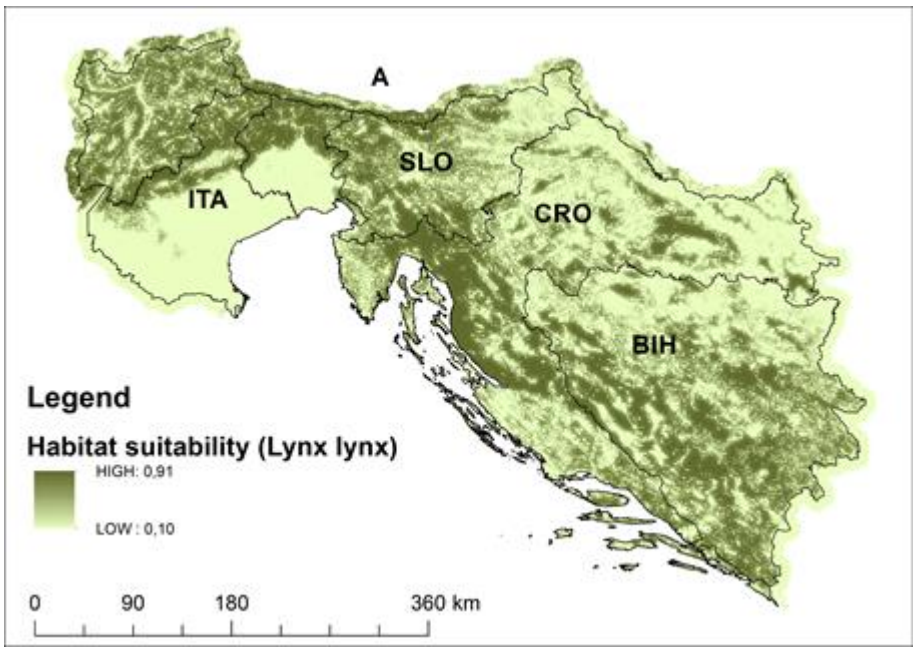

Figure 2: Habitat (home range) suitability map based on logistic regression model (after Schadt et al. 2002) and validated with GPS and VHF telemetry data from Dinarics in Slovenia, along with C1 and C2 presence data from lynx monitoring in Slovenia (SCALP methodology).

However, we still lack sufficient connectivity models. In the future these models must be aimed for reliable identification of lynx movement corridors and barriers both on the population and meta-population scale. In the second step, functional areas of identified corridors must be then protected in spatial management plans on different levels. For barriers management action plans with specific management actions to restore connectivity (i.e. green bridge infrastructure). Again, international collaboration is essential since corridors and barriers typically stretch over several countries and affect movement on a large scale.

To achieve described visions and objectives, we propose two main objectives.

1) Short-term objective: restoring the connectivity within the Dinaric-SE Alpine population

Title of the action	**Habitat fragmentation and connectivity**
Objective(s)	Increase in connectivity within the Dinaric – SE Alpine lynx population and its suitable habitat. Prevent a loss of suitable habitat adjacent to the current lynx population range. Protect existing corridors areas and restore connectivity within barriers at population level.
Description of the activities	Protecting existing corridors in spatial management and forest management, and agricultural management plans Increasing connectivity by enhancing permeability of infrastructure (new green bridges over HWs).
Expected result(s)	The (decline in) connectivity of the population is (halted)/secured.
Responsible for implementation	Management, infrastructure, agricultural and forestry authorities of each involved country.

Actions that need to be implemented beforehand	Identification of the existing corridors and main barriers for the habitat connectivity Recognition of identified corridors and barriers in landscape management and spatial management plans at national level.
Means of assessing success	Assessment of lynx distribution range and connectivity through transboundary monitoring.

2) Long-term objective: restoring the connectivity between the Dinaric-SE Alpine population and neighbouring populations

Title of the action	**Habitat connectivity between the Dinaric-SE Alpine population and neighbouring populations**
Objective(s)	Protect existing corridors areas and restore connectivity within barriers at meta-population level.
Description of the activities	Protecting existing corridors in spatial management and forest management, and agricultural management plans Increasing connectivity by enhancing permeability of infrastructure (new green bridges over HWs).
Expected result(s)	The Dinaric-SE Alpine population is connected with the other Alpine populations.

Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Identification of the existing corridors and main barriers for the habitat connectivity Recognition of identified corridors and barriers in landscape management and spatial management plans at national level.
Means of assessing success	Assessment of lynx distribution range and connectivity through transboundary monitoring.

