LIFE Lynx

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

LIFE16 NAT/SI/000634

Monitoring protocol for the Eurasian lynx (Lynx lynx) population in the Slovak Carpathian Mountains

A1. Assessment and selection of sites and lynx for live-capture from the Carpathian source population in Slovakia

D1. Monitoring the effects of lynx removal for translocations on the source populations

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Report for the implementation of action A1 and D1
Realized in the frame of action A1:

Assessment and selection of sites and lynx for live-capture from the Carpathian source population in Slovakia

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Content

Foreword

The purpose of this protocol is to provide detailed information about the objectives, attributes, sampling design and data management necessary for the implementation of the actions A1 and D1 within the LIFE LYNX - LIFE16 NAT/SI/000634

Together with the protocol on the A2 action in the Romanian Carpathians - Gazzola et al. (2018) it is required by the need to ensure a technical framework for the LIFE Lynx project team.

1. Introduction

The population of Eurasian lynx (*Lynx lynx*) in the Carpathian Mountains is considered to be one of the best preserved and largest in Europe (Kaczensky et al. 2013). It was the source of lynx for several reintroduction projects between the 1970s and the 1990s (Breitenmoser et al. 2000, Breitenmoser & Breitenmoser-Würsten 2008, Linnell et al. 2009). In total, there were approximately 172 – 177 lynxes translocated within these programmes and released in 8 European countries (Breitenmoser & Breitenmoser Würsten 2008, Linnell et al. 2009). Many of the translocated animals came from Slovakia (Kubala et al. 2017). The lynx captures were realized simultaneously with the legal hunting of this species. The average proportion of captured lynxes presented nearly 10 – 18% of all hunted animals (Hell & Slamečka 1996) and the actual translocations had no negative influence upon the lynx demography in the source population (Hell & Slamečka 1996, Hell et al. 2004, Smolko et al. 2018). On the contrary, the cooperation among the forestry, hunting and conservation communities alongside with the management of official reintroduction programmes in the Slovak Carpathians are regarded to be an excellent international model for sustainable international conservation of lynx in Europe (Breitenmoser & Breitenmoser Würsten 2008, Kubala et al. 2017).

Several reintroduced populations were prospering in the initial phase of the programme. Nevertheless, the positive population trend has stopped or it is even being considered negative (Skrbinšek et al. 2011, Sindičić et al. 2013, Boitani et al. 2015). These problems originate mainly in the low number of released source animals captured during a short period of time, which consequently caused the inbreeding, which is being the major threat for long-term survival of reintroduced populations (Breitenmoser-Würsten & Obexer-Ruff 2003, 2015, Skrbinšek et al. 2011, Sindičić et al. 2013). The solution to this compelling problem lies in the reinitiation of programmes supporting the reintroduced populations as well as their reinforcing by other animals from the source population in the Slovak Carpathians (Breitenmoser 2011, Sindičić et al. 2013, Boitani et al. 2015; action C1). However, following the IUCN directions (International Union for Conservation of Nature), the source population. must be monitored prior to any kind of intervention (action C1). At the same time, the population must be evaluated with the emphasis on the number of individual animals and their population trend, genetic diversity and health status (von Arx et al. 2009, IUCN 2013; actions A1, D1). Based on these data, it is consequently possible to evaluate whether the source population within an area of interest corresponds to the “favourable status” of lynx as a species of European importance (Kropil 2005) and whether it is suitable for captures of individual animals without any negative impacts on the source population (Smolko et al 2018; actions C1, D1). Only then it is possible to implement the trapping and reintroduction in the Central and Western Europe (Breitenmoser et al. 2000, Boitani et al. 2015, Smolko et al. 2018). This procedure also corresponds with the goals approved in a Management Plan for the Eurasian Lynx (*Lynx lynx*) in Slovakia (Antal et al. 2016), the Habitats Directive 92/43/EEC from 21st May 1992 on the conservation of natural habitats and of wild fauna and flora (hereafter "habitats directive") as well as in the Key Actions for Large Carnivore Populations in Europe (Boitani et al. 2015).

During the last two decades, lynx conservation and evaluation of its status in Slovakia was based solely on the so called "expert opinions", while relevant scientific data about lynx population were not available (Hell & Slamečka 1996, Kubala et al. 2017). Therefore, the status of lynx population in Slovakia was defined as unfavourable-inadequate in the official report about habitats and species of European importance (Černecký et al. 2014). On the other side, the Green Report of the Ministry of Agriculture and Rural Development from 2015 reports 1,739 lynxes living in Slovakia, which is being considered by many hunters as an "overpopulation" (MPRV 2016). However, our previous research clearly proved that lynx statistics provided by hunters are strongly biased by 6 to 7-fold overestimation (Kubala et al. 2017). This overestimation is likely caused by multiple counts of the same lynx individuals within several hunting grounds, because average area of hunting ground in Slovakia is much smaller (26.6 km^2) than the spatial requirements of lynx (150–300 km^2; Breitenmoser-Würsten et al. 2007). This fact is unfortunately being ignored on a long-term basis by the state administration and consequently leads to the presentation of vague and misleading information when describing the status and lynx population trend at local and national levels (Kubala et al. 2017, Smolko et al. 2018). The lack of a scientific basis when reporting and interpreting data on large carnivores subsequently leads to conflicts such as illegal hunting. Therefore, a regular monitoring is crucial to ensure an effective conservation management of the species based on information on the population status as well as its temporal and spacial variation and trends. Systematic robust monitoring will also provide information on the effects of lynx removal on the source population (action D1) and ensure that the population in Slovak Carpathians is not threatened. At the same time, achieved results will benefit designing future reinforcement and reintroduction programs for other endangered lynx populations in Europe, as well as other species that face similar conservation challenges.

