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LYNX MONITORING REPORT

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

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Ministerstvo životního prostředí

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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 near Arber mountain.

Content

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^2 with 2-8 camera traps per 10x10 km EU grid cells installed year-round. Lynx presence has been verified in 9000 km^2. We identified 118 independent lynx (subadults and adults), 33 reproducing females with 66 juveniles. The maximum population size was estimated at 146 independent lynx.

36.4% (n=43) 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 independent lynx from LY17 to LY18. 17 adult lynx (28 % of all adults) recorded in LY17 were not recorded in LY18: in two cases it was due to proven illegal killing, in two other cases it was due to road mortality, in 13 cases (22%) the fate was unknown. We assume that most of these cases, where fate remains unknown are probably representing the dark figure of illegal killing. 25 subadult lynx (51% of all subadults) recorded in LY17 were no longer recorded in LY18, in two cases it was due to road mortality, in 23 (47%) cases the subadult lynx disappeared. Due to these losses, the growth rate of the BBA lynx population is moderate with $\lambda = 1.08$ (8.3 % 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^2 - 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 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. 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.

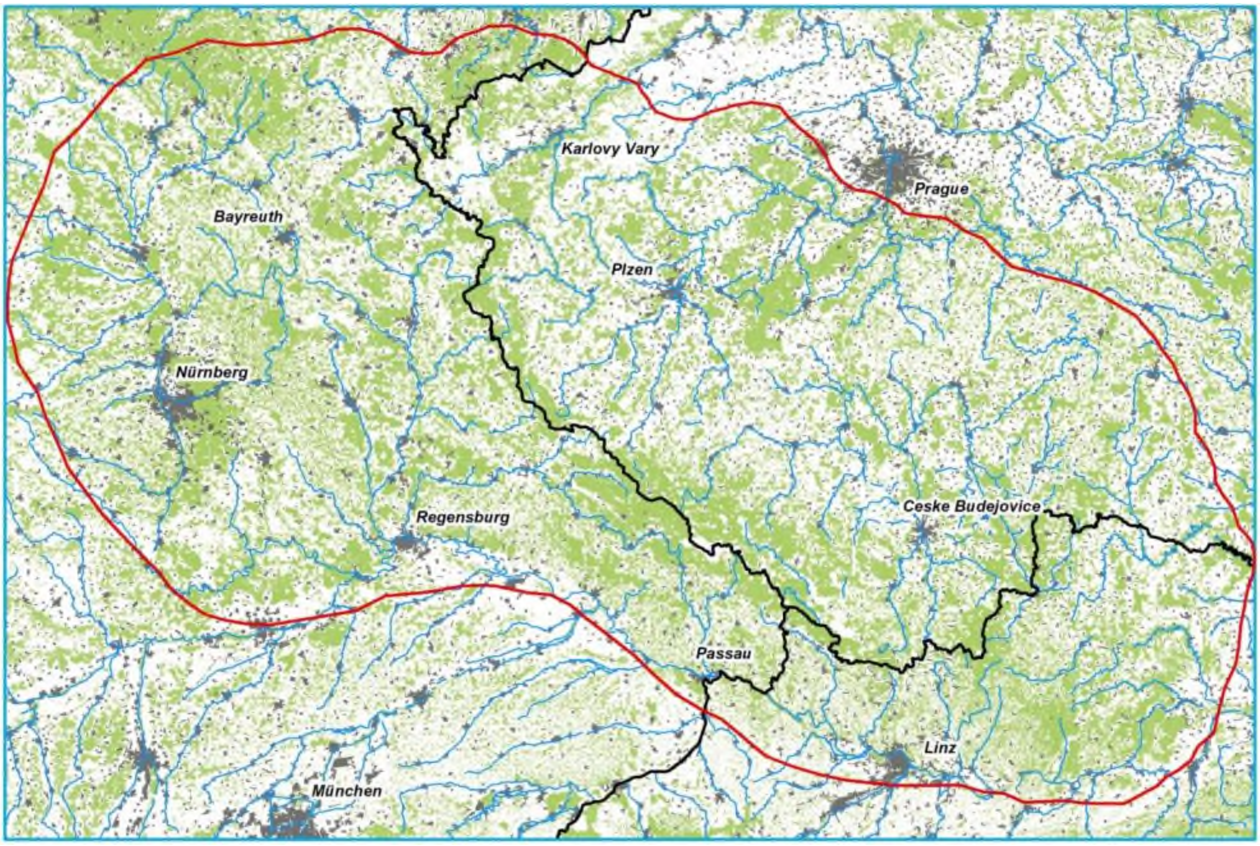

Fig. 1: Study area of the Bohemian-Bavarian-Austrian (BBA) lynx population

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^2 (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^2) 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^2) 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.

