

# LYNX MONITORING REPORT

for the Bohemian-Bavarian-Austrian Lynx  
Population in 2018/2019

2023  
(updated from 2020)



Ministerstvo životního prostředí



Bayerisches Landesamt für  
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Cover photo shows lynx female “Hope”. Photographed by © Julius Kramer with a high-resolution trail camera. This female was first registered in the Czech Republic and then dispersed to Bavaria and established a home range around the mountain Arber.



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## Summary

This report presents monitoring data of the BBA lynx population for the monitoring period 1.5.2018 - 30.4.2019 (LY18) and is one of two monitoring reports prepared for this population within the 3Lynx project, supported by Interreg CENTRAL EUROPE Programme. Our study area stretched along the border region of Germany, Czech Republic and Austria. Camera trapping was applied on an area of 13000 km<sup>2</sup> with 2-8 camera traps per 10 km x 10 km EU grid cells installed year-round. Lynx presence has been verified in 9100 km<sup>2</sup>. We identified 121 independent lynx (subadults and adults), 33 reproducing females with 66 juveniles. The maximum population size was estimated at 146 independent lynx.

36.4 % (n=44) of the recorded independent lynx were moving transboundary, in two or even three countries. 36.4 % (n=12) lynx families occupied a transboundary home range. We registered 9 cases of mortality (4 road accidents, 2 illegal killings, 1 orphan, 1 natural, 1 unclear).

We examined the survival of 110 independent lynx from LY17 to LY18. 15 adult lynx (23.1 % of all adults) recorded in LY17 were not recorded anymore in LY18: in one case it was due to road mortality, in 14 cases (21.5 %) the fate was unknown. We assume that most of these cases, where fate remains unknown are probably representing the dark figure of illegal killing. 19 subadult lynx (44.2 % of all subadults) recorded in LY17 were no longer recorded in LY18, in one case it was due to road mortality, in 18 (41.9 %) cases the subadult lynx disappeared. Two lynx whose age only could be determined as more than one year old, i.e. subadult or adult, were not recorded again in LY18. Due to these losses, the growth rate of the BBA lynx population is moderate with  $\lambda = 1.10$  (10 % growth rate).

We assume that illegal killing is the most important threat to the Bohemian-Bavarian-Austrian (BBA) lynx population, and road mortality is gaining in importance. Future conservation efforts must emphasize on taking effective measures against both threats.

Camera trapping proved to be a very valuable monitoring method and provided us with robust data on lynx distribution and population size. However, an ongoing and continuous approach is needed to monitor population dynamics effectively.



## 1. Introduction

Monitoring data are the base for decision-making in lynx conservation and management. Therefore, a lot of effort has been invested in improving and harmonizing monitoring methods for the Bohemian-Bavarian-Austrian (BBA) lynx population on a transboundary scale. The population-based monitoring stretches along the borders of Czech Republic, Germany and Austria. It includes almost the entire range of the current lynx population in these three countries of about 13000 km<sup>2</sup> - what to our knowledge is an exceptional case in Europe.

The harmonisation of data collection, data evaluation and data analysis started in 2013 during the TransLynx project, and is an ongoing process that continued with further methodical refinement within the 3Lynx project.

The present report is one of two monitoring reports in the scope of the 3Lynx project and represents collected monitoring data in the study area and for the BBA lynx population for the lynx year 2018 (1.5.2018-30.4.2019). The monitoring reports of lynx year 2017 (Minariková et al. 2023, updated from 2019) and lynx year 2018 represent the achievement of a fundamental goal of the 3Lynx project, the assessment of the BBA lynx population, which is part of the lynx conservation strategy prepared in the scope of the 3Lynx project (Output T3.3).

## 2. Study Area

The study area (Fig. 1) stretches across the border triangle of Czech Republic (Bohemia), Germany (Bavaria) and Austria. Its boundaries are determined by the Danube River in the South, Krušné hory and Frankenwald in the North, Waldviertel and Vysočina in the East and Fränkische Alb in the West.

The study area was defined for the purpose of lynx monitoring and habitat modelling in 2013 during TransLynx project. It was delineated by experts based on the knowledge of lynx habitat use, large-scale occurrence of signs of lynx presence over the previous 15 years and in accordance to the habitat models of Schadt (1998), Schadt et al. (2002), Rudolph & Fetz (2008), and Romportl in Anděl et al. (2010). Besides core habitat areas, it also includes adjacent suitable habitat patches where lynx is supposed to occur only sporadically. The study area was defined big enough to consider long-distance dispersers, migrants, habitat features and a possible future spreading of the BBA population.

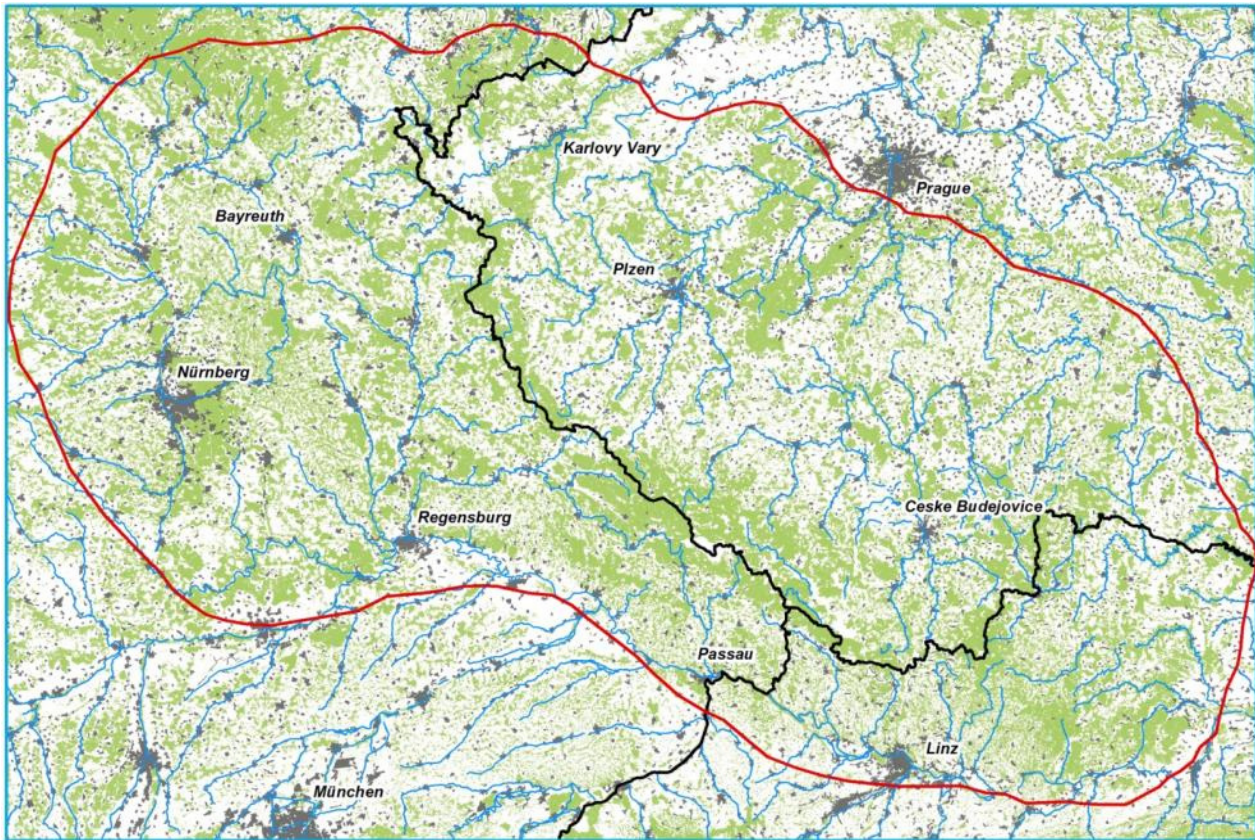


Fig. 1: Study area

## Area monitored with camera traps

The area monitored with camera traps consisted of 130 10x10 km ETRS89 grid cells. Therefore, its total size is 13000 km<sup>2</sup> (Fig. 2).