2. Objectives and attributes

Our main *goals* within the LIFE LYNX project are:

1) to collect data and information important to identify *the most suitable areas* and *micro-locations* (action A1) *for live-capture of lynx* in Slovak Carpathians (action C1).

2) to determine the *lynx population size* in the survey areas (action A1) during the whole project period. The *population size* estimated *before*, *during*, and *after* capture periods will be crucial to evaluate the effects of lynx removal on the local population in the Slovakia (action D1).

3. Survey areas

Three survey areas are identified for the project, the Volovské vrchy Mountains, the Vepor Mountains and the Vtáčnik Mountains (Fig. 1). These survey areas are selected on the basis of previous monitoring results from neighbouring areas (Muránska Planina NP and Štrážov Mountains PLA) indicating a viable lynx populations with densities 0.97 (± 0.25) lynx/100 km^2 of suitable biotop and 1.47 ± 0.37 lynx/100 km^2 of suitable biotop (Smolko et al. 2018, Kubala et al. in prep).

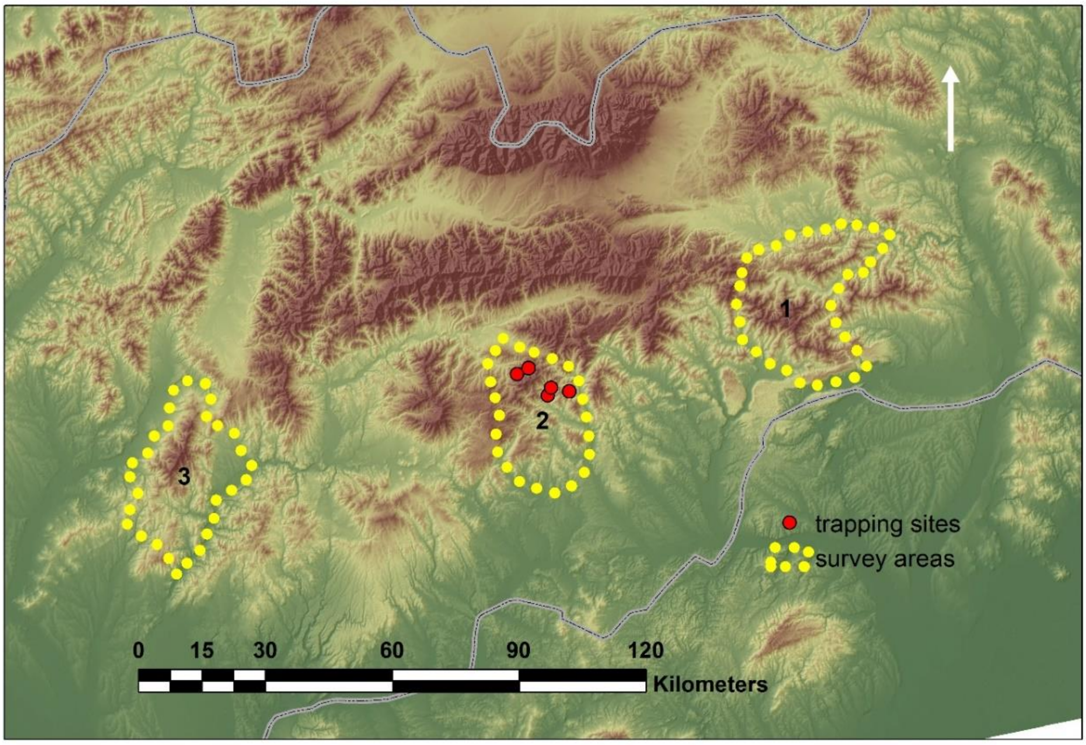

Figure 1. Three survey areas in the Slovak Carpathians. 1. the Volovské vrchy Mts., 2. the Vepor Mts. and 3. the Vtáčnik Mts. with potential trapping/capture sites within the Veport Mts.

The survey area Vepor Mountains (Fig. 2) are situated in central Slovakia, sub-province of Inner Western Carpathians, in the region of Banská Bystrica. The area of 870 km^2 is considerably rugged and reach 1,439 m a.s.l (Fabova hoľa) on its highest point. Vepor Mts. belong to slightly cold climatic areas. The average temperatures range from -6 ° C to 16 ° C. Majority of the survey area is covered by forests, mainly deciduous and mixed forests of maples, beeches, hornbeams and the spruce stands at higher elevations.