POPULATION LEVEL MONITORING

A common monitoring protocol based on the latest scientific recommendations (Hočevar et al. 2020) should be adopted for a population-level transboundary monitoring, as well as the data shared between the countries and the data interpreted regularly at the level of the Dinaric SE Alpine lynx population. The main aspects of the program should address monitoring of the genetic and demographic status and involve all countries hosting the Dinaric SE Alpine lynx population so the status of the population is representatively assessed at the level of its entire range.

Population Status

1. **Distribution and abundance:** To assess changes in population distribution, opportunistic data should be collected continuously and classified at an international

level according to SCALP categories. Opportunistic data is cheap and simple to process and under SCALP classification, it allows for obtaining information about the population distribution and occupancy (Molinari-Jobin et al. 2018). It gives us the first indication of the changes in lynx distribution and should therefore be collected and processed at the current rate. To assess changes in population abundance and density, coordinated camera trapping needs to continue at least with the intensity performed during 2020-2021 season (Fležar et al. 2022) in the current lynx distribution area but allow for the survey area to expand according to the detected changes in lynx distribution. To effectively monitor the changes in density and abundance it should be implemented at least for the next 5 years after the reinforcement activities finish. Camera trapping should follow the appropriate temporal and spatial framework to allow for assessing population density via spatial capture recapture models. In addition, reproductive units should be reported each year to define the core reproductive areas. Including key stakeholders, such as hunters, in activities related to monitoring lynx can also help raise awareness of the importance of lynx conservation and increase trust in the collected data. Hunters' involvement in camera trapping will also result in lower cost for best quality data (Cretois et al. 2020). To tap into these considerable benefits, lynx conservation projects should prioritise collaboration with and training of volunteers, such as local hunters (Hočevar et al. 2020), which has been well established over the course of camera trapping in Slovenia, Croatia and Italy between 2018 and 2021. Collection and analysis of camera trapping data should ideally be done in tight collaboration and coordination among the responsible authorities in all relevant countries/regions to obtain estimates on population density and abundance at the population level since this increases both cost-effectiveness and quality of results.

2. **Genetic status:** Genetic samples should be collected continuously and archived in a most efficient way (tissue samples can be archived for longer periods, DNA should be isolated from non-invasive samples and stored), while genetic analyses should be done every 1 - 3 years to estimate genetic variability, effective population size and inbreeding coefficient.

3. **Mortality and health**: All available carcasses should be examined by a qualified veterinarian with emphasis on appropriate archiving of collected data and all samples. Significant infectious diseases (e.g. FIV, FeLV, parvovirosis) should be monitored.

Title of the action	**Population level monitoring**
Objectives	1. Regular assessment of lynx distribution and density. 2. Regular assessment of lynx genetic and health status. 3. International coordination and joint reporting.
Description of the activities	1.1. Continuous (yearly) collection of opportunistic data and continuous (yearly) camera trapping involving stakeholders (hunters). 1.2. Annual reporting to SCALP network, reporting of camera trapping results and providing feedback to the involved stakeholders. 2.1. Monitoring of lynx genetic status; the inbreeding coefficient and the effective population size. 2.2. Routine examination of all detected lynx mortality according to a standardized protocol. 2.3. Analyses of infectious diseases. 3.1. International coordination of monitoring activities. 3.2. Sharing of monitoring data through the joint online database. 3.3. Reporting of lynx status at a population level.

Expected results	1.1. High-quality population status data (density, survival, reproduction, dispersal, pedigrees and distribution) for population-level conservation and management 1.2. Continuous stakeholder engagement (hunters). 1.3. Early detection of changes in lynx distribution and density. 2.1. Early detection of genetic problems (inbreeding becoming critically high). 2.2. Early detection of pathogens and zoonosis (health status). 2.3. Prevention of infectious diseases to spread. 3.1. Coordinated monitoring at population level, joint interpretation and reporting. 3.2. Increased capacity (human resources) in Bosnia and Herzegovina to conduct monitoring at the same level as other countries. 3.3. National as well as population-level data available to the competent authorities.
Activities to be implemented before	Organization of a regular population-level forum where monitoring activities are coordinated and discussed.
Responsible for implementation	Management authorities and other organisations responsible for implementation of lynx population monitoring.
Means of assessing success	1-3: Amount of collected data in the joint database. 1-3: Reports for each activity produced regularly.