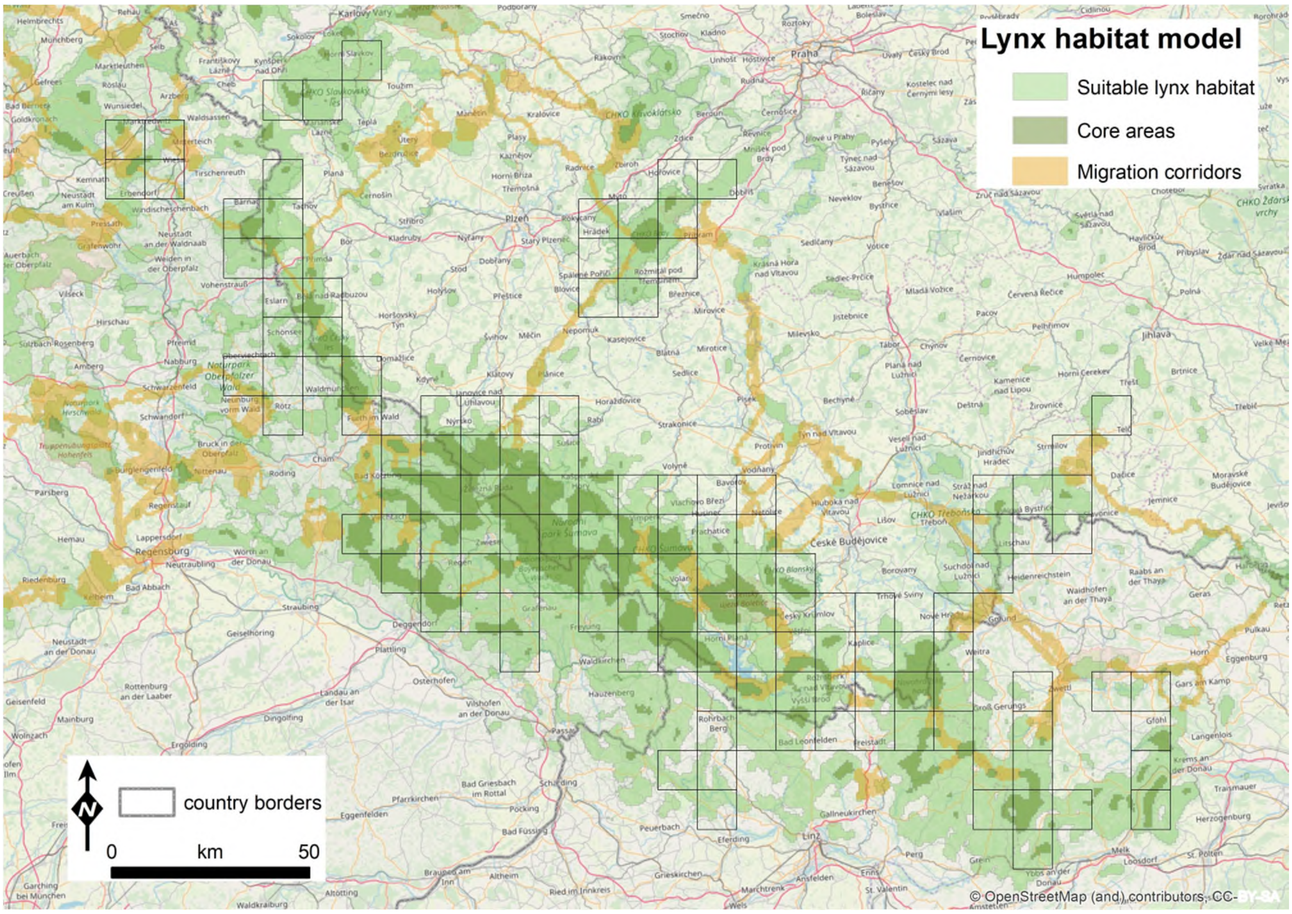

Fig. 2: Lynx habitat map with monitored 10x10 km ETRS89 grid cells, based on lynx habitat model (Romportl 2015).

