



**BALKAN  
LYNX**  

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**R E C O V E R Y  
P R O G R A M M E**

## **Balkan lynx monitoring protocol**

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## Glossary

BLRP	Balkan Lynx Recovery Programme. The Balkan Lynx Recovery Programme (BLRP) aims to restore a viable Balkan lynx population by addressing key threats. Through transboundary collaboration, research, monitoring, community engagement, policy advocacy and communication, the programme is working to improve conservation strategies, strengthen legal protection, and establish a sustainable habitat network for the species ( <a href="http://www.balkanlynx.com">www.balkanlynx.com</a> ).
ERA	The Environmentally Responsible Action (ERA) group is passionately dedicated to ensuring the Balkan lynx can thrive once more. Their work is committed to protect and restore a healthy, sustainable habitat for this critically endangered species by addressing its most significant threats. Their efforts include ongoing research, monitoring, and education to raise awareness and foster a sense of shared responsibility. ERA plays a key role within its country by promoting the Balkan lynx and actively integrating it into school curricula. By engaging local communities and advocating for strong policies, they aim to create a future where the Balkan lynx can flourish. Their ultimate goal is to enhance conservation strategies, strengthen legal protections, and develop a resilient network of habitats that will secure the long-term survival of this majestic feline for generations to come.
Intensive camera trapping	Intensive camera trapping refers to a survey design in which camera traps are deployed at high spatial density (at least two sites per female home range) and in a systematic manner, with two cameras per site to photograph both flanks, and operating continuously for at least 60 days, with the objective of maximizing detection probability and enabling robust inference on population parameters such as abundance or density. The trap array encompasses the home range of at least three females.
MES	Macedonian Ecological Society (MES). MES is the leading national expert on ecology and conservation in the civil society. With over 50 years of institutional expertise it has been active in providing publicly available scientific material and uniting experts from all related sciences.
Opportunistic camera trapping	Pictures by chance, no planned placement or standardization, i.e. all lynx photos which do not fulfil the criteria for systematic and/or intensive camera trapping.
PPNEA	Protection and Preservation of Natural Environment in Albania (PPNEA). It is the first environmental NGO, operating nationwide since its establishment on 5 June 1991. Since 2006, has led large-scale

efforts to conserve the critically endangered Balkan Lynx through the Balkan Lynx Recovery Programme. The programme's innovative approach has become a benchmark for wildlife monitoring, protected areas management and conservation in Albania.

Systematic camera trapping

Camera traps which had been working for at least 30 days during the respective year and for which the trapping effort is known. A distinction is made based on whether or not attractants were used (e.g. lure to attract lynx or the camera is used as surveillance of ungulate feeding stations).

# Introduction

Monitoring programmes are fundamental to much of our understanding of the natural world and play an integral role in biodiversity conservation by providing valuable knowledge about the state of ecosystems and populations (Jones, 2011). These programmes help track changes over time, offering crucial insights into species dynamics, habitat quality, and broader ecological trends. Effective monitoring is essential for assessing the impacts of environmental changes, human activities, and conservation interventions, allowing for adaptive management strategies that can mitigate potential threats to biodiversity (Nichols & Williams, 2006).

Among the most critical aspects of wildlife monitoring are the distribution and abundance of species, as these parameters serve as primary indicators of population health and viability (Yoccoz et al., 2001). Understanding where species occur and how their numbers fluctuate over time is vital for making informed management decisions, identifying priority areas for protection, and assessing the effectiveness of conservation and management actions. However, when dealing with populations of critical conservation status, such as those facing severe habitat loss, climate change pressures, or genetic bottlenecks, additional layers of information are required. Demographic data, including reproduction rates, mortality factors, and dispersal provide insight into population trends and long-term viability. Health assessments, encompassing disease prevalence and physiological condition, help identify emerging threats and inform mitigation efforts (Kophamel et al., 2022; Molinari-Jobin, Pavlov, et al., 2025). Genetic analyses further contribute to understanding population connectivity, genetic diversity, demographic history, and risks of inbreeding, all of which are crucial for formulating effective conservation strategies.

There is no single monitoring method capable of capturing all these aspects comprehensively. Instead, a suite of carefully selected methodologies must be integrated to obtain a holistic perspective on population status and trends. Camera trapping, telemetry, genetic sampling, direct observations, sign surveys and citizen science initiatives can each provide unique and complementary data, enhancing the overall reliability of monitoring results. The selection of appropriate methods depends on multiple factors, including species behaviour, habitat characteristics, data requirements, and logistical constraints.

Moreover, the implementation of monitoring programmes involves a delicate balance between the expected gain in knowledge and the feasibility and cost of surveys and analyses. While advanced techniques such as environmental DNA (eDNA) analysis and satellite tracking offer high-resolution data (Bohmann et al., 2014; Kays et al., 2015), they often require substantial financial and technical resources. On the other hand, traditional field surveys and community-based monitoring may be more cost-effective but can be limited in scope and accuracy (Danielsen et al., 2010). Thus, conservationists and researchers must carefully weigh the trade-offs between precision and resource availability when designing monitoring frameworks. Ultimately, a well-planned and adaptive monitoring strategy is key to ensuring that conservation actions are based

on robust scientific evidence, maximizing their effectiveness in preserving species and ecosystems.

Monitoring of large carnivores can involve passive or active approaches to data collection, both of which then require active handling, analysing and interpretation of the collected data (Breitenmoser et al., 2006). Opportunistic monitoring includes collecting all available data about a desired species from random sources or sources primarily serving another purpose. While opportunistic data collection is a realistic and important part of many monitoring programmes of large carnivores, systematic monitoring is the monitoring in the strict sense of the word (Breitenmoser et al., 2006).