Generally, monitored grid cells were selected, based on

- a) existing lynx habitat models (Romportl 2015, Rudolph & Fetz 2008, Schadt et al. 2002, Schadt 1998),
- b) the protection status of the area (protected landscape area, Natura 2000 sites),
- c) the probability of lynx occurrence in the area (given mainly by distance and connectivity to the known core area of the population), and
- d) the willingness of hunters and forest owners to cooperate.

In the Czech Republic, the National Park Šumava (680 km<sup>2</sup>) and the protected landscape areas (PLA) Šumava, Blanský les, Český les, Slavkovský les and Brdy were monitored together with unprotected areas between PLAs and in the Czech-Austrian border region and north from PLA Šumava. In Bavaria, the Bavarian forest region with the Bavarian Forest National Park (240 km<sup>2</sup>) and part of the Bavarian Forest Nature Park, the Oberpfälzer Wald along the Czech-German border and the Steinwald were monitored. In Austria, Mühlviertel and Waldviertel along the Czech-Austrian border and some suitable habitat patches along the Danube were monitored.



These areas cover the core of the range of the population with the largest patches of continuous lynx habitat (national parks Šumava and Bavarian Forest, PLA Šumava and Bavarian Forest Nature Park). They also cover other significant patches of suitable habitat, stepping-stones and corridors in the outskirts which are inhabited by lynx or which bear a high chance of lynx presence.

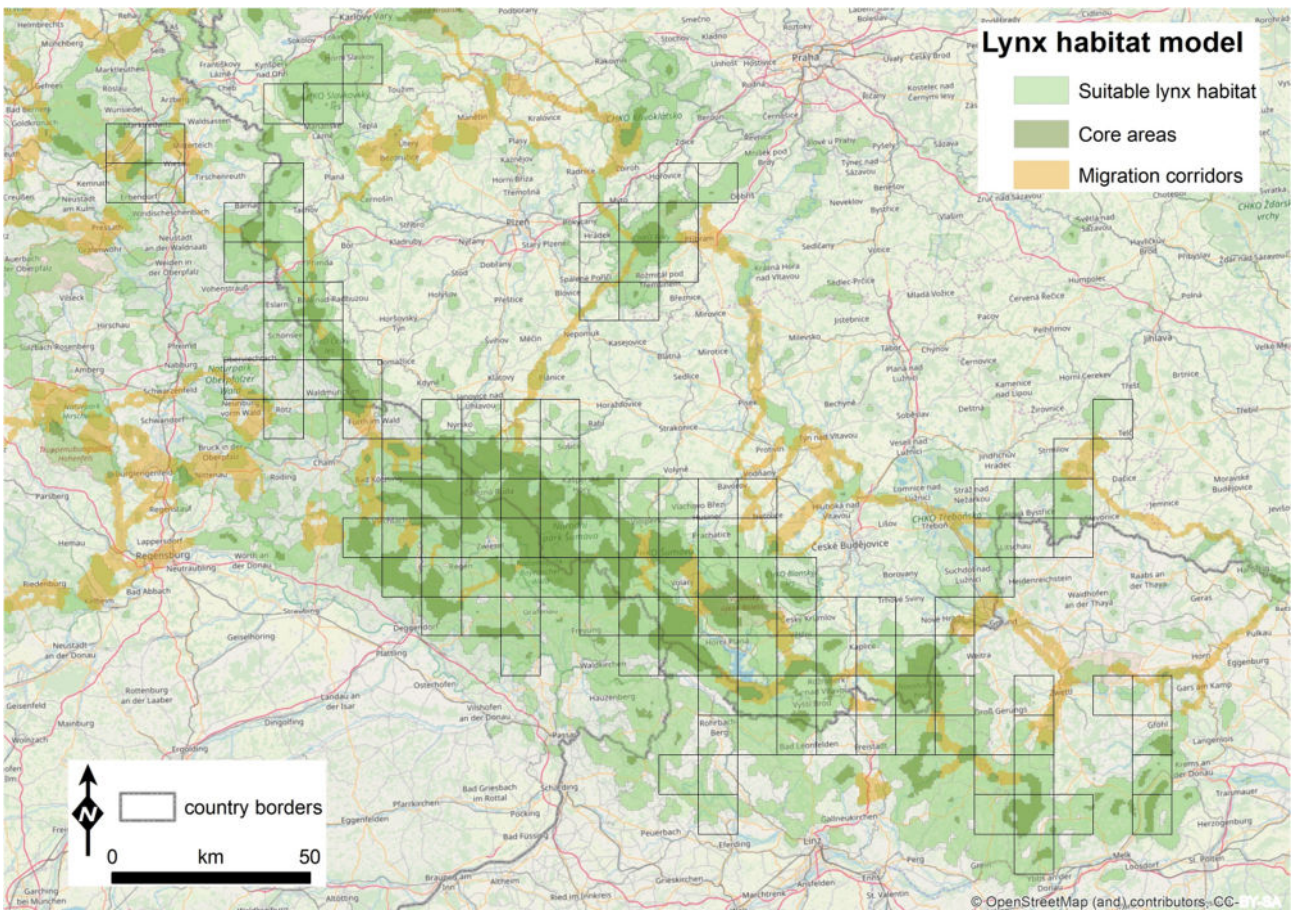


Fig. 2: Lynx habitat map with monitored 10x10 km ETRS89 grid cells, based on lynx habitat model (Romportl 2015).



## 3. Monitoring Methods

### 3.1. Standards for data analysis and evaluation

#### 3.1.1. Evaluation of monitoring data according to the SCALP criteria

All collected monitoring data was classified according to criteria described by the SCALP expert group (Molinari-Jobin et al. 2003, Molinari-Jobin et al. 2012). The classification was carried out according to the verifiability of records. This requires the standardized documentation of findings and verification by an expert with several years of field experience.

Three categories are distinguished:

- Category C1: represents ‘hard fact’ data (e.g. dead lynx, georeferenced lynx photo, genetic proof).
- Category C2: includes confirmed data (e.g. kills or tracks, verifiable due to a substantial documentation and verified by an expert).
- Category C3: summarizes unconfirmed data (e.g. direct visual observation and calls; kills, tracks which are not sufficiently documented but seem probable).

Data analyses (i.e. distribution, population size) were based only on data of the categories C1 and C2.

#### 3.1.2. European grid

For scaling of lynx monitoring effort and for spatial data analysis the 10x10 km ETRS89 grid in the ETRS LAEA 5210 projection was used.

#### 3.1.3. Reporting period: Lynx year (LY)

The reporting period in which the data were analysed was chosen according to the lynx life cycle, i.e. the birth of lynx kittens in spring (May/June) and their separation from their mother in late winter (April/May) of the following year. By definition the “lynx year” therefore begins on 1st of May and ends on 30th of April of the following year. This ensures correct population size assessment, as females with kittens are only counted once per monitoring period.





### 3.1.4. Terminology

Juvenile lynx	Lynx in the first year of life (also called “kitten”). From birth until 30 <sup>th</sup> of April of the following year (0-1 year of age).
Subadult lynx	Lynx in the second year of life. After separation from its mother until sexual maturity (1-2 years of age).
Adult lynx	Lynx older than 2 years, sexually mature.
Independent lynx	Lynx no longer dependent on its mother, i.e. subadult or adult (>1 year).
Resident lynx	Lynx staying for at least 12 months in the same area
Reproducing female	Female who had offspring/kitten(s) in the respective lynx year
Lynx family	Reproducing female with juvenile(s)
Orphaned lynx	Juvenile who was separated from its mother because (1) its mother died, (2) it was abandoned, or (3) it was captured by humans because of true or assumed absence of the mother.
Turnover rate	Percentage of individuals who were recorded in the previous lynx year but not recorded in the current lynx year, thus either died or vanished from one lynx year to the next.