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 30th 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 whose mother died or vanished

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 the 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. Due to the multiple year-round installation of camera traps, it was possible to detect areas, where a number of resident lynx suddenly disappeared, leaving unoccupied home ranges. This gave a strong indication of where unknown mortality (e.g. illegal killing) is most prominent.

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).

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 outskirt 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).

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 84 grid cells of 10x10 km size were occupied by C1 records and 6 grid cells with C2 records (Fig. 3).

These 90 grid cells comprise an area of 9000 km^2 with permanent or sporadic lynx presence (previous year: 84 C1 and 12 C2 grid cells). 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.

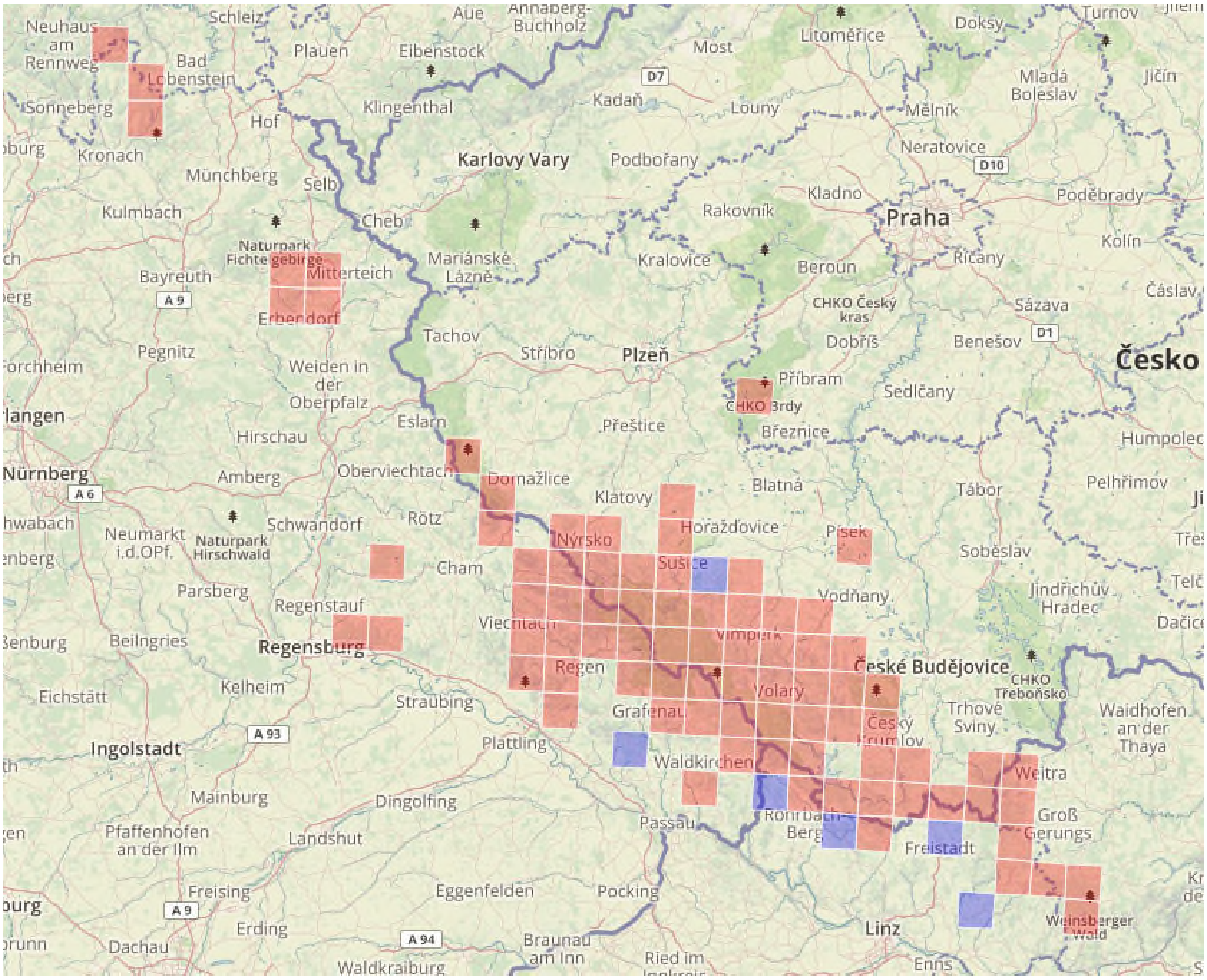

Fig. 3: Distribution map of Bohemian-Bavarian-Austrian lynx population in lynx year 2018. The size of grid cells is 10x10 km. Grid cells in red colour are occupied by at least one C1 data, grid cells in blue colour are occupied exclusively by one or more C2 data.

4.2. Population information

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 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

No.	Reproducing female (LynxCode_LynxName)	Number of proven juveniles	Country	Notes
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_Matylda	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	
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^2). 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.