To safeguard the future of the Balkan lynx (*Lynx lynx balcanicus*), accurate population estimates are essential for managers to implement targeted conservation measures and to assess their effectiveness. The Balkan lynx, a rare and elusive subspecies of the Eurasian lynx, is found in the mountainous regions of Albania, Kosovo and North Macedonia, and its population has been critically low for decades, with estimates suggesting fewer than 50 individuals in the wild (Melovski et al., 2015). Monitoring has started in 2006 (Breitenmoser et al., 2006) using questionnaire surveys (Melovski, Von Arx, et al., 2020). Intensive camera trapping started in 2008 to estimate population density using spatial capture recapture models in the population's core area (Melovski et al., 2025). However, so far there is no range-wide systematic monitoring in place.

Based on previous experiences and a comprehensive review of approaches, the Balkan Lynx Recovery Programme (BLRP) team has developed a standardized monitoring protocol for the Balkan lynx. This protocol is designed to be implemented across all range countries, ensuring consistency in data collection and facilitating the evaluation of effective conservation efforts for this critically endangered subspecies. While the stratified monitoring approach proposed by Breitenmoser et al. (2006) is maintained, we here provide detailed procedures of use in space and time of the different monitoring methods. The main objective of this monitoring scheme is to provide baseline data prior to reinforcement, during the releases and to track the population development after releases. The monitoring also needs to assure that the data can be used in case new methods are available.

## Chance observations

Citizen science is a valuable tool for collecting chance (opportunistic) observations because it mobilizes large numbers of volunteers across wide spatial and temporal scales, far beyond what professional monitoring alone can achieve (Dickinson et al., 2010). Such observations are especially useful for detecting rare, unexpected, or transient events, including uncommon species occurrences (Sullivan et al., 2014). When properly curated and statistically corrected for bias,

citizen science data can provide robust insights into species distributions and population trends (Bonney et al., 2014; Isaac et al., 2014). Moreover, citizen science strengthens public engagement with science and conservation, fostering awareness while simultaneously generating valuable ecological data (Theobald et al., 2015).

## Network of trained observers

To track population expansion into areas where no active monitoring is organised, contacts with local residents need to be established in order for them to report their findings of lynx signs of presence. Targeted presentations and disseminating booklets/brochures providing information about the status of the Balkan lynx as well as the identification of signs of presence to interest groups on a regular basis aims at facilitating the establishment of contacts. Potential observers such as hunters, farmers, forest workers, ornithologists, hikers, etc. are instructed about the importance of reporting chance lynx observations (Breitenmoser et al., 2006). As a consequence, additional data is collected (more eyes see more), and trust in the monitoring results is enhanced (Duchamp et al., 2011).



**Fig. 1.** Monitoring network member from Jasen Protected Area assisting the MES lynx team in the field.  
*Photo: Aleksandar Pavlov / MES*

While members of the general public can report signs of presence to [contact@mes.org.mk](mailto:contact@mes.org.mk) (North Macedonia) or [contact@ppnea.org](mailto:contact@ppnea.org) (Albania), the range countries have also established Monitoring Networks (MN) composed of trained observers who serve as local contact points. Network members are recruited from different sectors, such as hunters, foresters, game wardens, farmers, protected area staff, photographers, local guides, community residents, veterinarians, hikers, nature enthusiasts, journalists etc and are specifically trained in recognising lynx signs of presence, camera trapping and the collection of non-invasive genetic samples (Fig. 1). Across the Balkan lynx range, approximately 80-100 people are actively involved in helping with field work (camera trapping, box trap surveillance, sample collection). Network members provide information about lynx field observations (Fig. 2) and they receive regular information about the lynx population status and conservation efforts. The data and information collected through the monitoring network have contributed to improving the conservation status of the Balkan lynx, including better knowledge of its presence in new areas, evidence of reproduction and documentation of environmental crimes.



**Fig. 2.** Balkan lynx picture taken by touristic local guide using a mobile phone in the Albanian Alps in 2015.

## Types of signs of presence

The first step towards a systematic surveillance of a lynx population is to assure that chance observations are reported and compiled into a database (Breitenmoser et al., 2006). Opportunistic records include direct lynx sightings, findings of dead lynx, hearing of lynx calls, coincidental photos and videos recorded by people or camera traps, and various signs of lynx presence (tracks in snow, mud or sand, prey remains, resting sites, hair, scratch marks, faeces and urine, Fig. 3). All signs of presence are subsequently classified based on SCALP criteria<sup>1</sup> (Molinari-Jobin et al., 2012).

Signs of lynx presence are collected all year round by network members in the whole population range. This extensive survey aims at detecting any lynx presence, whether documented by hard facts (photograph, genetic analysis, mortality event) or by other signs of presence (visual observation, prey remains, tracks, etc.).



**Fig. 3.** Lynx footprint in snow (left) and lynx scat (right). *Photos: Aleksandar Pavlov / MES*

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<sup>1</sup> The collected data are classified in three categories: Category 1 (C1): “Hard facts”, verified and unchallenged observations such as dead lynx, clear photos of lynx and samples confirmed by means of genetic analysis. Category 2 (C2): Observations controlled and confirmed by a trained person such as killed livestock or wild prey and lynx tracks. Category 3 (C3): Unconfirmed but plausible observations of category 2 (kills, tracks, other field signs too old or badly documented) and all plausible observations such as direct observations, calls and scats which by their nature cannot be verified unless through photo, registration or laboratory analyses. Evidence of reproduction consists in photos of lynx kittens or young lynx found dead (C1), large and small tracks together (C2) and direct sighting of female with kittens (C3).