COOPERATION WITH STAKEHOLDERS

To develop close partnership with stakeholders, regular open communication is of crucial importance. Different types of interest groups' involvement include: communication of basic strategies, sharing of information, consultation, participation in decision making and transfer of decision-making power. All of the communication activities should therefore be bottom-up community-supported. To ensure formation of favourable attitudes in long-term, education activities for younger generations should also be considered. In lynx management, a combination of all these types, wisely selected for the local context and management objectives, should be used. It is important to carefully consider interest groups' characteristics, their expectations and even stakeholders' network dynamics when planning either communication campaigns or more involved interest group dialogue such as public consultations. When possible, it is advisable to use opportunities to actively involve interest groups in implementation of management measures, thus additionally increasing the sense of common responsibilities and ownership among the interest groups. Opinions and expectations of the interest groups should be periodically checked through the attitudinal and knowledge surveys to evaluate the success of implemented actions and plan suitable activities for the future. When planning conservation and management activities based on lynx population level, interest groups should be encouraged to meet and discuss these issues together.

Title of the action	Cooperation with stakeholders
Objective(s)	Ensure interest groups' commitment to long- term recovery and conservation of lynx population in coexistence with humans. Improve collaboration, dialogue, relationships, and trust amongst relevant interest groups by integrating them into the process of planning and preparing important documents. Integrate relevant interest groups into the implementation of actions in participatory manner.
Description of the activities	Continue cooperation with local consultative groups. Organize local consultative groups in Italy. Organise regular (every 1 - 2 years) stakeholder forums for exchange of information, experiences and ideas. Regularly exchange information with the non-EU neighbours (Bosnia and Herzegovina and Switzerland) as well as with neighbouring EU countries. Delegate representatives of national authorities to coordinate work with stakeholders. Improve active involvement of hunters and other volunteers in the population surveillance (snow tracking, camera trapping non-invasive genetic sampling) and share the results with them. Actively involve hunters, environmentalists, livestock breeders and other interest groups into planning and implementation of lynx management plans and in improving game management. Continue educating and informing the younger generations, general public, hunters, livestock breeders and other interest groups about the species' biology, ecology and ethology, ecosystem services (benefits) provided by the presence of lynx, measures to promote coexistence, and the species' recovery, especially in areas where lynx occur only recently or where expansion is very likely.

Expected result(s)	People are informed about the status and the conservation needs of the local lynx population and they understand the significance of the conservation and management measures to be taken. The public attitudes are in favour of the species' long term conservation. Concerns and ideas of key interest groups such as hunters, farmers, local communities and environmentalists provide regular input to planning and implementation of the coordinated population level management.
Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Standardization of the social sciences research methods (comparable social science data).
Means of assessing success	Number of events organized. Assessment of attitudes, knowledge gained and level of satisfaction among interest groups. Structures for active involvement of interest groups implemented.

POACHING

The first step is to recognize and understand all reasons why poaching occurs in order to establish appropriate measures to prevent such events. Awareness about poaching and the extent of the problem for the conservation status of the population should be presented to relevant stakeholders, such as law enforcement authorities. The main goal is to prevent poaching and also to detect and comprehensively investigate the crime with better resources. Poaching should be consistently persecuted through law enforcement. Among authorities responsible for investigation, best practices and investigation techniques should be shared.

Title of the action	**Poaching**
Objective(s)	Determine the main causes/motivations for poaching; (a) damages on human property, (b) economic interest, (c) fear, (d) trophies, (e) something else. Develop and improve close cooperation between field personnel (hunting wardens, professional hunters, foresters, rangers and wildlife managers) and authorities in charge of investigation and prosecution of wildlife crime. Raise public awareness about the negative consequences of poaching and develop the culture where poaching is unacceptable. Establish effective prosecution of lynx poaching. Develop a network of information sources to obtain data on poaching cases.

Description of the activities	Perform the survey (questionnaire) on the stakeholders' opinion on the lynx poaching issues: motivations, extent, ways to achieve the positive attitudes and to control poaching. Carry out a public information campaign, based on the results of the survey. Organize training for police officers, public prosecutors, hunting wardens, professional hunters, foresters, rangers and wildlife managers, for customs and border officials and other relevant institutions. Organize regular workshops with key stakeholders on the negative consequences of poaching and raise awareness about the importance of its prevention. Analyse and optimize relevant legislation in each country. Establish protocols on how to proceed in case of finding a dead lynx where poaching is suspected.
Expected result(s)	Poaching is significantly reduced. Fast and efficient system for detecting and prosecuting poaching. Personnel from all sectors trained for fast and appropriate reactions. Authorities are aware of their responsibilities and do apply them.
Responsible for implementation	Management authorities of each involved country. Hunting organizations with their inspecting bodies. State officials: police, border control, legal practitioners.
Actions that need to be implemented beforehand	The initial steps of this action should start independently of other actions.
Means of assessing success	Number of events organized for stakeholders. Number of educational events (for police, legal practitioners, border control and field personnel). Increase the rate of successfully investigated cases. Number of convictions in prosecuted cases.