## 3.2. Data collection

For lynx monitoring we used the following monitoring methods:

1. Camera trapping
2. Collection of observational data and chance findings (dead lynx, photos, kills, tracks, scat, hair, etc.)
3. Genetic monitoring
4. Snow tracking

### 3.2.1. Camera trapping

Camera trapping was the fundamental method of the BBA pilot lynx monitoring system and was applied extensively, i.e. on a large scale. A minimum of 2 camera trapping sites per 10x10 ETRS89 grid cell were selected. At every site, 1 or 2 camera traps, depending on terrain and available number of camera traps, were installed. In most areas with known or assumed cases of reproduction, 4 to 8 camera trapping sites were selected, in order to both record natality (number of kittens) and to obtain enough good quality pictures of the juveniles for later identification.

Due to the long-term and year-round installation of camera traps also data on abundance, survival and dispersal as well as changes in dispersion, age and sex structure in the course of the year were collected. Thanks to the multiple year-round installation of camera traps, we could calculate the “turnover rate” for adult and subadult lynx from LY17 to LY18, i.e. the percentage of individuals who were camera-trapped till LY17, and were not recorded anymore in LY18 (see chapter 3.1.4). Furthermore, it was



possible to detect areas, where a number of adult, resident lynx suddenly disappeared, leaving unoccupied home ranges.

At most locations, in order to get good quality pictures, white flash camera traps of the brand Cuddeback were used. Infrared or black-flash camera traps were mostly used at kill sites or scent-marking places. At these locations, lynx do not move very much and these camera trap types are capable of producing focused pictures with recognizable coat pattern.

Camera trap sites were chosen according to expert knowledge on lynx habitat and spatial use as well as information from snow tracking or past radio-telemetry locations (if available). They were installed at forest roads, hiking or wildlife trails and in rocky terrain to maximise the detection probability. Camera traps were equipped with information sheets about the owner and the objectives of the study. Due to logging activities in areas with bark beetle calamities or rolled lumber, thefts, sabotages or objections by landowners or hunters not every suitable camera trap site could be equipped with camera traps, which led to gaps in the otherwise even spacing of camera trapping sites.

### 3.2.2. Collection of observational data and chance findings

Observational data and chance findings (tracks, killed prey, hair, calls, camera trap pictures from hunters, foresters, general public or nature conservationists) were collected and evaluated according to the SCALP criteria. These types of data were collected from the entire study area. They serve as additional data set and can assist to complement data gathered with the systematic camera trapping. They can point out areas where it would be valuable to increase monitoring efforts, especially if these data originate from outside the area of extensive and systematic camera trapping.

As the use of camera traps is increasingly common practice among hunters and foresters they sometimes also record lynx by chance at ungulate feeding sites or at lynx kills. This produces an increased number of camera trap pictures which can help to complement or fine-tune our established monitoring system.

### 3.2.3. Genetic monitoring

Samples of lynx scat, hair, urine, saliva, blood or tissue were collected in the field at known marking places, during field surveys specifically organized for this purpose or when found by chance. Saliva was collected at freshly killed prey and blood or tissue samples were collected at lynx carcasses. All these samples were sent to a specialized lab for DNA extraction (Institute of Vertebrate Biology, Czech Academy of Sciences in Brno). The results of the genetic analysis are presented in a separate report (Krojerová and Turbaková 2020, Gajdárová et al. 2023).

### 3.2.4. Snow tracking

Following lynx tracks in the snow helps to adjust suitable camera trapping sites and to find lynx kills, scats or urine, also enabling genetic examination. However, snow tracking



depends on persistent snow cover. Due to unreliable snow conditions in the study area in the last years, it was not systematically applied on transects but rather as a complementary method.

In winter season 2018/2019, snow tracking was applied mostly by the associated project partner Hnutí Duha with their trained volunteers, so-called ‘lynx patrols’. The selected area for snow tracking was chosen at the edge of known lynx range, where insufficient lynx data existed, or where camera trapping was not implemented. In total, 190-day-long tracking walks were carried out. Minimum length of each tracking walk was 12 km. Appropriate snow conditions were defined as min. 60 % of the route covered by snow. All findings (tracks, scat, hair, urine) were documented and evaluated according to the SCALP criteria.

ALKA Wildlife organised five day-long snow tracking surveys in the outskirts areas.

All snow tracking data came from the grid cells, where the lynx occurrence was also confirmed by camera traps, with the exception of one grid cell in CZ (see Fig. 3). Thus, the data from snow tracking were mostly used for detecting potential camera trapping sites and gaining genetic samples rather than confirming lynx presence in the area.

### 3.3. Data analysis

Data were recorded in files and structured in a harmonized manner. Collected camera trap pictures were exchanged on a regular basis via online-cloud and underwent a final overall review by all monitoring partners to avoid double-counting of the same individual. The lynx individual was coded using a code system with characters and numbers, e.g. B33 or B500 or B020AT (“AT” stands for Austria). The code system was differentiated into number blocks for the CR and DE. In this way, the given number revealed the country of first registration of the respective individual, too. If sex of the identified lynx was known, the animal got a name, which facilitated memorization of the individual lynx in daily work.

Camera trapping data were pooled in 60-minute-events, if more than one picture was taken during this time period, e.g. at kill sites. If more than one lynx was photographed in one picture, e.g. lynx female with two kittens, every identified lynx was recorded as a separate data line. These data, together with additional C1 and C2 data obtained with other methods, were used for distribution maps and assessment of minimum and maximum population size, as described in the Results chapter later.

#### Distribution maps

We defined a grid cell of 10x10 km as “occupied” if at least one C1 or one C2 data was located and confirmed in the respective grid cell. Grid cells with C1 data are differentiated by colour from grid cells with C2 data, because of the reasons mentioned above (see section 3.1.1).



## Assessment of minimum and maximum population size

We assessed the minimum and maximum population size in two ways and named them i) documented minimum population size and ii) theoretical minimum and maximum population size.

The documented minimum population size was assessed by counting all independent lynx, which could be identified individually by their coat pattern (all lynx coded as B-animals). The animals which were recorded only from left side or only from right side (coded as L- or R-animals) were partly taken into account, also depending on their general coat pattern type (spotted versus marbled). The reasoning behind this is: animals which were recorded from only left side could be the same animals which were recorded from only right side, therefore we only took into account the higher number of animals recorded from only one side (either R- or L-animals). However, an individual recorded as „marbled“ from one side can not correspond to an individual recorded as „spotted“ from the other side. Thus, we obtained the documented minimum population size by summing the B-animals and the higher numbers of marbled and spotted individuals recorded only from one side (either left or right). Animals which could not be identified by camera-trap pictures - even if they were genetically identified based on genotype - were excluded from the minimum population count, to avoid double-counting.

The approach to assess the theoretical minimum and maximum population size is based on the share of reproducing females applying the results of the Population Viability Analysis (PVA, Poledníková et al. 2015) performed within the TransLynx project.

The data compilation necessary for the PVA revealed that the long-term share of reproducing females from the whole population is 17.5 % with 19 % standard deviation and is stable over the years. Thus, based on the recorded number of families and the calculated age structure of the population within the PVA deterministic model, size of the whole population including all animals of all age categories (adults, subadults, juveniles) can be re-calculated. This simple method is used for a rough but objective assessment of the BBA population size. It is partly similar to Andrén et al. (2002)'s method used in Scandinavia, where the share of reproducing females out of all independent individuals is used to calculate the total number of independent animals.

## 4. Results

### 4.1. Distribution and range

In the study area, in the lynx year 2018, in total 85 grid cells (incl. 2 grid cells in Erzgebirge/Krusné Hory) of 10x10 km size were occupied by C1 records and 6 grid cells with C2 records (Fig. 3).

These 91 grid cells comprise an area of 9100 km<sup>2</sup> with permanent or sporadic lynx presence (previous year: 86 C1 and 12 C2 grid cells, incl. 2 grid cell in Erzgebirge/Krusné Hory). The halving of grid cells with C2 records in LY18 compared to LY17 reflects the characteristic of C2 data: they are chance findings, that means, they are found only accidentally, and their number therefore naturally varies between years.