## Camera trapping

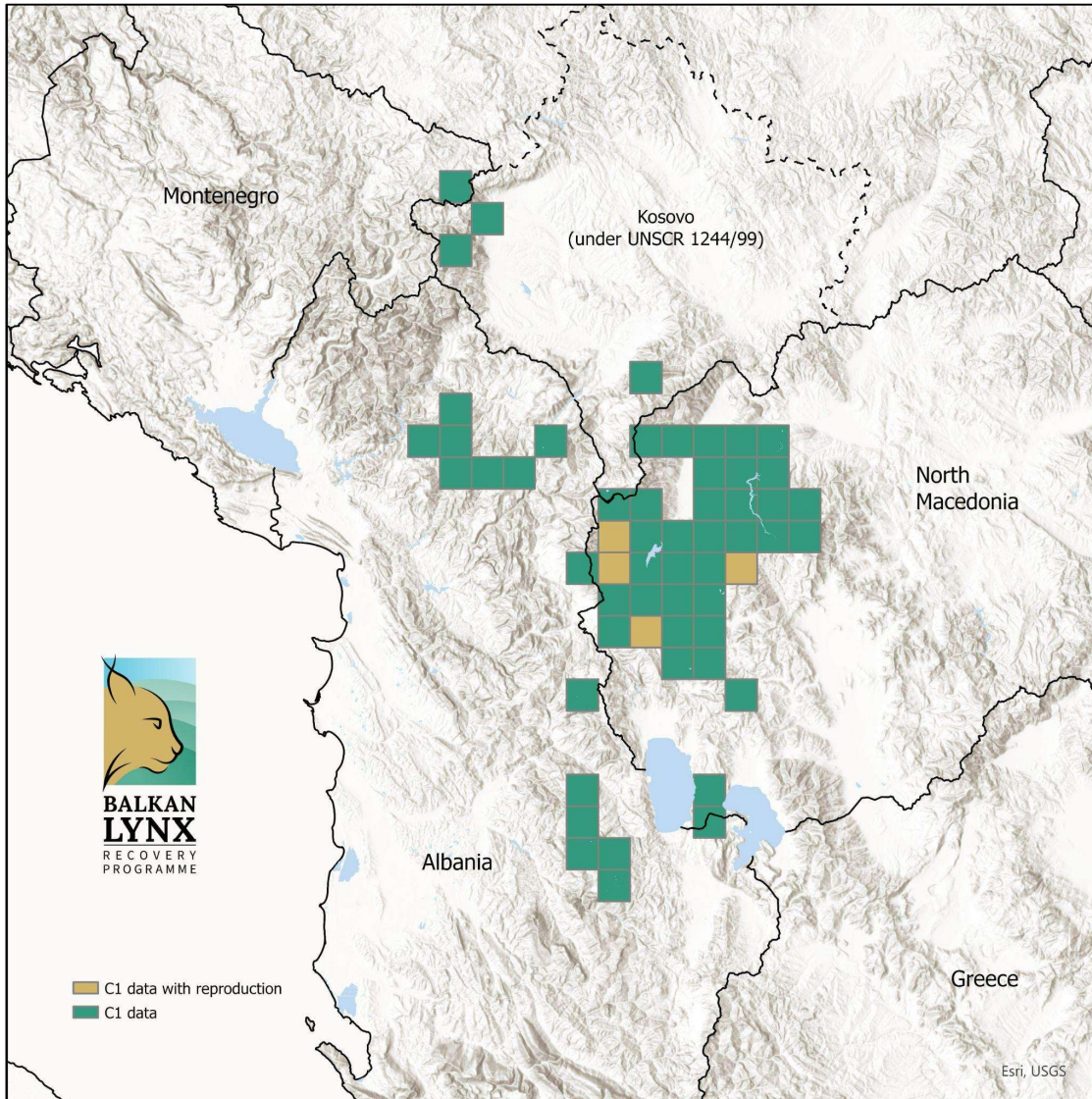
Camera trapping is nowadays one of the most important and widely used methods for lynx monitoring, as well as other feline species with spotted pelage (Hocevar et al., 2020). The pictures obtained with camera traps are objective and verifiable evidence of lynx presence (Molinari-Jobin et al., 2012) and allow individual identification based on the coat pattern (Thüler, 2002). We here do not treat the topics of selecting camera trap types and how to set them up, but refer to extensive literature (Rovero & Zimmermann, 2016) and web forums. Our aim is to use a uniform study design throughout the Balkan lynx range and make a clear distinction between different uses of camera traps.

### Systematic camera trapping

With the aim of obtaining as many lynx photos as possible throughout the whole range, systematic camera trapping is effectuated by the team itself or by network members (Fig. 3). The main difference to camera trap photos classified under “occasional report of signs of presence” is that the trapping effort is known by keeping track of the number of operating nights of each device. Systematic camera trapping is applied over the entire Balkan distribution area for the first time during winter 2025/2026. We aim to follow the subsequent protocol:

- In each 10x10 km grid cell, where a sign of C1 and/or C2 category had been reported in the previous five years, at least two camera traps are installed based on previous knowledge of lynx passages, hunter’s knowledge or topography.
- As soon as a lynx is pictured, the respective site is equipped with two camera traps in order to photograph both sides of the lynx simultaneously.
- Camera traps are working possibly all year long, and depending on collaboration with local hunters, they are maintained by them. Collaborators are visited regularly to exchange data.