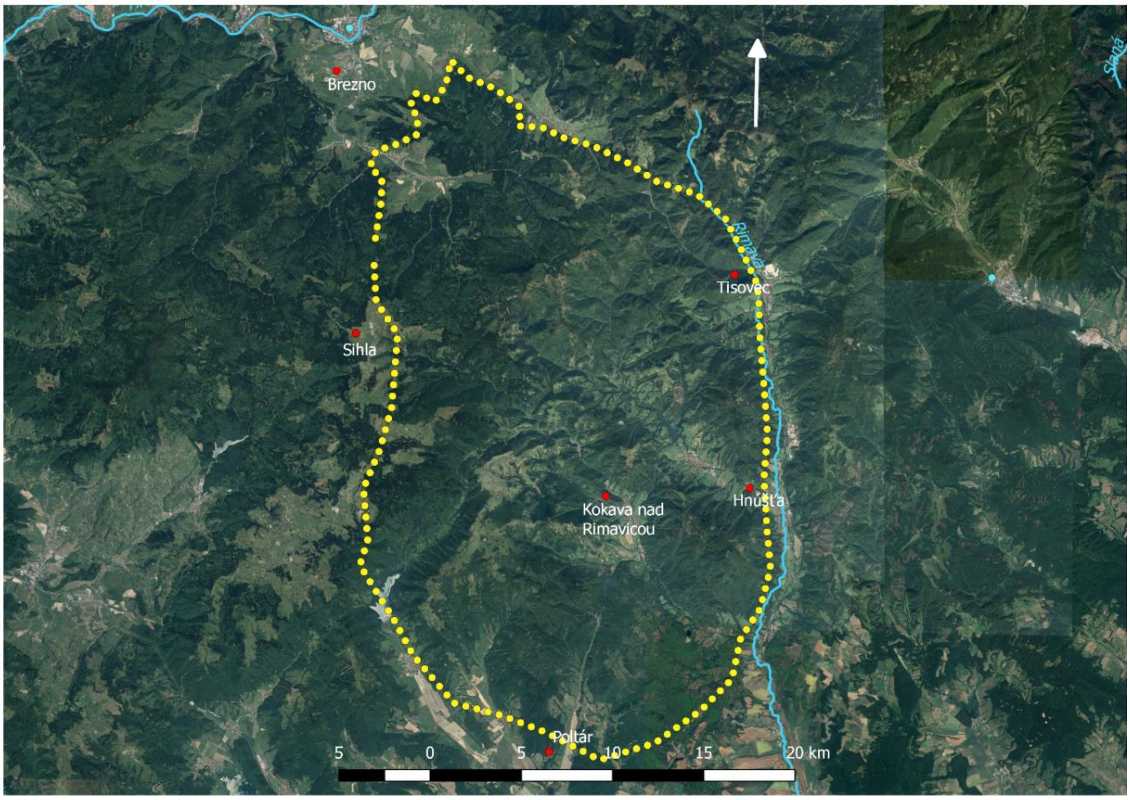

Figure 2. The survey area Vepor Mountains.

The Vtáčnik Mountains (Fig. 3) are situated in central Slovakia, sub-province of Inner Western Carpathians, in the region of Banská Bystrica, Trenčín and Nitra. The area of 736 km^2 is considerably rugged and reach 1,435 ma.s.l (peak Vtáčnik) on its highest point. Vtáčnik Mts. belong to the area of temperate to cold mountain climate. The average temperatures are -6 ° C and 18 ° C . The bulk of the survey area is covered by forests, however a minority of marginal parts are deforested and turned into grasslands. Vegetation at lower elevations is characterized by oak and hornbeam forests, at higher elevation by beech-fir forests.

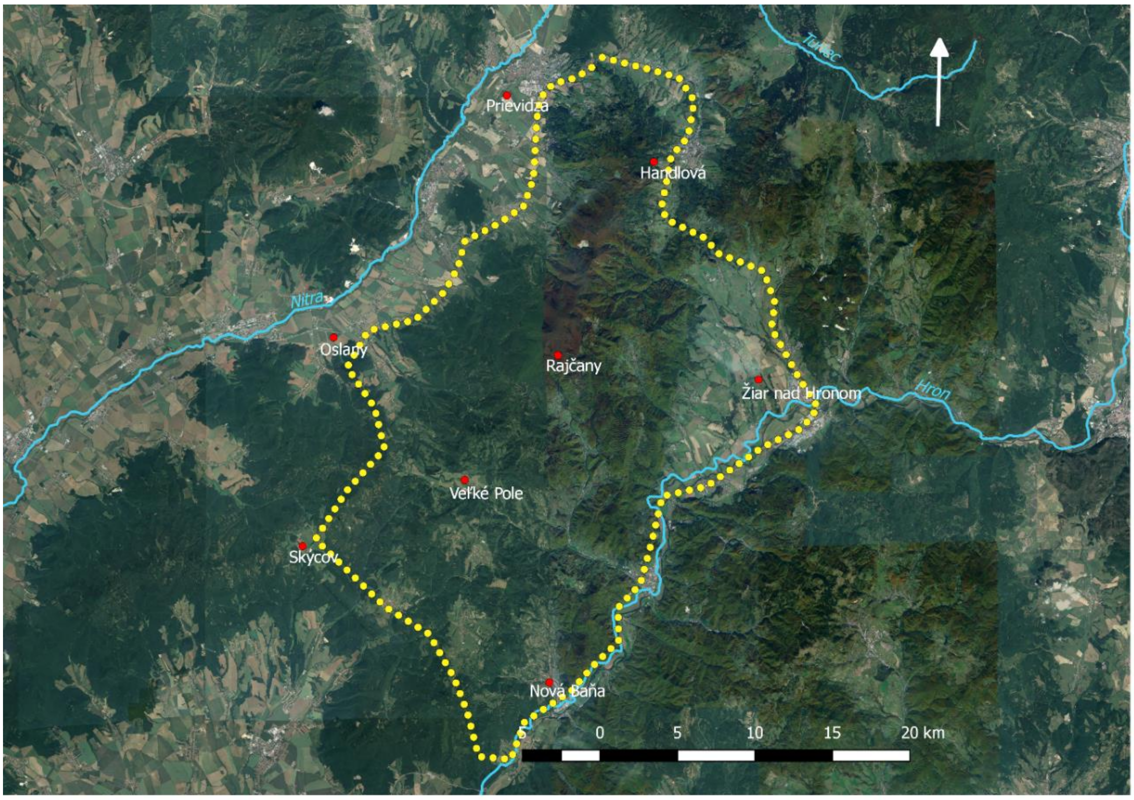

Figure 3. The survey area Vtáčnik Mountains.