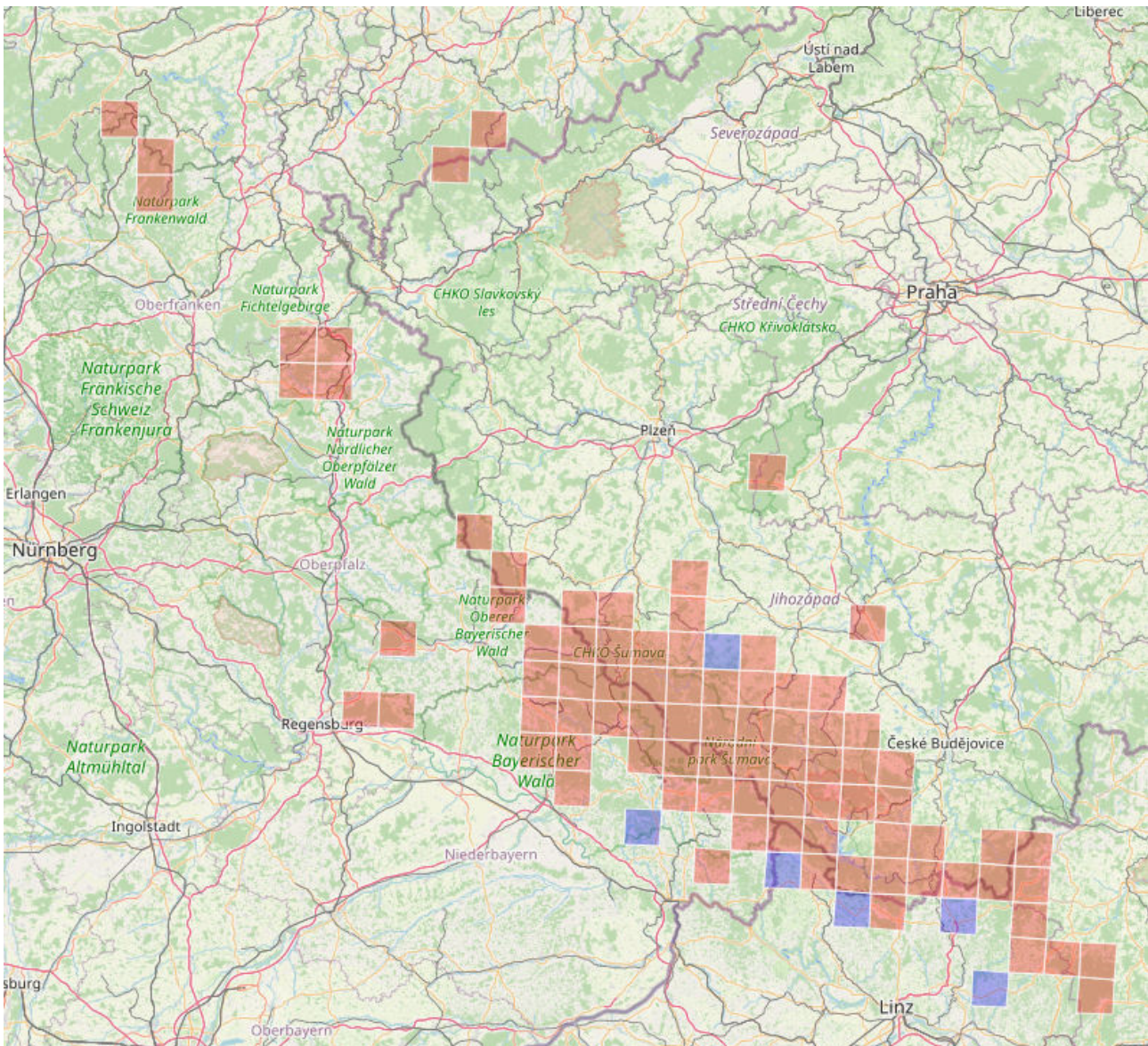


Fig. 3: The occupied 10x10 km grid cells projected in ETRS89 show the lynx distribution in the study area in lynx year 2018. Grid cells in red color are occupied by at least one C1 data, grid cells in blue color are occupied exclusively by one or more C2 data.



## 4.2. Population information (updated)

The following population information was updated in 2022 due to new data and the changed consideration of lynx in Steinwald and Erzgebirge/Krusne Hory. Despite isolated from BBA population these lynx were newly integrated in the population information. Generally, data which are provided later (sometimes up to three or more years later) can cause minor changes in population information.

### Lynx occurrence in northern Bavaria - region of Steinwald and Frankenwald

The lynx occurrence in the region of Steinwald was established in 2016 and 2018 by translocation of two lynx who were found orphaned in the Bavarian Forest region. Since 2016 the Steinwald is inhabited by a female lynx, called „Fee“. She was captured as orphaned kitten in 2015 in the Bavarian Forest and released in August 2016 in Steinwald. In 2017 another orphaned male juvenile, called „Hotzenplotz“, was captured in the Bavarian Forest and released in April 2018 in the Steinwald, too. At the end of year 2018 a third lynx appeared newly and first displaced „Hotzenplotz“ and then injured him severely during a territorial fight. „Hotzenplotz“ was found dead in March 2019. The origin of the third lynx, called „Ivan“, could be proved by comparing camera-trapping pictures to be the Harz mountains, 220 km beeline from Steinwald.

In the region of Frankenwald several records were registered since lynx year 2017. These records stem from a single roaming unidentifiable male lynx who could be genetically tagged as coming from Harz mountains. The last genetic prove of this lynx was in December 2017. In autumn 2018 another male lynx appeared in the Frankenwald. By comparing camera-trap pictures, his origin was proven to be the Bavarian Forest. This lynx B55, called „Bartl“, was lastly camera-trapped on 26.6.2018 in the Bavarian Forest and the first time on 1.9.2018 near Tschirn in Frankenwald, 190 km beeline from his last record in the Bavarian Forest. He was recorded regularly during lynx year 2018 by camera-traps installed by foresters in the forest district Nordhalben. This lynx showed an interesting dispersal behaviour by travelling 190 km beeline in two months and by crossing three highways between Bavarian Forest and Frankenwald. However, without encountering female conspecifics such a lynx is most probably lost for the source population despite he contributes to the enlargement of the registered lynx range in the study area.

The situation in the Steinwald differs insofar as the translocated lynx female “Fee” who established a home range there could initialize an occurrence outside the current BBA lynx population by binding the translocated male “Hotzenplotz” and the migrating lynx “Ivan”. It needs to be stressed that this occurrence is still isolated from the BBA lynx population as up to now a natural dispersal from BBA population has never been documented, i.e., the Steinwald occurrence is not yet connected with BBA population by regular dispersers coming from BBA population. This also leads to specific management implications for the further development of this occurrence.

However, the Steinwald occurrence contributes to the northward expansion of the registered lynx distribution in the study area and despite the Steinwald occurrence is



still isolated from the BBA lynx population we considered these lynx in the population information and in the following results about abundance and survival.

### Lynx occurrence in Erzgebirge / Krusne Hory

The border region of Saxony and Czech Republic is included in our study area in order to consider long-distance dispersers, migrants (immigrants/emigrants), habitat features and a possible future spreading of the BBA population. In the western part of Erzgebirge / Krusne Hory around Johanngeorgenstadt and Oberwiesenthal lynx is recorded since 2013 (Zschille et al. 2020). Zschille et al. (2020) assume that the records stem from one single lynx. A genetic sample collected in December 2017 on the Czech side revealed the origin of this male lynx to be the Harz mountains, appr. 180 km beeline from Erzgebirge / Krusne Hory (Gajdárová et al. 2021). The combination of the unspotted coat pattern, blurred pictures and/or only single-sided recording suggested to classify this lynx as unidentifiable. Therefore, this lynx - despite most probably the same lynx - was excluded from the minimum count and the turnover calculation of LY17 to LY18.

#### 4.2.1. Lynx families

##### 4.2.1.1. Number of documented lynx families

In total, **33 reproducing females with 66 juveniles** were proved in the BBA lynx population (Tab. 1, Fig. 4; previous year: n=32 reproducing females and 62 juveniles). These numbers have to be taken as minimum counts.