From 2020 to 2024, a total of 57 10x10 km grid cells have been occupied (Fig. 4). Based on the above monitoring scheme, at least 112 camera traps are deployed year-round (6-8 in Kosovo, 28-30 in Albania and 78-82 in North Macedonia). Whenever capacity allows, neighbouring cells are additionally equipped with camera traps, focusing on additionally monitoring areas in between existing subpopulations.



**Fig. 4.** Occupied 10x10 km grid cells during the five-year-period from May 1 2020 to April 30 2024. Only hard fact data, i.e. C1, was considered (Molinari-Jobin et al. 2012). A distinction is made between C1 data with and without proof of reproduction (photo of lynx kitten).

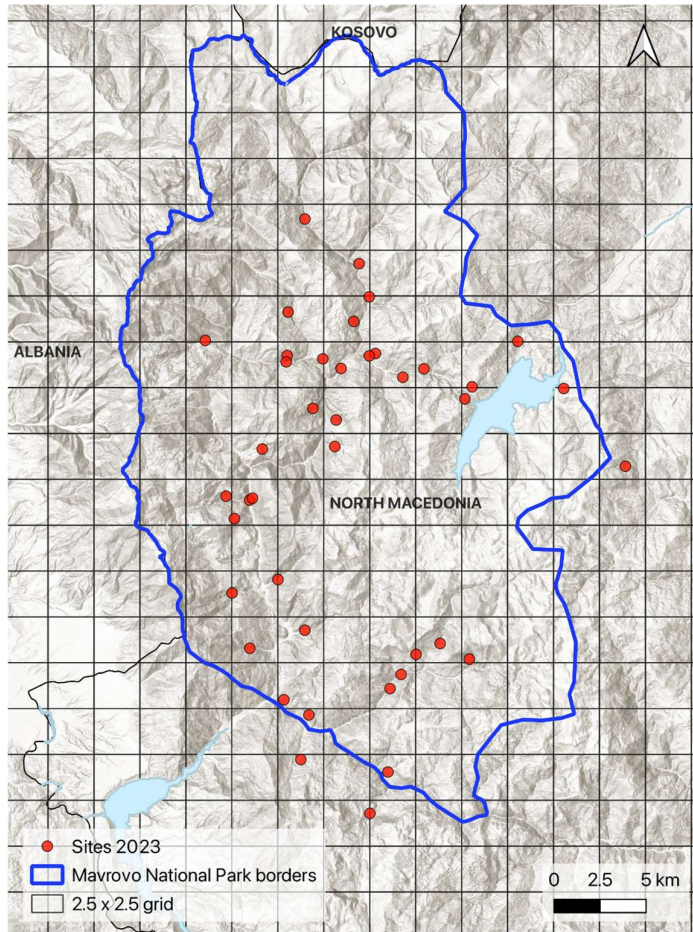
## Intensive camera trapping

With proper design, camera-trapping represents the best balance of rigor and cost-effectiveness for estimating density of cryptic species that can be identified individually (Balme et al., 2009). In contrast to the systematic camera trapping, during intensive camera-trapping camera traps are set up in order to estimate lynx density, with each site being equipped with two cameras to photograph both sides of a lynx. For density estimation, the camera-trapping array size and inter-camera spacing should be coupled to the species' spatial ecology (e.g. smallest home range size) to maximise sample sizes and spatial recaptures (Tobler & Powell, 2013). In their review of spatial capture recapture studies conducted with camera traps, Palmero et al. (2023) stated that the precision of population density estimates is mainly influenced by the number of individuals captured, the number of recaptures, and the capture probability. They concluded that researchers should mainly devote resources to enlarging the trap-array size. Besides, multiple sites should be set within the smallest home range area of the target species to increase the number of recaptures (Palmero et al., 2023).

In Central Europe, camera traps have been used to estimate lynx density in several studies, some of which followed the study design from Switzerland, where Laass (1999) used a grid with cell size 2.7 x 2.7 km, which was later changed to 2.5 x 2.5 (Zimmermann et al., 2013), and choosing sites for camera placement to optimise capturing the passage of a lynx in every second grid cell, but eliminating grid cells with unsuitable habitat. Based on this spatial design, at least four cameras were placed in each female's home ranges, i.e. 70 km<sup>2</sup> smallest home range documented in the north-western Swiss Alps of a female lynx (Breitenmoser-Wuersten et al., 2001). With an average female home range size of around 110 km<sup>2</sup> in the Balkans (Melovski, Stojanov, et al., 2020), this study design results in approximately 8 - 9 camera trap sites per female home range.

Recommendations for balancing the given number of camera traps between increase in trap-array or increasing the number of sites within a home range is under discussion within the Linking Lynx monitoring working group ([Monitoring Working Group | Linking Lynx](#)).

Density and trend estimations have been effectuated since 2008 and repeated every second or third year in the core area of the Balkan lynx range: a grid cell size of 2.5 x 2.5 km is used, where an optimal camera-trap site was chosen in every other grid cell after cells with more than two-third of their area above 1,800 m were discarded (Melovski et al., 2025). Depending on the year, a total of 30 to 41 sites were equipped with camera traps covering an area of 334 to 435 km<sup>2</sup> (Fig. 5). Two camera traps (with no bait) were deployed at each site to maximise identification chances by photographing both flanks of lynx. Camera traps were operative starting from mid to late February for a duration of at least 60 days.