PREY MANAGEMENT

To provide adequate prey base and maintain the tolerance of hunters, presence of lynx should be considered in hunting management plans for individual game species (red deer - *Cervus elaphus*, roe deer - *Capreolus capreolus*, chamois - *Rupicapra rupicapra* and mouflon - *Ovis amon musimon*). However, prey base itself is not a limiting factor since roe deer, red deer or chamois, lynx's main prey, have recolonized almost all suitable habitat in the Alps and Dinarics and are more abundant than ever (Apolonio et al. 2010). Still, in some parts of the lynx distribution reliable estimates of ungulate density are not available and this might be an issue in some parts of Croatia.

Title of the action	**Prey management**
Objective(s)	Ensure an adequate prey base for the recovering lynx population. Maintain the tolerance of hunters towards lynx.
Description of the activities	Consider lynx in national ungulate management plans.
Expected result(s)	Maintained or increased tolerance of hunters towards the lynx. Harmonization of lynx presence and ungulate management. Adequate prey base for lynx.
Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Involvement of hunters in the preparation of management plans (collection of proposals for adjustments, field observations).

Means of assessing success	Level of acceptance of lynx among hunters. Adequate abundance of prey species. Recovered lynx population.

LIVESTOCK PROTECTION

The use of high electric fences, livestock guarding dogs, night enclosures, and in some cases shepherding have proved to be effective measures to prevent damage caused by large carnivores, also lynx. Since the preventive measures can be fully effective only with appropriate use and maintenance, along with the adaption to the local specifics (especially ground requirements, the type of farming, and the size of the herd of grazing animals), the successful damage prevention therefore requires constant cooperation between farmers and experts, supervision of the proper use of protective measures, appropriate incentives from agricultural policy, and active promotion of effective measures. Inter-institutional cooperation and a cross-national exchange of experiences are particularly important. The compensation of losses in case of depredation events is an important measure to mitigate conflicts.

Title of the action	**Livestock protection**
Objective(s)	Prevent damages on livestock or farmed game by lynx. Address negative attitudes from certain stakeholder groups (mainly hunters and livestock breeders, also local inhabitants), caused by perceived or documented damages.

Description of the activities	Consider lynx in damage prevention and compensation subsidy systems.
Expected result(s)	Decreased or prevented damage cases to livestock or enclosure game caused by lynx. Maintained or increased tolerance of hunters, livestock breeders and local inhabitants to lynx.
Responsible for implementation	Responsible and management authorities of each involved country.
Actions that need to be implemented beforehand	Involvement of livestock breeders and other stakeholder groups in the process of improvement and adjustment of preventive measures (e.g. collection of the user experiences).
Means of assessing success	Level of acceptance of lynx among different stakeholder groups. Decreased or no documented damage case caused by lynx.

DISEASES

For the timely and preventive detection of lynx diseases, it is necessary to establish a comprehensive system of timely notification of disease states. The expert examination (autopsy) of each lynx specimen is crucial, especially those suspected of having a specific disease condition that may pose a serious threat to health, both at the level of the individual and at the population level. This provides an overview of diseases that threaten lynx, especially those resulting from inbreeding. Effective detection and prevention of potential diseases requires the effective cooperation of the competent veterinary services, both at

national and international level, following standardised procedures in the veterinary profession.

Title of the action	**Diseases**
Objective(s)	Develop and improve cooperation and communication between veterinary services at international level, especially in the detection of rare or dangerous diseases for the population. An international protocol specifying the method of lynx autopsy and which investigations must be carried out. Investigation and autopsy of any dead lynx found. Track all diseases that affect lynx, especially those that are contagious. Detailed medical examination for the existence of possible diseases in each individual lynx intended for translocation to a new area.
Description of the activities	Analysis and optimization of the current methods of information and communication between the veterinary services of individual countries. Organised meetings for representatives of the veterinary profession. Establishing an international veterinary protocol on lynx autopsies to standardise working methods and to obtain the same data. Before each lynx is translocated, a thorough veterinary check is carried out, focusing on potential diseases.
Expected result(s)	Fast and efficient notification system between the veterinary services of each country on detected diseases. Performing autopsies in accordance with the unified international veterinary protocol. Translocation of only proven healthy lynx to new areas. Detection of diseases, especially those resulting from inbreeding.