12 (36.4 %) lynx families occupied a transboundary territory, 14 lynx families (42.4 %) lived entirely on the Bohemian side, 7 families (21.2 %) lived entirely on the Bavarian side. There was no lynx family using a territory located entirely on the Austrian side.

In Bohemia 25 lynx families were documented during lynx year 2018 (previous year: n=25). 4 of these families were also documented in Austria, 7 in Germany, 1 family was recorded trilateral. One orphaned lynx kitten probably belonged to a separate female. Therefore, we assume 26 lynx families (previous year: 28 lynx families incl. 4 orphans).

In Bavaria 15 lynx families were documented (previous year: n=11); 7 of these families were also documented in the Czech Republic (previous year: n=6); 1 family was trilateral.

In Austria 5 lynx families were documented (previous year: n=5). All these families had cross-border territories with the Czech Republic (n=4) or lived trilateral (n=1).

Looking at the lynx families only from a national perspective without transnational cooperation would lead to a double or even triple counting of the families.



Tab. 1: Lynx families in lynx year 2018 (1.5.2018-30.4.2019) in the Bohemian-Bavarian-Austrian lynx population (C1 data only).

No.	Reproducing female (LynxCode_LynxName)	Number of proven juveniles	Country	Notes
1	B013AT_Boure	2	AT/CZ	
2	B014AT_Marylin	1	AT/CZ	
3	B015AT_Horecka	1	AT/CZ/DE	
4	B026AT_Medvedice	2	AT/CZ	probably 2nd kitten (B599_Wostei)
5	B23_Hakerl	3	CZ/DE	
6	B24_Tanja	2	CZ/DE	1 kitten killed by car 05.07.2018
7	B252_Luna	3	CZ/DE	
8	B255_Hawei	1	CZ/DE	
9	B271_Nika	3	DE	
10	B272_Julia	1	DE	1 kitten proved but unidentifiable, probably later identified as B70_Stummel
11	B283_Elisa	2	CZ	
12	B286_Olina	2	DE	killed by car in October 2018
13	B302_Malu	2	DE	
14	B31_Geli	3	CZ/DE	
15	B35_Vroni	2	DE	
16	B47_Marie	4	CZ/DE	
17	B510_Matyllda	2	CZ/DE	
18	B525_Misa	3	CZ	
19	B534_Agata	3	CZ	
20	B538_Michelle	1	CZ	illegally killed
21	B556_Hvezda	2	CZ	
22	B557_Anezka	1	CZ	
23	B585_Iris	3	CZ	
24	B593_Sara	1	CZ	
25	B595_Zoe	2	CZ	
26	B60_Frieda	3	DE	only 1 kitten survived winter
27	B706_Svetlana	1	CZ	
28	B718_Nela	3	CZ	
29	B724_Hracicka	1	CZ	
30	B727_Viola	1	AT/CZ	





No.	Reproducing female (LynxCode_LynxName)	Number of proven juveniles	Country	Notes
31	B742_Eliska	2	CZ	
32	B78_Hedy	2	DE	
33	N.N.	1	CZ	orphaned juvenile from unknown female near Luč

#### 4.2.1.2. Map of lynx families and resident females in LY 2018

The following map shows the approximate location and shape of home ranges of lynx families, resident females without proven reproduction and orphans (Fig. 4).

There is a noticeable differing dispersion pattern of females in the region of the central Šumava high plateau (Modrava-Kvilda region): we could not detect any resident female (with or without kitten) in this area (approx. 250 km<sup>2</sup>). We assume that the sudden disappearance of two resident females in the area (Otis, Majka) is the main reason for this striking distribution pattern of resident females.

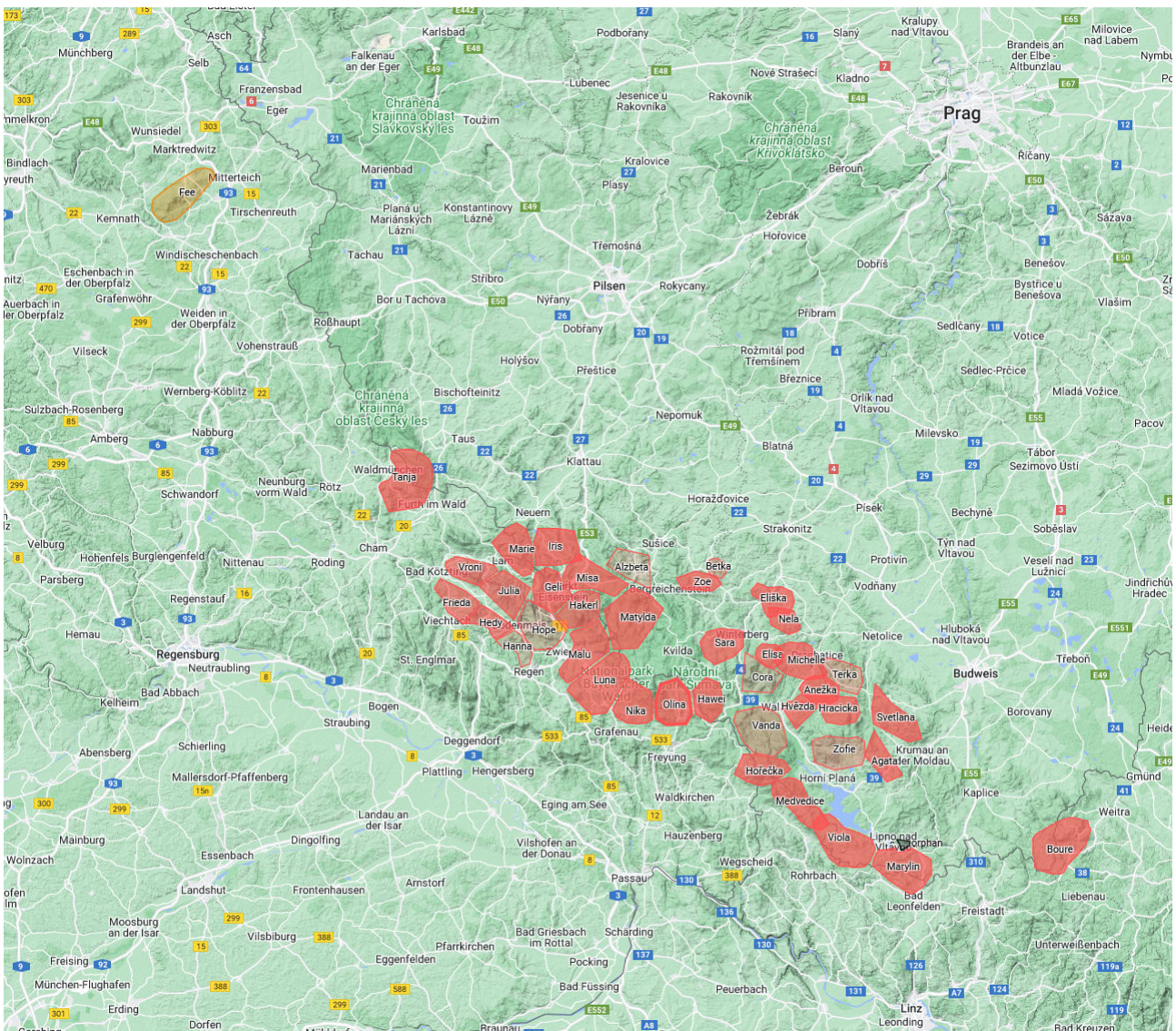


Fig. 4: Map of reproducing females with kittens (dark red shapes), resident females without proven reproduction (light red shapes), resident (translocated) female without mating partner (light orange shape), and one orphan (black shape) recorded in lynx year 2018. Size and shape of home ranges is approximate and based on available camera trapping and mortality data.



#### 4.2.2. Lynx mortality

The causes of mortality were differentiated into natural (starvation, disease, deadly interaction with other lynx), road mortality, illegal killing, probable illegal killing and unclear causes (lynx dead but cause could not be determined).