**Fig. 5.** Sites chosen for intensive camera trapping in the area of Mavrovo National Park in February/March 2023.

In the coming years, intensive camera trapping is effectuated every second year in Albania and North Macedonia at the same time to profit from a multisession approach: Multi-session spatial capture–recapture models allow detection parameters to be shared across sampling sessions while allowing density to vary between sessions, thereby increasing sample sizes for detection parameter estimation and improving the precision of density estimates (Tourani et al., 2020). The sample areas are chosen based on the number of signs of presence collected in the previous three years, as we aim to do intensive camera trapping in areas with highest lynx densities. If the sample areas are close to the Kosovan border, Kosovo participates in the intensive camera trapping in order to increase the trap array.

## Genetic sampling

Genetic monitoring can be conducted using either invasive or non-invasive sampling techniques. Invasive methods involve capturing individuals to obtain tissue or blood samples, whereas non-invasive approaches rely on the collection of biological traces such as hair, scat, saliva at prey remains, or environmental DNA. While these non-invasive techniques allow genetic analyses without causing harm to animals (Schwartz et al., 2007), the extremely small population size of the Balkan lynx makes it highly unlikely that samples from 30 distinct individuals can be obtained within a single generation (approximately five years), as has been recommended by Breitenmoser-Würsten (Breitenmoser-Würsten, 2024). Despite this challenge, genetic monitoring is crucial to evaluate genetic diversity, inbreeding levels, and kinship structures within populations. These are the metrics with which the success of the population reinforcement will be measured. Therefore, collecting DNA samples is a priority and samples are collected whenever possible according to Skrbinišek (2017) and Molinari-Jobin et al. (2025).

## Radio-telemetry

Radio-telemetry is the most efficient way to study the biology and the ecology of lynx in the field, and its application goes far beyond monitoring (Breitenmoser et al., 2006). However, it is an invasive method for which capturing and sedation of live animals is required, before the collar is fitted. This provides opportunities to also assess animal health and body condition, reproductive status, conduct morphometric measurements, collect genetic and blood samples, and photograph the coat pattern for potential later identification during camera-trapping surveys (Hocevar et al., 2020; Molinari-Jobin, Gonev, et al., 2025; Molinari-Jobin, Pavlov, et al., 2025). Thanks to the radio-collar, movements of the animals can be followed according to a pre-defined schedule, providing information about habitat use, home range size, dispersal, predation, reproduction, survival and mortality (Boutros et al., 2007; Molinari-Jobin et al., 2007; Premier et al., 2025; Zimmermann et al., 2005). Even when sample size of radio-collared lynx is low, this method still contributes valuable information for calibrating other monitoring methods.

Usually, the collar is programmed to take three to six positions per 24 hours in order to balance battery life and knowledge gain. In the frame of BLRP, the base schedule of all collars is defined to take four positions per 24 hours: at 00:00, 06:00, 12:00, 18:00. This assures that meetings between two lynx can be detected due to synchronized schedules between lynx captured in all countries involved. However, schedules may be adapted according to specific needs.

## Database requirements

Effective monitoring relies not only on the collection of high-quality data, but also on how those data are stored, managed, and accessed over time. Well-designed databases are therefore a fundamental component of any monitoring program. They provide a structured framework that ensures data are consistent, traceable, and securely archived, allowing information to retain its value far beyond the moment of collection.

Good databases reduce errors, prevent data loss, and enable efficient handling of large and complex datasets that typically arise from long-term monitoring. They support standardized data entry, clear metadata documentation, and transparent links between observations, locations, time periods, and methods. This is essential for ensuring data quality and for making results reproducible and comparable across years.

The BLRP has an online database which is shared by all project partners. It contains data about chance observations, camera trapping and lynx individuals (Table 1). Additional excel files are kept for lynx mortalities, prey items, genetic sampling and captures (Table 2). The database is an important part of cross border collaboration.

**Table 1.** Structure of the Balkan lynx monitoring database and recorded attributes.

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Chance observations	Date and time, coordinates, SCALP category, type of sign, number of animals, juvenile animal (yes or no), individual ID, reporting institution, informant, photo of proof, comment
Camera trapping / photos	Date and time, coordinates, photo(s), number of animals, juvenile animal (yes or no), Individual ID, camera, session, comment
Camera trapping / sessions	Session name, institution, type of camera trapping, start and end date (date of last picture), number of cameras (one or two), placed for lynx monitoring (yes or no), comment
Individuals	Lynx ID/name, sex, mother, birth year, birth place, genetic code, date of death, first recorded date, coat pattern, captured, father, comment

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**Table 2.** Fields used to store information about mortality, predation, genetic sampling and captures.

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Mortality	Date and time, coordinates, cause of death, individual ID, sex, age, genetic code, reporting institution, informant, comment
Predation	Date and time, coordinates, SCALP category (2 or 3), species killed, age, sex, camera trap installed (yes or no), lynx ID
Genetic sampling	Date and time, coordinates, type, genotyping successful (yes or no), lynx ID, genetic code
Captures	Date and time, coordinates, lynx ID, sex, age, genetic code, weight, body measurements

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Additionally, 1) GPS data is screened for obvious outliers. Both the original file as well as the cleaned version are stored. If applicable the cleaned version contains remarks of events that were noticed during field work (additional VHF locations and their precision, prey remains and den site found etc). 2) Camera trap data is also used to extract the information on presence of prey species using software such as e.g. Agouti, Camelot, DeepFaune or Trapper. The BLRP team is making regular back-ups of all databases.