Responsible for implementation	Umbrella veterinary services of individual countries. State officials: veterinary staff.
Actions that need to be implemented beforehand	The initial steps of this action should start independently of other actions.
Means of assessing success	Number of expert meetings of the main veterinary services of individual countries performing lynx autopsies. Number of autopsies performed in accordance with international protocol. Detection rate of individual diseases, especially those resulting from inbreeding.

ORPHANED LYNX

Often orphaned lynx become conspicuous when approaching inhabited houses in the search for food. These orphans can usually be captured quite easily and should in a first step undergo a thorough health check. If the veterinary health-check concludes that the rehabilitation of the individual is not recommended, the lynx is euthanized. Otherwise, the lynx should be rehabilitated and subsequently released back to nature, either in the vicinity where the orphaned lynx was found or in another area to numerically and/or genetically support the population. During the whole rehabilitation process, care should be taken to avoid habituation to humans, a special challenge when the orphaned lynx is too young to consume meat. The release of habituated lynx is not recommended. If rehabilitation capacities (appropriate enclosure and trained personnel) are not available in the country where the animal was found, it is recommended to organize rehabilitation in an experienced institution in another country. We are discouraging rehabilitation attempts in inappropriate enclosures by inexperienced staff. Another option is feeding orphaned lynx in the wild until its

independence, which was practiced in a few cases with success (Premier et al. 2021; Borel et al. 2022). The monetary and time costs of monitoring orphans in the wild are significantly lower than care in a rehabilitation centre, which requires expensive infrastructure and trained staff (Borel et al. 2022).

Title of the action	**Orphaned lynx**
Objective(s)	Ensure adequate procedures with orphaned animals. Decrease orphan mortality and habituation. Secure possible source for translocations.
Description of the activities	Revision of legal background, facilities and personnel educated for lynx rehabilitation. Preparation of protocols for management of orphan animals according to local resources. Education of all interest groups involved in management of orphan animals.
Expected result(s)	Protocol for management of orphan lynx. Decreased orphan mortality and avoiding habituation.
Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Revision of legal background, facilities and personnel educated for lynx rehabilitation.
Means of assessing success	Protocol adopted by authorities. Number of rehabilitated animals.

LYNX REMOVAL

Protocols, guidelines have to be established and need to be followed in cases of Lynx removal. Here we are providing some general principles and procedures which should be taken into consideration:

Before each removal, it should be evaluated whether it is possible to find alternatives to solve the problem. For example, the treatment of a sick or injured animal or aversive conditioning of a problematic (habituated) animal.

Problem animals specialized in the predation of domestic animals (i.e. stock raiders) even in the face of effective preventive measures, could be dissuaded with different techniques, before deciding to remove them. Apart from the high costs of such techniques/measures and the very low chances of obtaining a good result, they must be assessed on a case-by-case basis. The positive effects of these measures on public opinion, in particular to the public sensitive and favourable to the presence of felines, must also be carefully considered and evaluated. At the same time measures to improve livestock protection should be implemented to prevent further predation.

If it was proven that animal is infected with pathogen that presents danger to the rest of the lynx population or to humans, euthanasia should be considered. In cases of infectious disease that might cause the individual to die or suffer, but the disease is curable and the capturing and treatment will not harm the animal, veterinarian(s) experienced in wildlife medicine should assess if it is possible to treat and rehabilitate the animal (considering both the available medical treatments and available veterinary capacities), or to euthanize it.

For severely injured or poisoned individuals, a veterinarian(s) experienced in wildlife medicine should assess, depending on the condition of the animal, if it is possible to treat and rehabilitate the animal (considering both the severity of the injury and available veterinary capacities), or to euthanize it.

As far as is empirically known, the only dangerous individuals are lynx that have contracted rabies. In this case, the animal must be lethally removed immediately. Other cases are not known, and if they occur they must be evaluated by managing authority and lynx experts.

Alternatively, to lethal removal, an animal can be captured and transferred to enclosure or translocated to another area. That can be done in case of repeated livestock killing where the predator is identified and removed from the problem area. Finally, an animal can be captured, sterilized and released. It should be established in the guidelines under what conditions/if this is a useful option.