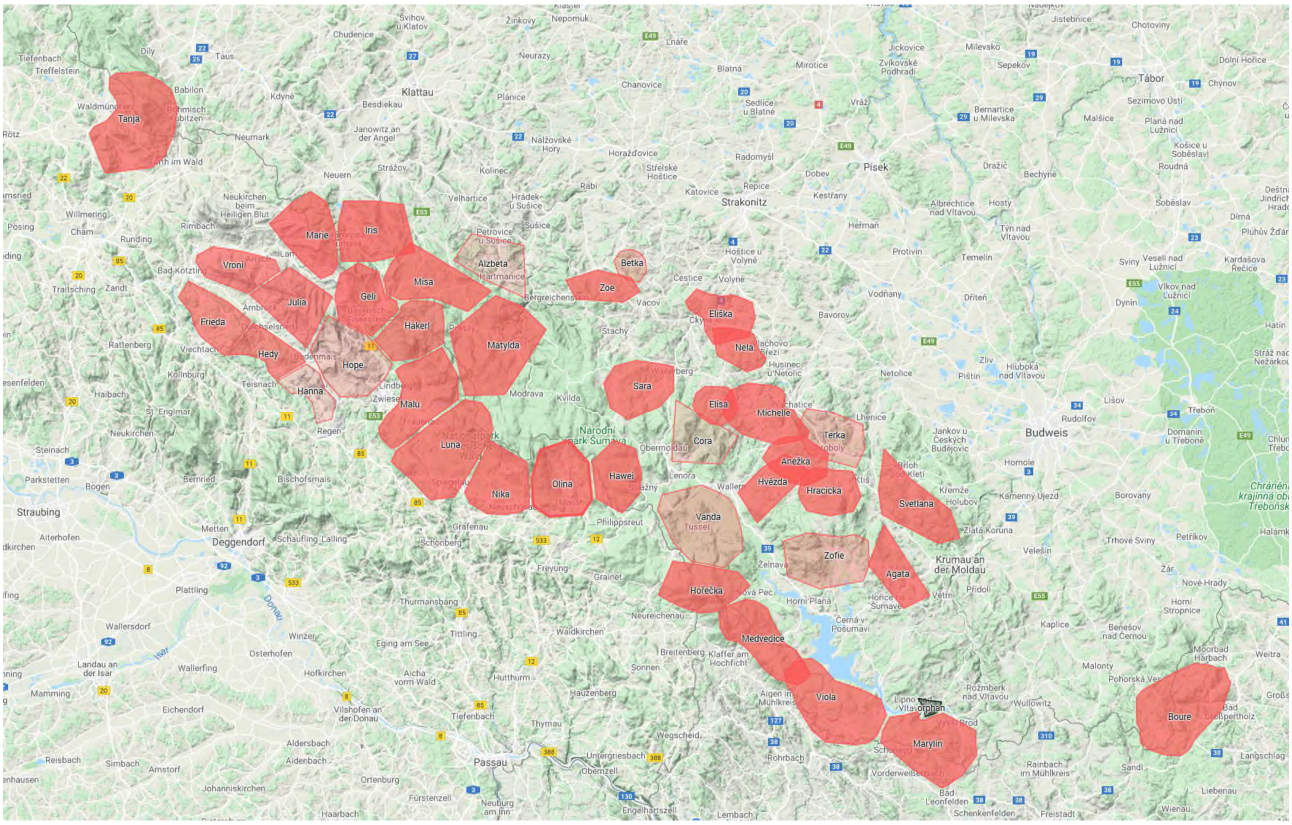

Fig. 4: Map of reproducing females with kittens (dark red shapes), resident females without proven reproduction (light red shapes) and one orphan (black shape) recorded in lynx year 2018. Size and shape of home ranges is approximate and based on available camera trapping and mortality data.

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 a 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). The cases of probable illegal killing are reported in section 4.2.2.2.

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

No	Date	Country	District, Community	Coordi-nates	Individual	Sex	Age	Cause of death
1	5.5.2018	DE	Eschlkam	12.890561 49.267492	_	f	subadult	unclear
2	5.7.2018	DE	Wald-münchen	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	Tirschen-reuth	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 15th-21st January

Two adult females were illegally killed (no. 6, 8).

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. 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); 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). There is an unclear cause of mortality of a subadult lynx (no. 1): 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") died through a violent interaction with another male lynx (no.9). 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.