## Analyses

Collecting opportunistic records is an easy way of collecting data from the field, but a difficult element to interpret and integrate in detailed management or conservation schemes (Hocevar et al., 2020) as they are not collected in a systematic way. Moreover, the effort of collecting opportunistic data may change considerably in time, depending on the motivation and information provided to the public, or the network members. Therefore, the opportunistic records are biased and can give an imperfect picture of species distribution and trend.

Even though the type of data collected can be reliable (e.g. geo-tagged photos) or verified (e.g. re-visiting and inspecting a potential lynx kill) its reporting is often still dependent on the (random) observer (Hocevar et al., 2020). While false positive records are dealt with based on SCALP categorisation (Molinari-Jobin et al., 2012), false negative records can be estimated in a site-occupancy framework (MacKenzie et al., 2002). An important assumption of occupancy modelling

is that the probability of detecting and reporting a sign of presence does not equal 0 in any given site. We distinguish four levels of monitoring intensity:

1. camera trap nights > 700,
2. camera trap nights < 700 and > 182
3. Monitoring network members present; and
4. No information available.

Reporting of monitoring results cannot be delayed until scientific papers have been published. Consequently, popular interpretation and reporting must often be done ahead of sound scientific analyses. In most cases, large carnivore conservation is a controversial issue. A monitoring programme is a good opportunity to involve stakeholders and inform the public. A thoughtful presentation of the monitoring results is therefore an important part of the conservation programme (Breitenmoser et al., 2006). The small population size of the Balkan lynx population (Melovski et al., 2015) calls for a timely analysis of the collected data. This implies that databases are kept up to date. Depending on the camera trap site accessibility, SD cards from camera traps may be retrieved with considerable delay. However, the delay of data input should never exceed one year.

Based on all the collected data, annual monitoring reports are produced which contain:

1. Annual “naïve” distribution maps which distinguish between SCALP categories as well as signs with/without reproduction;
2. The trend of signs of presence;
3. Table of all known fatalities and causes of mortality;
4. Results of genetic sampling;
5. The minimal number of lynx photographed;
6. A map of camera trap search effort;
7. Information about home ranges / dispersal based on telemetry (if applicable); and
8. Lynx and prey abundance index based on camera trapping.

These reports are an important tool for providing feedback to monitoring network members as well as informing managers and the general public about the status of the Balkan lynx. Distribution dynamics evaluated by means of dynamic site-occupancy models (MacKenzie et al., 2003) and density estimates based on intensive camera trapping and spatial capture recapture analysis (Royle & Young, 2008) need a greater effort and are subject of scientific publications.

## Conclusions

Lynx monitoring in Europe mainly relies on family group counts (Andrén et al., 2002), collection of signs of presence (Molinari-Jobin et al., 2012), camera trapping (Rovero & Zimmermann, 2016), and radio telemetry (Breitenmoser et al., 1993). These methods have all been used for more than 20 years and are well adapted to local situations. Genetic monitoring has been used less frequently in lynx compared to brown bear and wolf, probably due to difficulty in finding genetic samples. However, genetic monitoring is crucial for monitoring small and isolated populations, or to track the effect of population reinforcements (Krofel et al., 2025). In the Balkan lynx range, we opt for a combination of several methods that combine low-cost range-wide collection of signs of presence with local high-intensity monitoring following the stratified monitoring approach proposed by Breitenmoser et al. (2006). We have not specifically mentioned methods which rely on snow, such as family group counts and snow tracking, because the climate in the Balkan lynx range does not assure a reliable snow cover. However, whenever snow is available, it is an optimal way of gaining more knowledge: finding lynx tracks (signs of presence), following lynx tracks finding prey remains (predation pattern, saliva sample for genetic analysis) and urine/scat (genetic samples).

Monitoring methods are developing fast, with the most recent tests providing promising results regarding DNA extraction based on snow collected from a lynx track (De Barba et al., 2024). As in the future the data gained during a monitoring programme may allow the answering of questions which we have not even begun to ask yet, it is important to store all data in save archives and to document thoroughly the methodology behind their collection (Breitenmoser et al., 2006). Last but not least, collaboration with local informants on one hand and between local conservation organizations in Albania, Kosovo and North Macedonia, governments, and international partners on the other hand is a key factor for gathering scientific data to inform conservation strategies and promote awareness.

## References

- Andrén, H., Linnell, J. D. C., Liberg, O., Ahlqvist, P., Andersen, R., Danell, A., Franzén, R., Kvam, T., Odden, J., & Segerström, P. (2002). Estimating total lynx *Lynx lynx* population size from censuses of family groups. *Wildlife Biology*, 8(4), 299–306. <https://doi.org/10.2981/wlb.2002.027>
- Balme, G. A., Hunter, L. T. B., & Slotow, R. (2009). Evaluating Methods for Counting Cryptic Carnivores. *The Journal of Wildlife Management*, 73(3), 433–441. <https://doi.org/10.2193/2007-368>