Altogether, 8 cases of mortality and 1 case of an assumed dead juvenile lynx were documented in lynx year 2018 (Tab. 2, Fig. 5). To this list adds 1 case of an assumed orphaned kitten from an unknown mother. It was found near Loučovice, Czech Republic, was removed from the wild and cared for in an enclosure (see section 4.2.2.1).

Tab. 2: Registered and confirmed population losses in lynx year 2018

No	Date	Country	District, Community	Coordinates	Individual	Sex	Age	Cause of death
1	5.5.2018	DE	Eschlkam	12.890561 49.267492	–	f	subadult	unclear
2	5.7.2018	DE	Waldmünchen	12.778343 49.326884	Tanja-Juv.18-2	m	juvenile	road mortality
3	13.8.2018	CZ	České Žleby	13.802705 48.892116	B568 Vanda	f	adult	road mortality
4	10.10.2018	CZ	Volary	13.861179 48.903489	B7 Cora	f	adult	road mortality
5	14.10.2018	DE	Freyung-Grafenau	13.507330 48.880812	B286 Olina	f	adult	road mortality
6	17.11.2018	CZ	Zábrdí	-	B538 Michelle	f	adult	illegal killing
7	November 2018	CZ	Prachatice region	-	B746 (Michelle-Juv18-1)	-	juvenile	orphaned
8	January 2019	CZ	precise location unknown	-	B580 Žofie	f	adult	illegal killing
9	17.3.2019	DE	Tirschenreuth	12.027103 49.913985	B0070 Hotzenplotz	m	subadult	natural
10	05.09.2018	CZ	Luč near Loučovice	14.279340 48.630550	B733	m	juvenile	Orphan brought to enclosure

4 The exact date of death is unknown as the body was already in state of decomposition when it was found

5 Reproducing female with 2 kittens

8 Probably between 15<sup>th</sup> and 21<sup>st</sup> January



Two adult females were illegally killed (no. 6, 8 in Tab. 2, Fig. 5). The body of female lynx Michelle was seized by custom officials and based on its coat pattern identified by the Czech 3Lynx team. With no doubt, Michelle was illegally killed (shot). The investigation of this case is still ongoing. The kitten of Michelle is assumed dead as well due to its young age at the time when the mother was killed (no. 7 in Tab. 2, Fig. 5). Illegal killing of female lynx Žofie couldn't be verified by autopsy. Only a photo of shot lynx Žofie was gained anonymously.

Three adult females died in a car accident (no. 3, 4, 5 in Tab. 2, Fig. 5); one of these females had 2 kittens (see section 4.2.2.1).

A 2-month old juvenile was hit by a car when it tried to cross the road with its mother (no. 2 in Tab. 2, Fig. 5). There is an unclear cause of mortality of a subadult lynx (no. 1 in Tab. 2, Fig. 5): The reported cause of death was road mortality. However, the body could not be examined and the cause could not be verified by the pictures made by the hunter who collected the body to stuff it for a local hunting club.

A subadult male lynx (B0070, "Hotzenplotz") in the Steinwald region died through a violent interaction with another male lynx (no. 9 in Tab. 2, Fig. 5). The subadult was severely injured by big 2,5-year-old male lynx ("Ivan") and died due to injuries sustained. The adult male originated from the Harz mountains (Middelhoff, pers. comm.) and migrated to northern Bavaria.

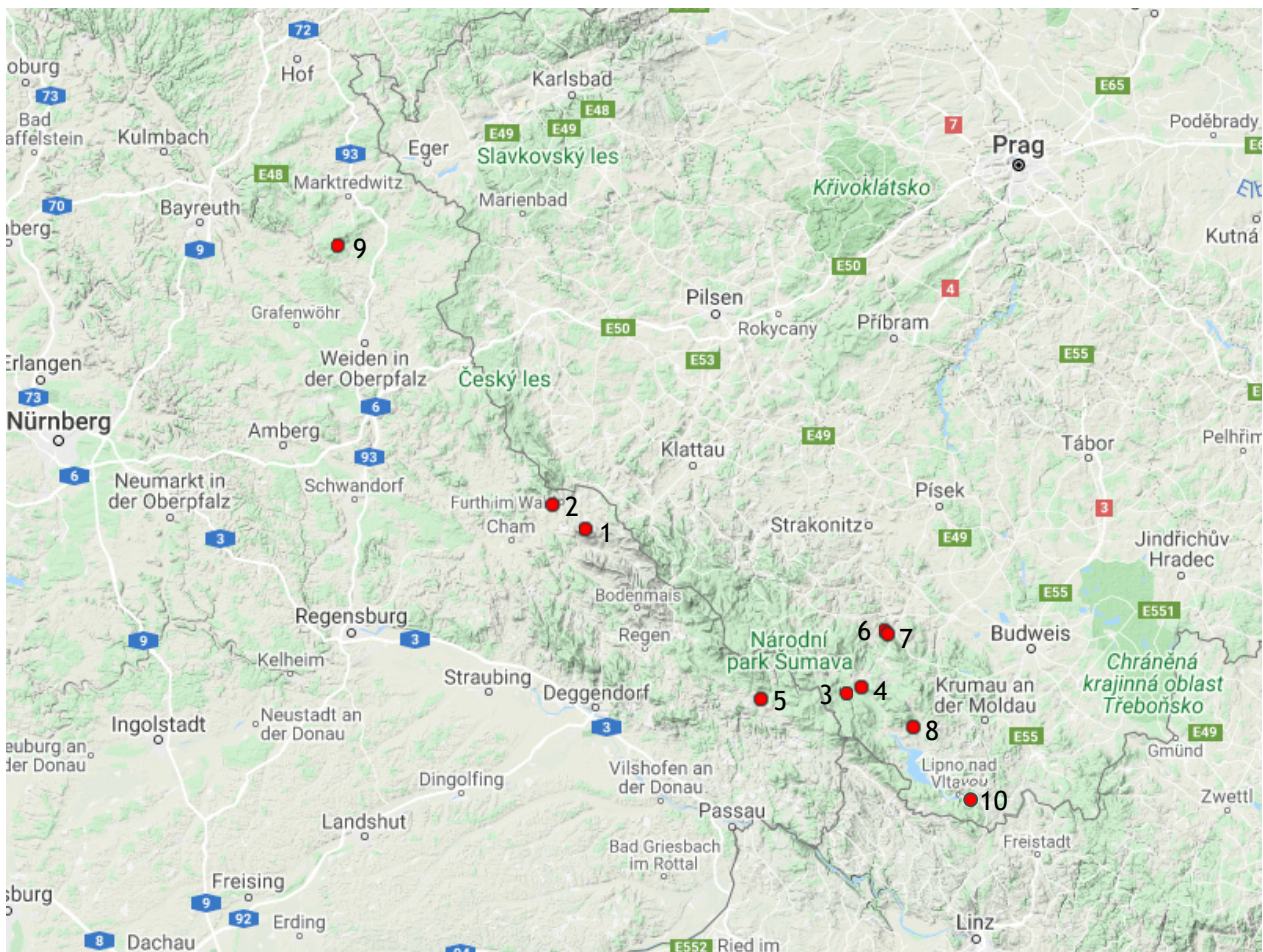


Fig. 5: Registered population losses in lynx year 2018. Numbers refer to Tab. 2.



#### 4.2.2.1. Lynx orphans

In total, we had evidence of 4 orphaned kittens (previous year: n=5). One kitten was orphaned because its mother (B538\_Michelle) was illegally killed (case no. 6 in population losses table). It is very likely that this juvenile died because a juvenile is not able to sustain itself at such a young age. However, we did not find the body and therefore have no information about where and when it died.

One orphaned kitten from an unknown mother was found alone in the forest near Luč in Czech Republic. It was captured on 5<sup>th</sup> September 2018 and transferred to the animal rescue station at ZOO Ohrada, where it lives until today (June 2020).

Two kittens were orphaned because their mother B286 Olina died in a car accident near Neuschönau in October 2018 (case no. 5 in population losses table). Both kittens survived in the wild at least until the end of lynx year 2018 thanks to human intervention, i.e. the siblings were attracted and fed with roe deer inside the adjacent national park during the winter months (Gahbauer, pers. comm., Premier et al. 2021).