The Volovské vrchy Mountains (Fig. 4) are situated in the eastern part of Slovakia, sub-province of Inner Western Carpathians, in the regions of Banská Bystrica, Košice and Prešov. The area of 703 km^2 consists of rugged mountains with an altitude of 300 to 1100 meters. Highest point is the peak Zlatý stôl with a height of 1322 m a.s.l. Local vegetation is diverse and species-rich due to the overlap of the Carpathian mountain climate and warmer lowland climate. The average temperatures are -4 ° C and 17 ° C. The bulk of the survey area is covered by forest with a predominance of spruce and fir. Beech and oak stands bind to the southern edge of the mountains.

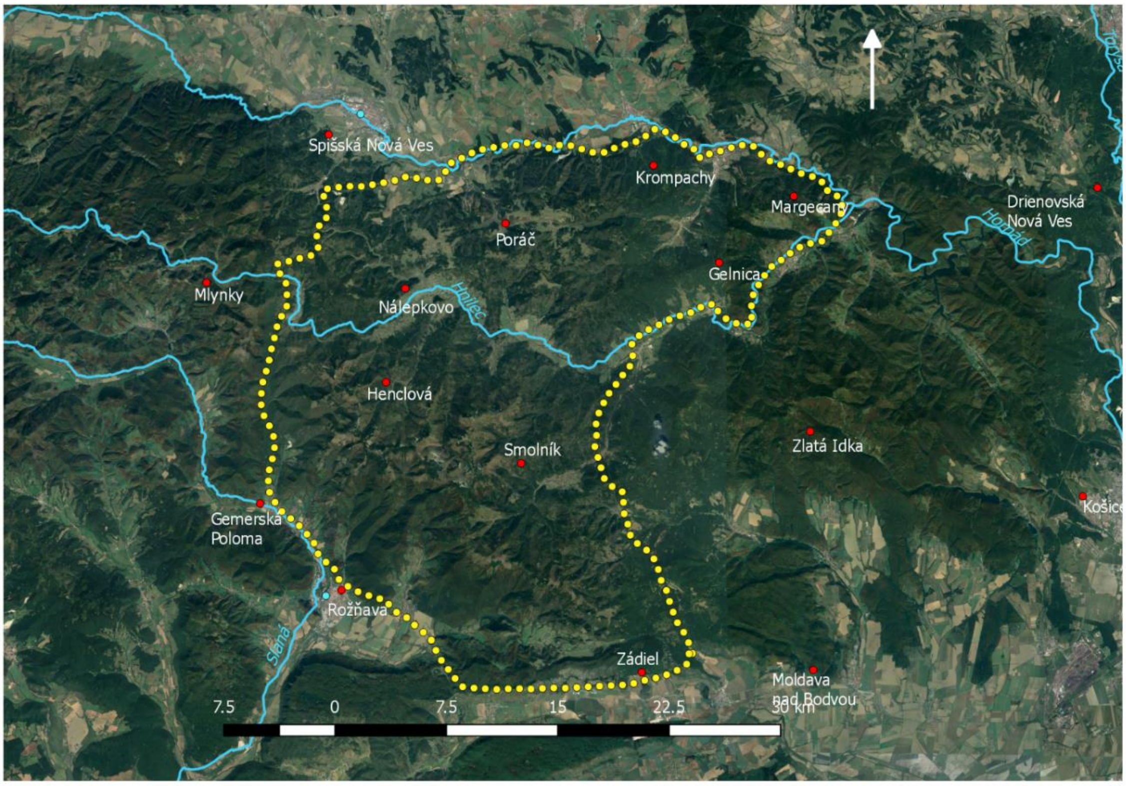

Figure 4. The survey area Volovské vrchy Mountains.

Along with the lynx, there are other carnivores such as brown bear (*Ursus arctos*), grey wolf (*Canis lupus*) and wild cat (*Felis sylvestris*) steadily present in the survey areas. Wild ungulates living in the areas include mostly red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*).

Due to the achievement of sufficient monitoring effort, each survey area will have a different importance over the course of the project. Consequently, survey areas will be considered as primary, and secondary. Within the primary survey area the majority of the effort and activities will be concentrated. Whereas in the secondary survey areas opportunistic activities will be conducted. A study area can be primary for the monitoring activities and secondary for capture activities or vice versa.

4. Aims and principles of monitoring

Conservation and management of species should always be based on a sound knowledge of the situation of its population (Breitenmoser et al. 2006). In order to gain such information of special concern, a field survey of lynx must be carried out, and the population must be monitored over time. Repeated surveys of the lynx population on a regular basis allows the detection of changes in the population over time. Long-term monitoring data will help to distinguish long-term population trends of increase or decrease from short-term fluctuations (Primack 1993) or random or methodological variation.

Monitoring is determined as a series of surveys, of which the results are continuously compared with a desired project objectives/goals (actions A1, A3).

Within the LIFE LYNX project two monitoring approaches are used:

(1) Passive monitoring: Within a passive monitoring system the data and information are not gained specifically for the purpose of monitoring the species or population. The collection, compilation and analysis of such data is an active process, however the data are collected for another purpose, randomly (or not), and will most likely be biased.
(2) Active monitoring: The gaining of data and information achieved specifically for the purpose of monitoring the lynx and its population. Scale, resolution, and rhythm of field activities as well as the methods used consider the objective of the monitoring system, the species' biology and the environmental conditions so that the data have the least possible bias and the result of the monitoring can directly answer the question asked with an absence of bias (Breitenmoser et al. 2006).

5. What will be monitored?

For the purpose of lynx population management and conservation (including the reintroduction and reinforcement programmes), the parameters being surveyed include distribution, population size and trend, abundance, health and genetic status. Parameters can be measured directly or indirectly, in absolute or relative figures.