- Bohmann, K., Evans, A., Gilbert, M. T. P., Carvalho, G. R., Creer, S., Knapp, M., Yu, D. W., & De Bruyn, M. (2014). Environmental DNA for wildlife biology and biodiversity monitoring. *Trends in Ecology & Evolution*, 29(6), 358–367. <https://doi.org/10.1016/j.tree.2014.04.003>
- Boutros, D., Breitenmoser-Würsten, C., Zimmermann, F., Ryser, A., Molinari-Jobin, A., Capt, S., Güntert, M., & Breitenmoser, U. (2007). Characterisation of Eurasian lynx *Lynx lynx* den sites and kitten survival. *Wildlife Biology*, 13, 417–429.
- Breitenmoser, U., Breitenmoser-Würsten, C., Von Arx, M., Zimmermann, F., Ryser, A., Angst, C., Molinari-Jobin, A., Molinari, P., Siegenthaler, A., & Weber, J.-M. (2006). *Guidelines for the monitoring of lynx* (KORA Report No. 33; pp. 1–31).
- Breitenmoser, U., Kaczensky, P., Dötterer, M., Breitenmoser-Würsten, C., Capt, S., Bernhart, F., & Liberek, M. (1993). Spatial organization and recruitment of lynx (*Lynx lynx*) in a re-introduced population in the Swiss Jura Mountains. *Journal of Zoology*, 231, 449–464.
- Breitenmoser-Würsten, C. (2024). *Genetic monitoring and recommendations at metapopulation level*. Linking Lynx. [https://www.linking-lynx.org/?action=get\\_file&id=24&resource\\_link\\_id=8e](https://www.linking-lynx.org/?action=get_file&id=24&resource_link_id=8e)
- Breitenmoser-Würsten, C., Zimmermann, F., Ryser, A., Capt, S., Laass, J., Siegenthaler, A., & Breitenmoser, U. (2001). *Untersuchungen zur Luchspopulation in den Nordwestalpen der Schweiz 1997–2000* (No. 9; KORA Bericht, p. 88).
- Danielsen, F., Burgess, N. D., Jensen, P. M., & Pirhofer-Walzl, K. (2010). Environmental monitoring: The scale and speed of implementation varies according to the degree of peoples involvement. *Journal of Applied Ecology*, 47(6), 1166–1168. <https://doi.org/10.1111/j.1365-2664.2010.01874.x>
- De Barba, M., Baur, M., Boyer, F., Fumagalli, L., Konec, M., Miquel, C., Pazhenkova, E., Remollino, N., Skrbinšek, T., Stoffel, C., & Taberlet, P. (2024). Individual genotypes from environmental DNA: Fingerprinting snow tracks of three large carnivore species. *Molecular Ecology Resources*, 24(3), e13915. <https://doi.org/10.1111/1755-0998.13915>
- Duchamp, C., Boyer, J., Briaudet, P.-E., Leonard, Y., Moris, P., Bataille, A., Dahier, T., Delacour, G., Millisher, G., Miquel, C., Poillot, C., & Marboutin, E. (2011). Wolf monitoring in France: A dual frame process to survey time- and space-related changes in the population. *Hystrix, the Italian Journal of Mammalogy*, 23(1). <https://doi.org/10.4404/hystrix-23.1-4559>
- Hočevar, L., Fležar, U., & Krofel, M. (2020). *Overview of good practices in Eurasian lynx monitoring and conservation* (pp. 1–65) [INTERREG CE 3Lynx report]. University of Ljubljana.
- Jones, J. P. G. (2011). Monitoring species abundance and distribution at the landscape scale. *Journal of Applied Ecology*, 48(1), 9–13. <https://doi.org/10.1111/j.1365-2664.2010.01917.x>
- Kays, R., Crofoot, M. C., Jetz, W., & Wikelski, M. (2015). Terrestrial animal tracking as an eye on life and planet. *Science*, 348(6240), aaa2478. <https://doi.org/10.1126/science.aaa2478>

- Kophamel, S., Illing, B., Ariel, E., Difalco, M., Skerratt, L. F., Hamann, M., Ward, L. C., Méndez, D., & Munns, S. L. (2022). Importance of health assessments for conservation in noncaptive wildlife. *Conservation Biology*, 36(1), e13724. <https://doi.org/10.1111/cobi.13724>
- Laass, J. (1999). *Evaluation von Photofallen für ein quantitatives Monitoring einer Luchspopulation in den Alpen*. Natur- & formalwissenschaftliche Fakultät der Universität Wien.
- MacKenzie, D. I., Nichols, J. D., Hines, J. E., Knutson, M. G., & Franklin, A. B. (2003). Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. *Ecology*, 84(8), 2200–2207. <https://doi.org/10.1890/02-3090>
- MacKenzie, D. I., Nichols, J. D., Lachman, G. B., Droege, S., Andrew Royle, J., & Langtimm, C. A. (2002). Estimating site occupancy rates when detection probabilities are less than one. *Ecology*, 83(8), 2248–2255. [https://doi.org/10.1890/0012-9658\(2002\)083%255B2248:ESORWD%255D2.0.CO;2](https://doi.org/10.1890/0012-9658(2002)083%255B2248:ESORWD%255D2.0.CO;2)
- Melovski, D., Breitenmoser, U., Von Arx, M., Breitenmoser-Würsten, C., & Lanz, T. (2015). *Lynx lynx ssp. balcanicus* (errata version published in 2016). The IUCN Red List of Threatened Species. <https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T68986842A68986849.en>
- Melovski, D., Moreno, I., Stojanov, A., Pavlov, A., Gonev, A., Avukatov, V., Halotel-Diez, Y., Ivanov, G., & Zimmermann, F. (2025). A decade of monitoring the critically endangered Balkan lynx in its core area: Insights from spatial capture recapture models. *Global Ecology and Conservation*, 60, e03615. <https://doi.org/10.1016/j.gecco.2025.e03615>
- Melovski, D., Ivanov, G., Stojanov, A., Avukatov, V., Gonev, A., Pavlov, A., Breitenmoser, U., von Arx, M., Filla, M., Krofel, M., Signer, J., and Balkenhol, N. (2020). First insight into the spatial and foraging ecology of the critically endangered Balkan lynx (*Lynx lynx balcanicus*, Buresh 1941). *Hystrix the Italian Journal of Mammalogy*, 31(1), pp.26–34. <https://doi.org/10.4404/hystrix-00254-2019>
- Melovski, D., Von Arx, M., Avukatov, V., Breitenmoser-Würsten, C., Đurović, M., Elezi, R., Gimenez, O., Hoxha, B., Hristovski, S., Ivanov, G., Karamanlidis, A. A., Lanz, T., Mersini, K., Perović, A., Ramadani, A., Sanaja, B., Sanaja, P., Schwaderer, G., Spangenberg, A., ... Breitenmoser, U. (2018). Using questionnaire surveys and occupancy modelling to identify conservation priorities for the Critically Endangered Balkan lynx *Lynx lynx balcanicus*. *Oryx*, 54(5), 706–714. <https://doi.org/10.1017/S0030605318000492>
- Molinari-Jobin, A., Gonev, A., Hoxha, B., Lajçi, F., Leschinski, L., Melovski, D., Pavlov, A., Shyti, I., Trajçe, A., & von Arx, M. (2025). *Best practices for handling lynx: Guidelines for the Balkan Lynx Recovery Programme* (No. 1; Balkan Lynx Recovery Programme Report, p. 15). [www.balkanlynx.com/handling-lynx](http://www.balkanlynx.com/handling-lynx)
- Molinari-Jobin, A., Kéry, M., Marboutin, E., Molinari, P., Koren, I., Fuxjäger, C., Breitenmoser-Würsten, C., Wölfl, S., Fasel, M., Kos, I., Wölfl, M., & Breitenmoser, U. (2012). Monitoring in the