#### 4.2.2.2. Turnover and survival of lynx

The survival of 110 independent lynx, which were recorded in LY17, was examined (Tab. 3). Those lynx were known to be adult (n=65) or subadult (n=30), respectively most probably subadult (n=13) in LY17. The age of two individuals could only be determined as adult or subadult (n=2) in LY17.

Tab. 3: List of adult lynx recorded in LY17 and their fate in LY18. Within the column “Fate from LY17 to LY18”, “DEAD” indicates all cases of documented death within LY17 (described in Mináriková et al., 2019 - updated 2023); “MISSING” indicates all cases of lynx individuals whose last record alive was during LY17, thus the animal is not included anymore in the list of recorded last independents for LY18, and it most probably also disappeared within the end of LY17.

No.	LynxCode	LynxName	Sex	First registration (LY)	Fate from LY17 to LY18
1	B010AT	Joachim	m	2013	MISSING
2	B014AT	Marylin	f	2016	Recorded
3	B015AT	Horecka	f	2016	Recorded
4	B017AT	Roman	-	2014	MISSING
5	B018AT	Eos	-	2016	Recorded
6	B026AT	Medvedice	f	2016	Recorded
7	B11	Kika	m	2008	Recorded
8	B111	Fee	f	2015	Recorded
9	B22	Otis	f	2012	MISSING
10	B23	Hakertl	f	2011	Recorded
11	B238	Rico	m	2011	Recorded



No.	LynxCode	LynxName	Sex	First registration (LY)	Fate from LY17 to LY18
12	B24	Tanja	f	2013	Recorded
13	B252	Luna	f	2011	Recorded
14	B255	Hawei	f	2011	Recorded
15	B271	Nika	f	2014	Recorded
16	B272	Julia	f	2014	Recorded
17	B273	Alina	f	2014	MISSING
18	B274	Sancez	m	2014	Recorded
19	B275	Kristof	m	2014	Recorded
20	B281	Milo	m	2015	Recorded
21	B287	Moritz	m	2016	Recorded
22	B288	Robert	m	2015	Recorded
23	B30	Hope	f	2012	Recorded
24	B31	Geli	f	2013	Recorded
25	B32	Gestiefelter Kater	m	2013	Recorded
26	B35	Vroni	f	2014	Recorded
27	B37	Zdenek	m	2015	Recorded
28	B38	Stefan	m	2015	Recorded
29	B39	Veit	m	2014	Recorded
30	B41	Hanna	f	2014	Recorded
31	B45	Gregor	m	2015	MISSING
32	B47	Marie	f	2015	Recorded
33	B508	Ctirad	m	2009	Recorded
34	B510	Matylda	f	2009	Recorded
35	B514	Julien	m	2011	Recorded
36	B52	Gerald	m	2015	Recorded
37	B525	Misa	f	2013	Recorded
38	B53	Juri	m	2015	MISSING
39	B534	Agata	f	2014	Recorded
40	B537	Ludek	m	2014	Recorded
41	B538	Michelle	f	2014	Recorded
42	B541	Majka	f	2014	MISSING
43	B55	Bartl	m	2017	Recorded
44	B552	Jiskra	f	2014	MISSING
45	B556	Hvezda	f	2014	Recorded



No.	LynxCode	LynxName	Sex	First registration (LY)	Fate from LY17 to LY18
46	B559		-	2015	MISSING
47	B563	Kilian	m	2015	MISSING
48	B565	Bartho	m	2015	Recorded
49	B568	Vanda	f	2014	Recorded
50	B574	Serava	f	2016	MISSING
51	B580	Zofie	f	2014	Recorded
52	B581	Pepik	m	2014	Recorded
53	B585	Iris	f	2012	Recorded
54	B593	Sara	f	2017	Recorded
55	B7	Cora	f	2009	Recorded
56	B704	_	f	2016	DEAD (road mortality in 6.2017)
57	B707	Rostenka	f	2017	MISSING
58	B710	Makini	f	2017	MISSING
59	B711	Bertik	m	2017	Recorded
60	B716	Karlos	m	2014	Recorded
61	B742	Eliska	f	2017	Recorded
62	B718	Nela	f	2015	Recorded
63	L021AT	_	-	2016	MISSING
64	R507	Alzbeta	f	2015	Recorded
65	R521	_	-	2016	MISSING



21,5 % (n=14) of adult lynx which were recorded in LY17 were not recorded anymore in LY18. Adding the cases of proven adult lynx mortality in LY17, this number increased to 23,1 % (n=15). The survival rate of all independent lynx was 0.67. Separated by age class the survival of adults was 0.77, of subadults 0.56 and of individuals whose age was adult or subadult 0.00 (Tab. 4). A larger proportion of the losses took place outside of the National Parks.

Tab. 4: Types of losses and survival rate\* from LY17 to LY18 for adult and subadult lynx, respectively. The calculation is based on 110 independent lynx (65 adults, 43 subadults, 2 adult/subadults) recorded in LY17. The percentages refer to the respective age class.

	Road mortality	Illegal killing	Missing in LY18	Total Dead + Missing (turnover rate)	Survivors	Survival rate
Adults (> 2 years) (n=65)	1 (1.6%)	0	14 (21.5%)	15 (23.1%)	50 (76.9%)	0.77
Subadults (1-2 years) (n=43)	1 (2.3%)	0 (0%)	18 (41.9%)	19 (44.2%)	24 (55.8%)	0.56
Subadult or adult (n=2)	0 (0%)	0 (0%)	2 (100%)	2 (100%)	0 (0%)	0.00
Independents (n=110)	2 (1.8%)	0 (0%)	34 (30.9%)	36 (32.7%)	74 (67.3%)	0.67

\* The survival rate is calculated as  $N(t) / N(0)$ , where  $N(t)$  is the number of lynx at the end of the time period and  $N(0)$  is the start of the time period. Survival rate for independent lynx is calculated as  $\lambda = 74/110 = 0.67$ , for adult lynx  $\lambda = 50/65 = 0.77$ , for subadult lynx  $\lambda = 24/43 = 0.56$ .

#### 4.2.3. Documented minimum population size

In lynx year 2018, in total **121 independent lynx** were documented based on coat pattern.

For 117 lynx, both flanks were well documented, for 3 lynx only the right flank (2 spotted + 1 marbled), and for 4 lynx only the left flank (2 spotted + 2 marbled). As L- and R-animals could be identical, only the higher number of the animals documented from one side and distinguished by coat pattern type (spotted versus marbled) were taken into account (n=117 + 2 + 2).

36.4 % (n=44) of the recorded independent lynx were moving transboundary between two or even three countries (Tab. 5). On German side, in total 55 independent lynx were recorded, 30 (54.5 %) of which were also recorded in Czech Republic (CR) or Austria. In CR, in total 92 independent lynx were recorded, 44 (47.8 %) of which were also recorded in Germany or Austria. In Austria, in total 24 lynx were recorded, 20 (83.3 %) of which were also recorded in CR or Germany. This shows that every country considerably shares “its” lynx with the neighbouring countries.





Tab. 5 Number and percentage of nationally or internationally living lynx in lynx year 2018.

Country	N	%
Bohemia, Bavaria, Austria	6	5.0
Bohemia and Bavaria	24	19.8
Bohemia and Austria	14	11.6
Bavaria and Austria	0	0
Bohemia	48	39.7
Bavaria	25	20.7
Austria	4	3.3
Sum	121	100.0

#### 4.2.4. Theoretical minimum and maximum population size derived from number of families

The steps for estimating the theoretical population size for lynx year 2018 based on the share of reproducing females are shown in the table below (Tab. 6). See chapter 3.3 for information about the estimation of the theoretical minimum and maximum population size.

Tab. 6: Estimation of maximum population size in lynx year 2018.