Distribution: The most basic information about a species is its presence in a certain area. Surveys of species distribution are widely used and show in which areas a species is present, and where it is absent. Lynx usually have a rather compact distribution pattern, but there can nevertheless be a significant difference between the total area occupied and the areas of reproduction (Breitenmoser et al. 2006).

Population trend: Along with the information on the lynx distribution, it is possible to record its relative abundance in different areas. The frequency of direct or indirect signs (e.g. tracks, number of known mortalities, livestock and wild prey killed, etc.) can be used to detect a population trend in a given area or over time (if collected consistently in a standardised way over time). Indices are commonly used mainly because of the problems with obtaining precise population estimates. Moreover, in indices it is not certain how they are related to changing population density. A common assumption is that indicates are a linear function of population density, which is however often not the case (Breitenmoser et al. 2006).

Abundance: Rather than trying to count all lynx present within a survey area, population estimators attempt to sub-sample the population and calculate the proportion of individuals that are not counted (Breitenmoser et al. 2006). Methods such as the capture-recapture (CR) belong to this category and generally produce an estimate of statistical error that can be expressed as a confidence interval. Lynx occur often at low densities and small populations which are problematic to estimate with classical CR approaches, as the error tends to be quite large. This can be however compensated through an increased sampling effort (e.g. use of more camera traps etc.) and use of the spatial models (SCR; Royle et al 2009a, b), due to their wider flexibility in the design of the monitoring (Zimmermann et al. 2013, Pesenti & Zimmermann 2013, Rovero & Zimmermann 2016, Kubala et al. 2017, Smolko et al. 2018).

Health and Genetics: Diseases and parasites may have a considerable effect on large carnivore populations (Ryser-Degiorgis 2015). Therefore, the health, condition and genetic status of lynx within a population should also be part of a robust monitoring programme (Nowell & Jackson 1996, Ryser-Degiorgis 2001). Such data can be gained from lynx found dead (Stahl & Vandel 1999, Schmidt-Posthaus et al. 2002), as well as from animals handled during the captures (Ryser-Degiorgis 2015) and from the genetic samples collected in the field. For the lynx population in Slovakia, representing a previous and future source for reintroduction and reinforcement programmes, it would be particularly important to be able to carry out comparisons between populations in the future.

For the calibration process and the presentation of monitoring data over a large scale (e.g. the Slovak Carpathians), a standardized interpretation of the data and information collected on local scale is needed (Breitenmoser et al. 2006). This includes a common terminology and an agreement on how to classify the data (Molinari-Jobin et al. 2003, 2017, Breitenmoser et al. 2006, Molinari et al. 2012). For the monitoring of the lynx in the Slovak Carpathians the frame of the SCALP surveys and the following terminology and standards were adopted (Molinari-Jobin et al. 2003, 2017, Antal et al. 2016): The collected data are classified in three categories:

Category 1: "Hard facts", verified and clear data such as (1) dead lynx, (2) orphaned young lynx or lynx captured, (3) clear lynx pictures, and (4) samples (e.g. scats, urine, saliva, hair) attributed to lynx by means of genetic analyses (Molinari-Jobin et al. 2003, 2017).

Category 2: Data verified and confirmed by a specialist (game warden, wildlife ranger, biologist, trained member of the network, etc.) such as (1) livestock or (2) wild prey killed by lynx, (3) lynx tracks or other field signs, (4) scats, and (5) documented (recorded) and confirmed lynx calls (Molinari-Jobin et al. 2003, 2017). Category 2 data encompass a certain uncertainty. They are however collected and reported in a consistent way (most often by means of prepared forms) by trained people and build the core of the set of chance observations used for the monitoring (Breitenmoser et al. 2006).

Category 3: Unconfirmed category 2 data (livestock or wild prey kills, tracks, scats, calls) and all unverifiable informations such as direct observations (Molinari-Jobin et al. 2003, 2017). The classification of the data in different categories is a first step in the analyses and already includes a degree of interpretation. Sightings may not be confirmed and are therefore difficult to handle. Repeated sightings – or other category 3 data – may indicate a newly settled or not seriously monitored area, where more survey effort may be needed.

The distribution of the data of the three categories may vary considerably: The dispersion of C1 data reflects mainly the distribution of the vital part of a population, with reproduction and mortalities (Molinari-Jobin et al. 2003, 2017). However, both, dead lynx found or young lynx observed are relatively rare events. Thus, missing just a few records may lead to a biased interpretation. C2 data show the distribution of the entire population including core and expansion areas. For the collection of C2 data, an expert network is needed and members need to be specially trained. C3 data are "cheap" information, because they do not depend on a trained network of observers. They are chance observations contributed by the interested groups and public, which can be informed through media announcements. The distribution in time and space of category 3 data is consequently strongly biased. It however helps to identify regions where the monitoring effort needs to be intensified.

6. Monitoring network

Monitoring a rare and elusive species such as the lynx over a large area (within multiple survey areas) requires a network of well-trained collaborators (observers and reporters; Breitenmoser et al. 2006, Molinari-Jobin et al. 2003, 2017). Monitoring network can be compiled from the professionals such as game wardens and forestry or wildlife managers, who are regularly trained. It is also necessary to involve volunteers such as foresters, hunters or naturalists into the monitoring, especially if the professional staffs do not have the time, resources, or capacity to implement the monitoring activities. Volunteers will collect chance observation on a local scale and help with transects or camera trapping.