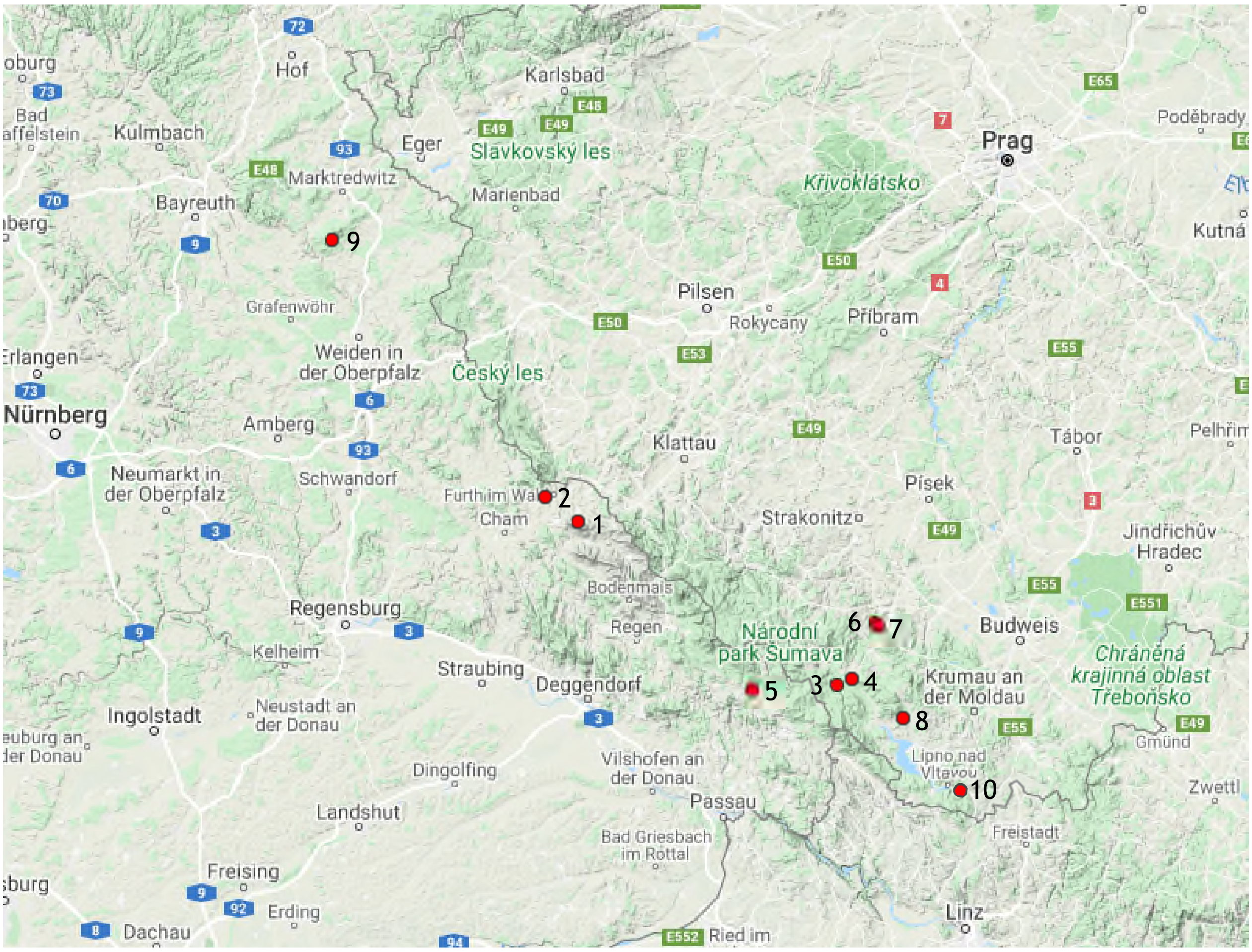

Fig. 5: Registered population losses in lynx year 2018. Numbers refer to Tab. 2.

4.2.2.1. Lynx orphans

We had in total 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 5th 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 road-mortality near Neuschönau/Bavarian Forest National Park 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 due to human intervention, i.e. the siblings were attracted and fed with roe deer inside the national park during the winter months (Gahbauer, pers. comm.).

4.2.2.2. Turnover and survival of lynx

The survival of 109 recorded independent lynx, which were recorded in LY17, was examined. Those lynx were known to be adult (n=60) or subadult (n=31), respectively most probably subadult (n=18) in LY17 (Tab. 3).

Tab. 3: List of adult lynx recorded in LY17 and their fate in LY18.

No.	LynxCode	LynxName	Sex	Age class	First registration (LY)	Fate in LY18
1	B010AT	Joachim	m	adult	2013	MISSING
2	B014AT	Marylin	f	adult	2016	Recorded
3	B015AT	Horecka	f	adult	2016	Recorded
4	B017AT	Roman	-	adult	2014	MISSING
5	B018AT	Eos	-	adult	2016	Recorded
6	B026AT	Medvedice	f	adult	2016	Recorded
7	B11	Kika	m	adult	2008	Recorded
8	B22	Otis	f	adult	2012	MISSING
9	B23	Hakerl	f	adult	2011	Recorded
10	B238	Rico	m	adult	2011	Recorded
11	B24	Tanja	f	adult	2013	Recorded
12	B252	Luna	f	adult	2011	Recorded