Calculations	Explanation
<b><math>33 / 17,5 * 100 = 188,6</math></b>	33 = number of lynx families recorded in lynx year 2018 17,5 = long-term share [%] of reproducing females out of the whole population 188,6 = theoretical population size including all individuals (juveniles, subadults, adults)
<b><math>188,6 - 66 = 122,6</math></b>	66 = number of juveniles recorded in lynx year 2018 122,6 = theoretical population size incl. independent individuals only (subadults, adults)
<b><math>122,6 * 1,19 = 145,9</math></b>	145,9 = theoretical population size incl. independent individuals only, plus standard deviation of 19%
<b><math>122,6 * 0,81 = 99,3</math></b>	99,3 = theoretical population size incl. independent individuals only, minus standard deviation of 19%

Based on the number of families recorded by C1 data in lynx year 2018, the number of independent individuals in the population has been calculated as 123 animals +-19% [99-146]. The number of independent lynx (n=121) we were able to document lies well within this range.



## 5. Discussion

The monitoring system established during the 3Lynx project in the border region of Germany, Austria and Czech Republic is up to now the most comprehensive and large-scaled monitoring approach in Central Europe: it covered 13000 km<sup>2</sup>. The same monitoring standards are applied in all three countries; therefore, the data are comparable and produce a valuable and robust data set.

The area with confirmed lynx presence within the study area decreased from 9700 km<sup>2</sup> in LY17 to 9100 km<sup>2</sup> in LY18 (see LY17 report: Minariková et al. 2023, updated from 2019). However, there was a slight increase in the number of recorded lynx: from 110 independent lynx in LY17 to 121 independent lynx in LY18 ( $\lambda = 1.10$ , 10 % growth rate). This, however, may be also influenced by the delayed start of camera trapping in some Czech areas in LY17. The number of reproducing females changed from 32 in LY17 to 33 in LY18 ( $\lambda = 1.03$ ). The number of juveniles slightly increased from 62 juveniles to 66 juveniles ( $\lambda = 1.06$ ). The estimation of the population size which is based on the number of reproducing females is stable with 97-143 independent lynx in LY17 and 99-146 independent lynx in LY18.

The last transboundary population assessment in LY13 and LY14 done in the scope of the TransLynx project (Wölfl et al. 2015a, Wölfl et al. 2015b) revealed a smaller distribution: 5100 km<sup>2</sup> in LY13 and 5500 km<sup>2</sup> in LY14, and much lower documented minimum population size: 63 independent lynx in LY13 and 59 independent lynx in LY14. Also, the number of reproducing females were lower: 15 lynx families in LY13 and 15 in LY14.

The change from LYs 2013-2014 to LYs 2017-2018 in range and population numbers is very likely due to an increase of the monitoring effort, especially in Austria and Czech Republic, i.e. the size of the monitored area increased from 7600 km<sup>2</sup> to 13000 km<sup>2</sup>. In Germany (Bavaria), where the monitoring effort has been kept almost the same over the years, a genuine but minor expansion took place and some areas without past lynx presence are now inhabited by lynx, that are even reproducing.

Theoretically, the increase of the total number of recorded lynx may reflect a slight increase in numbers of the entire population. This increase could be caused by regional higher survival rates of kittens and subadults in recent years. Subadults represent the most variable part of the lynx population. They do not yet have their own territories, but are dispersing through territories of resident animals. On the one hand, these dispersing and migrating young, subadult lynx compensate losses among the resident lynx and on the other hand induce a range expansion if they are able to establish a home range in a formerly uninhabited area. In the latter case (and if the slight increase continues) we would expect a measurable range expansion during the next 1-2 years.

However, a substantial change of the population size in time and space would be better indicated by a change in the number of families, which form the most stable part of the population. The number of families in LY17 and LY18 is similar, suggesting that the population is currently stable.



Compared to the assessment in the 1990s (Wölfl et al. 2001), a decline of the range of the BBA lynx population can be observed, followed by a stagnation. However, the data base in the 1990s was much worse than today and unfortunately cannot be directly compared. Nevertheless, the stagnation of the lynx population in numbers and range during the last 25 years points out the two main threats to the BBA lynx population which are both human-induced: illegal killing and road mortality.

It is only rarely possible to prove illegal killing because the dead body of a lynx is not often found. However, there are two indicators for the magnitude of illegal killing: firstly, the number of juveniles found orphaned, and secondly, the turnover rate in the population.

To quantify the probable illegal killing out of the turnover rate, i.e. to differentiate between disappearance out of unknown reasons and illegal killing is difficult because the disappearance of lynx can have several reasons: natural death, long-distance dispersal beyond the study area and missed detection by camera traps.

In this study, the estimation of the turnover rate was solely based on the number of adult lynx, which were not recorded in the following year in the study area. In fact, in the age class of subadult lynx it is much more difficult than in the age class of adults or even impossible to estimate how many of the animals that were not recorded anymore were most likely illegally killed. Subadult lynx are known to disperse long distances until they find an empty territory, conveniently with connection to conspecifics. They either settle down at the edge of the known lynx range or migrate beyond the monitored study area. Subadults are more prone to starvation and other causes of mortality than adult lynx, subsequently their survival is also naturally reduced. Due to their specific dispersal behaviour they are confronted with a greater risk of dying during their dispersal and it is more difficult to detect them by monitoring, even though our study area is very large and covers all of the currently known lynx range. For these reasons, we excluded the subadult dispersing individuals from the estimation of turnover rates. However, the number of subadult lynx which were not recorded the following year is of interest as it is in line with the findings from other populations in Central Europe. In Switzerland, 50% loss are reported for subadults, including assumed cases of illegal killing (Breitenmoser & Breitenmoser-Würsten 2008). In our study, out of 110 independent lynx in LY17 39 % were subadult (n=30) or most probable subadult (n=13). 41.9 % of these lynx, supposed to be subadults, were not recorded anymore in LY18. The total loss (including known/documentated road mortality) in this age class was 44.2 %.

Most of adult lynx, especially reproducing females, usually do not leave their home ranges. Sometimes they shift their home ranges due to changes in the social organization of neighbouring lynx (esp. males), which is often detected by our dense network of camera traps.

Of course, natural death, e.g. due to high age or disease, occurs in adult lynx as well and is hard to detect. In Scandinavia and Switzerland the mean natural yearly mortality rate in adult lynx was 1 % or 1.5 %, respectively (Andrén et al. 2006, Schmidt-Posthaus et al. 2002). In our study, however, more than one fifth (21.5 %) of the adult lynx suddenly disappeared from LY17 to LY18. Accounting for the aforementioned percentage of natural causes of death in other populations in adult lynx per year, there still remains



a percentage of appr. 20 % of adult lynx in the BBA population which disappeared because of other reasons than natural mortality. Together with the cases of mortality with known causes the percentage of losses in the adult part of the population increases to 23.1 %. These high losses explain the only moderate increase in population size.

Illegal killing is not a new problem. The turnover of adult or resident lynx was already revealed during the first population-wide assessment in the TransLynx project from LY13 to LY14: out of 14 females that reproduced in LY13, 7 could no longer be detected in LY14 (Wölfl et al. 2015b). A population viability model developed for lynx in Bavaria revealed that if the mortality among adult resident lynx exceeded the threshold of 20 %, it would correspond to a 74-100% probability risk of extinction in combination with a moderate (10-35 %) mortality rate in subadults. In combination with a high mortality of subadult dispersers (> 30 %) the risk of extinction would be even 82-100 % (Kramer-Schadt 2004).

In conclusion, we suggest that illegal killing (and increasingly also road mortality) is the most important threat to the BBA lynx population and has the potential to bring the population to the brink of extinction. However, we are aware that the two population-wide monitoring studies conducted during the TransLynx and 3Lynx project could only examine two lynx years each. For more robust estimations of the turnover rate in the BBA lynx population, data from several consecutive years would provide better insights into the negative demographic and genetic effects, that illegal killing poses for the BBA lynx population.

Future conservation efforts should be based on a continuously and closely monitored BBA lynx population. This would provide us not only with more robust data, it would also allow us to better monitor and identify the hot spots of mortality. This would also allow more effective measures to be taken against illegal killing and other immanent threats and in this way improve and enhance conservation efforts for the BBA lynx population.



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