7. Passive monitoring: Collecting a chance (opportunistic) information

The crucial fact towards a systematic monitoring of a lynx population is to assure that chance observation or opportunistic data are reported and compiled into a database, most efficiently attached to a geographic information system (GIS). There are three types of information, which can be integrated into a passive monitoring (according to Breitenmoser et al. 2006):

(1) lynx found dead,

(2) livestock or wildlife killed by lynx

(3) chance observations.

8. Active monitoring: Systematic surveys and monitoring system

Data from the active monitoring are collected in a targeted and systematic way to assure that the sample is as homogenous as possible. On one hand, data gained in a systematic monitoring process can often be used to answer basic scientific questions, and on the other hand, baseline data about life history, land tenure system, predator-prey-relation, etc. can be used to calibrate monitoring data (Breitenmoser et al. 2006).

8.1. Snow tracking

Snow tracking is a widely used method for wildlife monitoring during winter season on appropriate snow conditions (Smolko et al. 2018).

Methodology: The snow tracking is performed on transects prepared in advance and representing habitats situated in the survey area proportional to the overall representation (Smolko et al. 2018). The entire transect is recorded in to an GPS device. All geographical coordinates of the presence signs of lynx and other large carnivores, as well as the number of tracks of ungulates for every 1 km section of the transect are recorded.

Analysis and specific data representation: In contrast to camera trapping burdened by a spatial bias, transects offer a reliable and objective view on animal distribution in a relatively large territory and in a short period of time (D'Eon 2001). The occurrence of lynx and the number of tracks per 1 km of transect are spatially displayed and subsequently statistically evaluated.

Interpretation: The biggest advantage of the method is the immediate current overview of the occurrence of particular species. Moreover, in comparison to camera traps, the advantage lies mainly in precision, or rather in the representativeness of results, economical costs and the speed of implementation.

Reporting: The data and information collected within the transects are compiled in a monitoring report and together with results from different methods included in scientific publications.

Requirements and Efforts: Snow tracking is a more demanding method in terms of man power, physical effort, logistics and safety. The technical equipment must be provided along with training of the responsible persons. Furthermore, communication, coordination analysis and subsequent reporting are needed as well.

8.2. Opportunistic and standardized collection of samples (scat, urine, hair, saliva, blood and tissues) for genetic analysis

Methodology: Scat collection is possible during the autumn, winter and spring periods under stable weather. Samples are collected in ethanol-filled tubes or silica gel tubes. Collection of the lynx scats is very demanding, so it is necessary to combine it with the collection of other samples as well. Urine can only be collected under suitable conditions (within the presence of a snow cover). The hair is collected and stored in a dry state until the DNA extraction phase. Blood as a source of DNA is taken from the captured lynx and animals released into the wild after their rehabilitation. Saliva is taken from the mucous membranes of the oral cavity and the lynx prey.

Analysis and specific data representation: The extracted DNA is archived in a frozen state. Individual genotypes are analysed by fragmentation analysis or sequencing. Outcomes from the laboratory analyses to study genetic variability, genetic structure, and gene flow among fragmented populations are processed in statistical programs developed for population and landscape genetics.

Interpretation: By combining genetic results from collected samples with landscape elements, we are able to identify the core populations, marginal populations, important migration corridors for gene flow, migration rate and relatedness. By analysing samples from the robust systematic monitoring, we can estimate the current population size and the effective population size.

Reporting: The data and information collected are included in a monitoring report, and together with results from different methods used for scientific publications.

Requirements and Efforts: This approach is implemented through the cooperation of all interested groups, institutions and individuals. It is also necessary to provide technical equipment, to train responsible persons and to communicate amongst the interest group, to coordinate and analyse the data recorded and to report it as well.

8.3. Camera trapping

Camera trapping is a standard method for monitoring and research of rare species, in particular felids, which can be identified on the basis of their phenotypic characteristics – natural markings (e.g., spotting in lynx Breitenmoser and Breitenmoser-Würsten 2008). This non-invasive method has a great potential and is used for a wide variety of species (Rovero & Zimmermann 2016), including the Eurasian lynx (Laas 1999, Melovski et al. 2009, Weingarth et al. 2012, Pesenti and Zimmemann 2013, Avang et al. 2014, Kubala et al. 2017). The principle of this method is to record as many pictures of the lynx within the project area and a predefine time period with estimating the size of its population using the statistical nonspatial and spatial methods (Breitenmoser et al. 2006, Rovero & Zimmermann 2016). Camera trapping in the Slovak Carpathians is implemented since 2011 (Kubala 2014, Kubala et al. 2017). The use of this monitoring method is realized through two approaches: 1. opportunistic or extensive monitoring during a specific period of the year, vegetation or non-vegetation period, or throughout the year with the aim of recording and identifying as many lynx as possible, and 2. Deterministic monitoring using "classical" estimates of the population size estimates in the project areas. Both approaches have to be combined because the opportunistic monitoring records can help to identify lynx during the deterministic monitoring (Breitenmoser et al. 2006).

8.3.1. Opportunistic camera trapping

Opportunistic monitoring is the use of camera traps on the project areas throughout the year without methodological or statistical requirements.

Methods: The opportunistic use of camera traps allows the collection of data on lynx throughout the year in the survey areas with relatively little effort and cost (Breitenmoser et al. 2006). Overall ≥ 10 camera traps within each survey area are placated in locations with the highest probability of lynx pictures, or at the confirmed lynx kills by the project team in collaboration with all interested groups (wildlife rangers, foresters, hunters etc.). This approach will promote mutual cooperation and confidence among interested groups as well as the collection of data on the presence of lynx, other species of carnivores or all prey species (Kubala et al. 2017).