A communication strategy should be prepared in advance and carefully followed in cases of lynx removal - a plan of what, how and who communicates before, during and after the action. When possible, the reasons for removal should be communicated in advance.

Title of the action	**Lynx removal**
Objective(s)	Ensure adequate procedures for lynx removal in different situations by trained personnel. Secure appropriate communication.
Description of the activities	Preparation of protocols for lynx removal. Preparation of communication strategy. Training of the personnel.
Expected result(s)	Protocol for lynx removal. Trained personnel. Communication strategy.

Responsible for implementation	Management authorities of each involved country.
Actions that need to be implemented beforehand	Revision of legal background and personnel trained for lynx removal.
Means of assessing success	Protocol and communication strategy adopted by authorities.

LEGISLATION

It is recommended to carry out gap analysis of national legislation and strategic documents in order to identify changes that are needed for successful implementation of lynx conservation and management. It is also very important to review all existing legislation that is not being implemented and the reasons for that.

Title of action	**Legislation**
Objective(s)	Secure the legal background for long-term conservation and coexistence of lynx and humans.
Description of the activities	1. Revision of existing legislation (including national management documents) to determine parts that are not being implemented and the reasons for that. 2. Improvement of existing legislation dealing with habitat connectivity, primarily guidelines for environmental impact assessment studies and permeability of traffic infrastructure for wildlife. 3. Preparation of recommendations for regulation of border fences to mitigate their influence on lynx. 4. Preparation of protocols for handling orphan, injured and sick lynx.

	5. National Strategic documents adopted in each country
Expected results	The legal background for science-based management of lynx is established.
Responsible for implementation	Responsible authorities of each involved country.
Actions that need to be implemented beforehand	Gap analysis of existing legislation and potential improvements. Dialogue with all involved stakeholders, managers and legislators.
Means of assessing success	New legislative documents adopted and implemented or existing documents improved and executed.

LITERATURE

- Apollonio, M. et al. (Eds.) (2010) European ungulates and their management in the 21st century. Cambridge University Press, Cambridge, UK, pp. 604.
- Bele, B. et al. (2022) Assessment of public attitudes toward lynx and lynx conservation in Slovenia, Croatia and Italy. Intermediate report of the Action D.4. University of Ljubljana, Biotechnical Faculty, pp. 35.
- Boitani, L. et al. (2015) Key actions for Large Carnivore populations in Europe. Report to DG Environment, European Commission, Bruxelles.
- Bonn Lynx Expert Group (2021) Recommendations for the conservation of the Eurasian lynx in Western and Central Europe. Cat 14, 78-86.
- Breitenmoser, U. et al. (2010) The changing impact of predation as a source of conflict between hunters and reintroduced lynx in Switzerland, in Biology and Conservation of Wild Felids, Eds D. W. Macdonald and A. J. Loveridge, Oxford University Press. pp 493–506.
- Breitenmoser, U. et al. (1998) Re-introduction and present status of lynx (*Lynx lynx*) in Switzerland. Hystrix 10, 17-30.
- Breitenmoser, U. (1998) Large predators in the Alps: the fall and rise of man's competitors. Biological Conservation, 83 (3), 279-289.
- Breitenmoser, U. et al. (2000) Action Plan for the Conservation of the Eurasian Lynx (Lynx lynx) in Europe; Council and Europe Publishing: Strasbourg, France, pp. 1–69.
- Chapron, G. et al. (2014) Recovery of large carnivores in Europe's modern human-dominated landscapes. Science, 346 (6216), 1517-1519.
- Čop, J. (1972) Ponovna naselitev risa (Lynx lynx) v Sloveniji (Kočevska). Ljubljana, 17 pp (in Slovenian)
- Čop, J. 1994. Spremljanje ponovne naselitve risa (Lynx lynx L.) v Sloveniji 1973–1993. I. del. 151 pp (in Slovenian)
- Čop, J. & Frković, A. (1998) The re-introduction of the lynx in Slovenia and its present status in Slovenia and Croatia. Hystrix 10, 65–76