- presence of species misidentification: The case of the Eurasian lynx in the Alps. *Animal Conservation*, 15(3), 266–273. <https://doi.org/10.1111/j.1469-1795.2011.00511.x>
- Molinari-Jobin, A., Pavlov, A., Cvetkovikj, A., Gonev, A., Hoxha, B., Husaj, A., Leschinski, L., Moreno, I., Shikoska, I., Sindičić, M., Vasili, A., Von Arx, M., & Kvapil, P. (2025). *Guidelines for health monitoring of the Balkan lynx* (Balkan Lynx Recovery Programme Report No. 2; p. 21). [www.balkanlynx.com/health-monitoring](http://www.balkanlynx.com/health-monitoring)
- Molinari-Jobin, A., Zimmermann, F., Ryser, A., Molinari, P., Haller, H., Breitenmoser-Würsten, C., Capt, S., Eyholzer, R., & Breitenmoser, U. (2007). Variation in diet, prey selectivity and home-range size of Eurasian lynx *Lynx lynx* in Switzerland. *Wildlife Biology*, 13, 393–405.
- Nichols, J., & Williams, B. (2006). Monitoring for conservation. *Trends in Ecology & Evolution*, 21(12), 668–673. <https://doi.org/10.1016/j.tree.2006.08.007>
- Palmero, S., Premier, J., Kramer-Schadt, S., Monterroso, P., & Heurich, M. (2023). Sampling variables and their thresholds for the precise estimation of wild felid population density with camera traps and spatial capture–recapture methods. *Mammal Review*, 53(4), 223–237. <https://doi.org/10.1111/mam.12320>
- Premier, J., Bastianelli, M. L., Oeser, J., Anders, O., Andren, H., Aronsson, M., Bagrade, G., Belotti, E., Breitenmoser-Würsten, C., Bufka, L., Černe, R., Červený, J., Drouet-Hoguet, N., Đuľa, M., Fuxjäger, C., Herdtfelder, M., Hočevár, L., Jędrzejewski, W., Kont, R., ... Heurich, M. (2025). Survival of Eurasian lynx in the human-dominated landscape of Europe. *Conservation Biology*, e14439. <https://doi.org/10.1111/cobi.14439>
- Rovero, F., & Zimmermann, F. (Eds.). (2016). *Camera trapping for wildlife research*. Pelagic Publishing.
- Royle, J. A., & Young, K. V. (2008). A hierarchical model for spatial capture-recapture data. *Ecology*, 89(8), 2281–2289. <https://doi.org/10.1890/07-0601.1>
- Schwartz, M., Luikart, G., & Waples, R. (2007). Genetic monitoring as a promising tool for conservation and management. *Trends in Ecology & Evolution*, 22(1), 25–33. <https://doi.org/10.1016/j.tree.2006.08.009>
- Skrbinšek, T. (2017). *Collecting lynx noninvasive genetic samples* (LIFE Lynx Report, pp. 1–21).
- Thüler, K. (2002). *Spatial and Temporal Distribution of Coat Patterns of Eurasian Lynx (Lynx lynx) in two Re-introduced Populations in Switzerland*. Master's thesis, University of Berne.
- Tobler, M. W., & Powell, G. V. N. (2013). Estimating jaguar densities with camera traps: Problems with current designs and recommendations for future studies. *Biological Conservation*, 159, 109–118. <https://doi.org/10.1016/j.biocon.2012.12.009>
- Yoccoz, N. G., Nichols, J. D., & Boulinier, T. (2001). Monitoring of biological diversity in space and time. *Trends in Ecology & Evolution*, 16(8), 446–453. [https://doi.org/10.1016/S0169-5347\(01\)02205-4](https://doi.org/10.1016/S0169-5347(01)02205-4)

Zimmermann, F., Breitenmoser-Würsten, Ch., & Breitenmoser, U. (2005). Natal dispersal of Eurasian lynx (*Lynx lynx*) in Switzerland. *Journal of Zoology*, 267, 381–395.