Analysis and specific data representation: data are stored (archived) in the database. For individuals identification, all new lynx pictures are compared to the already identified animals. The results can be presented in the form of statistical or spatial outputs and used for actions or events in the context of education and cooperation with the public (Breitenmoser & Breitenmoser Würsten 2008).

Interpretation: opportunistic camera trapping does not allow statistical estimates of the lynx population size, but provides the possibility of evaluating the presence of a minimum number of animals within a survey area (Breitenmoser et al. 2006). Furthermore, information on the known lynx is gained, unknown individuals can be identified, and occasionally, reproduction success or dispersal distances and spatial use can be documented. The identification of unknown lynx with pictures of their both body sides is of special importance for the deterministic camera trapping in the same area (Breitenmoser et al. 2006, Kubala et al. 2017). If the opportunistic use is applied over several years, the documentation of the individual history of lynx allows certain statements on survival and population trend (Rovero & Zimmermann 2016).

Reporting: information and data obtained through opportunistic camera trapping must first of all needs to be reported to all interested and involved groups and people. The results are included in the regular monitoring reports and scientific publications.

Requirements and Efforts: This approach is implemented through the collaboration of several interested groups, institutions and individuals. It is necessary to provide the technical equipment, to train the responsible persons, to communicate, coordinate and analyse the recorded data with their subsequent reporting.

8.3.2. Deterministic camera trapping

Deterministic camera trapping allows the estimation of population size with evaluation of their accuracy (standard error, 95% confidence interval, etc.).

Methods: in survey areas whose size and shape must be sufficient to include a representative part of the population (≥ 350 km^2; Smolko et al. 2018, Kubala et al. in prep), camera traps are placed in a systematic structure so that no lynx in the population has a zero probability of successful detection (Karnath & Nichols 2002). Camera traps are placed within a square grid of 2.5 x 2.5 km^2 (6.25 km^2) and locations with the highest probability of lynx (Fig. 4; Breitenmoser et al. 2006, Avgan et al. 2014, Kubala 2014, Kubala et al. 2017, Smolko et al. 2018). Overall 28 camera stations (2 camera traps positioned opposite to each other) are located into every 2nd square with the suitable habitat. The particular locations are primarily identified during the opportunistic monitoring. The most appropriate period for deterministic monitoring is late autumn and early winter (60 to 80 days during November – to first half of February; Breitenmoser et al. 2006, Wingarth et al. 2015, Kubala et al. 2017, Smolko et al. 2018).

Analysis and specific data representation: the results of statistical analyses can be supported by an already existing database of lynx identified during opportunistic monitoring (Breitenmoser et al. 2006, Zimmermann et al. 2007). Because the loss of information (or power of the statistics) is considerable if both sides of an lynx were not identified it is necessary to photograph both of its profiles (Rovero & Zimmermann 2016). The procedure to calculate capture-recapture statistics must be defined before the fieldwork, as it will influence the distribution pattern and duration of the camera trapping session (Breitenmoser et al. 2006). Standard non-spatial CR models generally require assumption of the demographic population closure, which is very difficult to achieve in species with large home ranges, and for this reason, spatial models (SCR) have to be used for population size estimates (Royle et al 2009a, b), because they allow wider flexibility in the design of the monitoring (Fig. 4; Zimmermann et al. 2013, Pesenti & Zimmermann 2013, Rovero & Zimmermann 2016, Kubala et al. 2017, Smolko et al. 2018). Lynx are long-living animals, which can disperse over large distances, and so the pictures must be considered over a large area and over several years. It is therefore essential to create a good database of all pictures and to maintain it with discipline (Breitenmoser et al. 2006).

Interpretation: Interpretation of the achieved results is straightforward. It provides an estimate of population size with its upper and lower confidence interval (Breitenmoser et al. 2006, Smolko et al. 2018). In the case of a large range of confidence interval and lack of statistical accuracy, analyses allow the estimation of the minimum number of lynx within the survey areas (Breitenmoser et al. 2006, Rovero & Zimmermann 2016). The data also provides important information on the reproduction, the spatial activity of different lynx and the presence of other species (including large carnivores and hunting species). Deterministic monitoring also allows the calibration of results obtained using other monitoring methods (Breitenmoser et al. 2006).

Reporting: Pictures of lynx indicate clear evidence for the presence of the species. Moreover, they are also a perfect tool for communication and public relation. The data and pictures collected are compiled in a monitoring report after each survey, and can be used for scientific publications (Breitenmoser et al. 2006).

Requirements and Efforts: Deterministic camera trapping is a relatively demanding approach with higher financial costs in context of the technical equipment. Quite a lot of effort is required for fieldwork, coordination as well as for the data analysis. The continuous controls of the camera traps and the database must also be ensured.