13	B255	Hawei	f	adult	2011	Recorded
14	B271	Nika	f	adult	2014	Recorded
15	B272	Julia	f	adult	2014	Recorded

No.	LynxCode	LynxName	Sex	Age class	First registration (LY)	Fate in LY18
16	B273	Alina	f	adult	2014	MISSING
17	B274	Sancez	m	adult	2014	Recorded
18	B275	Kristof	m	adult	2014	Recorded
19	B281	Milo	m	adult	2015	Recorded
20	B287	Moritz	m	adult	2016	Recorded
21	B288	Robert	m	Adult	2015	Recorded
22	B30	Hope	f	Adult	2012	Recorded
23	B31	Geli	f	Adult	2013	Recorded
24	B32	Gestiefelter Kater	m	Adult	2013	Recorded
25	B35	Vroni	f	Adult	2014	Recorded
26	B37	Zdenek	m	Adult	2015	Recorded
27	B38	Stefan	m	Adult	2015	Recorded
28	B39	Veit	m	Adult	2014	Recorded
29	B41	Hanna	f	Adult	2014	Recorded
30	B45	Gregor	m	Adult	2015	MISSING
31	B47	Marie	f	Adult	2015	Recorded
32	B508	Ctirad	m	Adult	2009	Recorded
33	B510	Matylda	f	adult	2009	Recorded
34	B514	Julien	m	adult	2011	Recorded
35	B52	Gerald	m	adult	2015	Recorded
36	B525	Misa	f	adult	2013	Recorded
37	B53	Juri	m	adult	2015	MISSING
38	B534	Agata	f	adult	2014	Recorded
39	B537	Ludek	m	adult	2014	Recorded
40	B538	Michelle	f	adult	2014	DEAD (illegal killing)
41	B541	Majka	f	adult	2014	MISSING
42	B55	Bartl	m	adult	2017	Recorded
43	B552	Jiskra	f	adult	2014	MISSING
44	B556	Hvezda	f	adult	2014	Recorded
45	B559		-	adult	2015	MISSING
46	B563	Kilian	m	adult	2015	MISSING
47	B565	Bartho	m	adult	2015	Recorded
48	B568	Vanda	f	adult	2014	DEAD (road