- Fležar, U. et al. (2019) Eurasian lynx (Lynx lynx) monitoring with camera traps in Slovenia in 2018–2019. LIFE Lynx project report. Slovenia Forest Service and University of Ljubljana, Ljubljana.
- Fležar, U. et al. (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. et al. (2002) Introduction to Conservation Genetics. Cambridge University Press, Cambridge.
- Frković, A. (1998) Ponovo naseljavanje i ulov risa (*Lynx lynx* L.) u Županiji Primorsko Goranskoj u razdoblju od 1974.-1996. godine. Zbornik radova Prirodoslovna istraživanja Riječkog područja, Prirodoslovni muzej Rijeka. pp 493 - 500.
- Gomerčić, T. et al. (2021): Retroviral survey in endangered Eurasian lynx (*Lynx lynx*) from Croatia. Veterinarski arhiv 91 (1): 65 – 71. doi: 10.24099/vet.arhiv.0857
- Iuell, B. et al. (2003) Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions. Habitat Fragmentation due to Transportation Infrastructure. COST 341.
- Kaczensky, P. et al. (2012) Status, management and distribution of large carnivores - bear, lynx, wolf and wolverine in Europe. Report. European Commission, pp. 72.
- Koren, I. et al. (2006) Status and distribution of the Eurasian lynx (Lynx lynx L.) in Slovenia in 2000–2004 and comparison with the years 1995–1999. Acta Biologica Slovenica 49: 27–41
- Koritnik, M. (1974) Še nekaj o risu. Lovec 67, 198-199.
- Kos, I. et al. (2012) Stanje in razširjenost evrazijskega risa (Lynx lynx) v Sloveniji v obdobju 2005–2009. Acta Biologica Slovenica 55: 49–63
- Kos, I. et al. (2005) Ris v Sloveniji. 2. izdaja. Ljubljana, Univerza v Ljubljani.
- Kos, F. (1928) Ris (*Lynx lynx*) na ozemlju etnografske Slovenije. Glasnik muzejskega društva za Slovenijo. 1(1-4), 57-72.
- Kratchovil, J., Vala, F. (1968) History of occurrence of the Lynx in Bohemia and Moravia. Acta Sc. Nat. Brno 2(4), 33-48.
- Kratochvil, J. (1968) Survey of the distribution of populations of the genus Lynx in Europe. Acta Sc. Nat. Brno 2(4), 5-12.

- Krofel, M. et al. (2021) Surveillance of the reinforcement process of the Dinaric - SE Alpine lynx population in the lynx-monitoring year 2019-2020. LIFE Lynx project. 45 p.
- Krofel, M. (2011) Diet of Eurasian lynx *Lynx Lynx* in the northern Dinaric mountains (Slovenia and Croatia): Importance of edible dormouse *Glis Glis* as alternative prey.
- Lacy, R. (1997) Importance of Genetic Variation to the Viability of Mammalian Populations. Journal of Mammalogy. 75(2), 320–335.
- Linnell, J. et al. (2001) Home Range Size and Choice of Management Strategy for Lynx in Scandinavia. Environmental Management 27, 869–879.
- Linnell, J. et al. (2008) Guidelines for the 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). 85p.
- Linnell, J. et al. (2020) Status of large carnivores in Europe 2012-2016. Distribution, numbers, and red list assessments. NINA Report 1708. Norwegian Institute for Nature Research.
- Majić, A. (Ed.) (2004) Plan upravljanja risom u Hrvatskoj. Ministarstvo zaštite okoliša i prostornog uređenja Republike Hrvatske. Zagreb.
- Majić Skrbinšek, A. et al. (2020) Assessment of public attitudes towards lynx and lynx conservation in Slovenia, Croatia and Italy. Life Lynx project.
- Matjuškin, E.N. (1978) Der Luchs Lynx lynx. Die Neue Brehm-Bücherei 517, 160.
- Molinari-Jobin, A. et al. (2003) Pan-Alpine Conservation Strategy for the Lynx. Council of Europe 130: 25.
- Molinari, P. (1998) The lynx in the Italian south-eastern Alps. Hystrix 10, 55–64.
- Molinari, P. et al. (2021) The contribution of steppingstone releases for enhancing lynx distribution. Cat News. Special Issue no. 14: 46–49.
- Molinari-Jobin, A. et al. (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. et al. (2020) SCALP Monitoring Report 2017 (1. May 2017 – 30. April 2018). KORA.