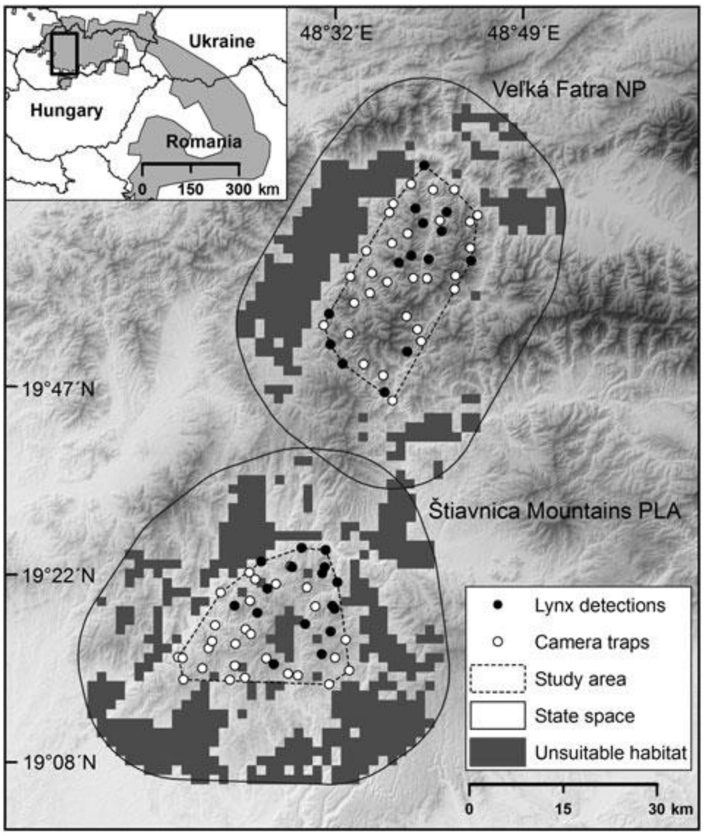

Figure 4. Locations of camera traps in two survey areas (Štiavnica Mountains PLA a Veľká Fatra NP) in the Slovak Carpathians. Mean convex polygons were enlarged by buffers, resulting in state-spaces with unsuitable (shaded) and suitable lynx habitat. The shaded area in the inset shows the lynx´s distribution in the Carpathian Mountains (Kaczensky et al. 2013),

8.4. Captures and GPS/GSM telemetry

GPS/GSM telemetry monitoring and captures of lynx carried out within it provides very important information that can be used to calibrate the results obtained using different methods as well as the entire monitoring program (Breitenmoser et al. 2006). This approach is the most effective method for surveying the lynx biology and ecology (Breitenmoser & Breitenmoser-Würsten 2008) and its use exceeds the monitoring requirements (Breitenmoser et al. 2006). If the telemetry survey and the monitoring takes place at the same time in the same survey area, the mutual benefit is obvious and direct. The monitoring can provide information about uncollared individuals, and the telemetry survey allows optimising the design of the monitoring programme (Breitenmoser et al. 2006).

Methods: Based on the spatial design of suitable locations and identified lynx prey, animals are captured (≥ 3 box traps in each survey area) in the shortest possible time by a registered veterinarian and trained professionals. Tranquilization of lynx is carried out using certified products and professional approach. Morphological and phenotypic data are collected for better identification of the same individuals during the camera trapping surveys. In addition, biological and genetic samples are collected, subsequently analysed and archived during the continuous health and genetic surveillance.

Analysis and specific data representation: telemetry monitoring provides information on lynx spatial behaviour and requirements (parameters of home ranges, migrations and movements, or the habitat use etc.) and also allows identification of suitable locations for camera trapping (Breitenmoser et al. 2006). Absolute values and numbers gained by telemetry can be used to estimate the lynx population size from relative values obtained using other monitoring methods (Molinari-Jobin et al. 2001, Breitenmoser et al. 2006, Breitenmoser & Breitenmoser Würsten 2008). Habitat models calculated from telemetry data are an important component for evaluation of the suitable habitat connectivity. Lynx diet analysis allow an assessment of the impact on the ungulate populations. Data from telemetry monitoring will also allow the survival evaluation of the rehabilitated lynx, their adaptive capacities as well as their success in reproduction within the reintroduced populations in Europe.

Interpretation: Interpretation of any results is difficult if basic data on species biology and ecology are not available (Breitenmoser & Breitenmoser Würsten 2008). For this reason, telemetric monitoring is necessary to calibrate the results obtained from other monitoring methods and, in combination with them, more relevant outputs needed for actions in the framework of the lynx management and conservation (Breitenmoser et al. 2006).

Reporting: Results are reported to all interested groups and public in the form of regular reports and scientific publications.

Requirements and Efforts: Telemetry monitoring is a financially very demanding approach. Its implementation must be ensured through the collaboration of several interest groups, institutions and professionals.

9. Survey, monitoring and capture time-frame

Year 1 (August 2017 - May 2018)

1- Vepor Mts. – primary survey area, deterministic monitoring, captures;

2- Vtáčnik Mts. – secondary survey area, opportunistic monitoring;

3- Volovské vrchy Mts. – secondary survey area, opportunistic monitoring.

Year 2 (September 2018 – May 2019)

1- Vepor Mts. – secondary survey area, opportunistic monitoring, captures;

2- Vtáčnik Mts. – primary survey area, deterministic monitoring, captures;

3- Volovské vrchy Mts. – secondary survey area, opportunistic monitoring.

Year 3 (September 2019 – May 2020)

1- Vepor Mts. – secondary survey area, opportunistic monitoring, captures;

2- Vtáčnik Mts. – secondary survey area, opportunistic monitoring, captures;

3- Volovské vrchy Mts. – primary survey area, deterministic monitoring, captures.

Year 4 (September 2020 – May 2021)

1- Vepor Mts. – primary survey area, deterministic monitoring, captures;

2- Vtáčnik Mts. – secondary survey area, opportunistic monitoring, captures;

3- Volovské vrchy Mts. – secondary survey area, opportunistic monitoring, capture.

Year 5 (September 2021 – May 2022)

1- Vepor Mts. – secondary survey area, opportunistic monitoring, captures;

2- Vtáčnik Mts. – primary survey area, deterministic monitoring, captures;

3- Volovské vrchy Mts. – secondary survey area, opportunistic monitoring, captures.

Year 6 (September 2022 –April 2023)

1- Vepor Mts. – secondary survey area, opportunistic monitoring, captures;

2- Vtáčnik Mts. – secondary survey area, opportunistic monitoring, captures;

3- Volovské vrchy Mts. – primary survey area, deterministic monitoring, captures.

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