- Molinari-Jobin, A. et al. (2010) Recovery of the Alpine lynx *Lynx lynx* metapopulation. Oryx, 44 (2), 267-275.
- Molinari-Jobin, A. et al. (2003) The pan-alpine conservation strategy for the lynx. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) Nature and environment, No. 130. Council of Europe Publishing, 1-24.
- Potočnik, H., et al. (2009) The reintroduced Dinaric lynx population dynamics in PVA simulation: the 30 years' retrospection and the future viability. Acta Biologica Slovenica, 52 (1), 3-18.
- Potočnik, H. et al. (2019a) Handbook for integrating the bear habitat suitability and connectivity to spatial planning: prepared within the framework of the Life Dinalp Bear project. University of Ljubljana, Ljubljana, Slovenia, pp. 66.
- Potočnik, H., et al. (2019b) Evrazijski šakal. Zlatorogova knjižnica 42. Lovska zveza Slovenije, Ljubljana, Slovenia, pp. 248.
- Potočnik, H., et al. (2020) Characteristics of spatial use and importance of landscape features for recovering populations of Eurasian lynx (*Lynx lynx*). Acta Biologica Slovenica, 63 (2), 65-88.
- Premier, J. et al. (2021) In situ feeding as a new management tool to conserve orphaned Eurasian lynx (Lynx lynx). Ecology and Evolution https://doi.org/10.1002/ece3.7261
- Reinhardt, I. et al. (2019) Military training areas facilitate the recolonization of wolves in Germany. Conservation Letters, 12, e12635.
- Santini, L. et al. (2016) Effectiveness of Protected Areas in Conserving Large Carnivores in Europe. In: Protected Areas. John Wiley & Sons, Ltd, pp. 122–133.
- Schadt, S. et al. (2002) Assessing the suitability of central European landscapes for the reintroduction of Eurasian lynx. Journal of Applied Ecology 39: 189–203.
- Schadt, S.A. (2002) Scenarios assessing the viability of a lynx population in Germany. Szenarien für eine lebensfähige Luchspopulation in Deutschland (Doctoral dissertation). Technisches Univeritat München, Germany.
- Schnidrig, R. et al. (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.

- Sindičić, M. (2013) Genetic data confirm critical status of the reintroduced Dinaric population of Eurasian lynx. Conservation Genetics 14:1009–1018.
- Sindičić, M. et al. (2016) Mortality in the Eurasian lynx population in Croatia over the course of 40 years. Mammalian Biology 81: 290–294.
- Sindičić, M. et al. (Eds.) (2010): Plan upravljanja risom u Republici Hrvatskoj, za razdoblje od 2010. do 2015. Ministarstvo kulture.
- Sindičić, M. et al. (2009) Legal status and management of the Dinaric lynx population. Veterinaria 58: 229–23.
- Skrbinšek, T. et al. (2019) Baseline (pre-reinforcement) genetic status of SE Alpine and Dinaric Lynx population. Ljubljana.
- Skrbinšek, T. (2004) Model primernega prostora za risa v Sloveniji. eng. Lynx in Slovenia, background documents for conservation and management. University of Ljubljana, Biotechnical Faculty, Ljubljana, Slovenia, 122-147.
- Slijepčević, V. et al. (2019) Baseline demographic status of SE Alpine and Dinaric lynx population. Technical report. Ljubljana, January 2022, 59 p.
- Staniša, C. et al. (2001) Situation and distribution of the lynx (Lynx lynx L.) in Slovenia from 1995–1999. Hystrix 12, 43–51
- Von Arx, M. et al. (Eds) (2004) Status and conservation of the Eurasian lynx (Lynx lynx) in Europe in 2001, KORA Bericht. Bern.
- Zimmermann, F. (2003) Lynx habitat fragmentation of the Alps-a preliminary model. In: Molinari-Jobin, A. (ed.): 2nd SCALP Conference, Amden, 7-9 May 2003.
- Zimmermann, F. (2004) Conservation of the Eurasian Lynx (*Lynx lynx*) in a fragmented landscape-habitat models, dispersal and potential distribution (Doctoral dissertation). Université de Lausanne, Faculté de biologie et medicine, Switzerland.
- Zimmermann, F., Breitenmoser, U. (2007) Potential distribution and population size of the Eurasian lynx *Lynx lynx* in the Jura Mountains and possible corridors to adjacent ranges. Wildlife Biology, 13 (4), 406-416.
- Zimmermann, F. et al. (2005) Natal dispersal of Eurasian lynx (*Lynx lynx*) in Switzerland. Journal of Zoology, 267 (4), 381-395.

- Zimmermann, F. et al. (2007) Importance of dispersal for the expansion of a Eurasian lynx *Lynx lynx* population in a fragmented landscape. Oryx, 41 (3), 358-368.