No.	LynxCode	LynxName	Sex	Age class	First registration (LY)	Fate in LY18
						mortality)
49	B574	Serava	f	adult_prob *	2016	MISSING
50	B580	Zofie	f	adult	2014	DEAD (illegal killing)
51	B581	Pepik	m	adult	2014	Recorded
52	B585	Iris	f	adult	2012	Recorded
53	B593	Sara	f	adult	2017	Recorded
54	B7	Cora	f	adult	2009	DEAD (road mortality)
55	B710	Makini	f	adult	2017	MISSING
56	B711	Bertik	m	adult_prob *	2017	Recorded
57	B716	Karlos	m	adult	2014	Recorded
58	B718	Nela	f	adult	2016	Recorded
59	R507	Alzbeta	f	adult	2015	Recorded
60	R59		-	adult	2016	MISSING

* The age class “adult_prob” means that these lynx were judged as most probably adult.

22 % (n=13) of adult lynx which were recorded in LY17 were not recorded anymore in LY18. Adding the cases of proven mortality, this number increased to 28% (n=17). The survival rate of independent lynx was 0.61. Separated by age class the survival of adults was 0.72, and of subadults 0.49 (Tab. 4). A larger proportion of the losses took part 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 109 independent lynx (60 adults and 49 subadults) recorded in LY17. The percentages refer to the respective age class.

	Road mortality	Illegal killing	Missing in LY18	Losses (total)	Survivors	Survival rate
Adults (> 2 years) (n=60)	2 (3%)	2 (3%)	13 (22%)	17 (28%)	43 (72%)	0.72
Subadults (1-2 years) (n=49)	2 (4%)	0 (0%)	23 (47%)	25 (51%)	24 (49%)	0.49
Independents (n=109)	4 (3.7%)	2 (1.8%)	36 (33%)	42 (38.5%)	67 (61.5%)	0.61

* 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 $\lambda = 67/109 = 0.61$, for subadult lynx $\lambda = 24/49 = 0.49$, for adult lynx $\lambda = 43/60 = 0.72$.

4.2.3. Documented minimum population size

In lynx year 2018, in total **118 independent lynx** were documented.

For 114 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=114 + 2 + 2).

36.4% (n=43) of the recorded independent lynx were moving transboundary between two or even three countries (Tab. 5). In Bavaria, in total 53 independent lynx were recorded, 30 (56.6 %) of which were also recorded in Bohemia or Austria. In Bohemia, in total 91 independent lynx were recorded, 43 (47.3 %) of which were also recorded in Bavaria or Austria. In Austria, in total 23 lynx were recorded, 19 (82.6 %) of which were also recorded in Bohemia or Bavaria. 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	5.1
Bohemia and Bavaria	24	20.3
Bohemia and Austria	13	11.0
Bavaria and Austria	0	0
Bohemia	48	40.7
Bavaria	23	19,5
Austria	4	3,4
Sum	118	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
33 / 17,5 * 100 = 188,6	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)
188,6 - 66 = 122,6	66 = number of juveniles recorded in lynx year 2018 122,6 = theoretical population size incl. independent individuals only (subadults, adults)
122,6 * 1,19 = 145,9	145,9 = theoretical population size incl. independent individuals only, plus standard deviation of 19%
122,6 * 0,81 = 99,3	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=118) 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^2. 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 occupied by the BBA lynx population decreased from 9600 km^2 in LY17 to 9000 km^2 in LY18 (see Minarikova et al. 2019 for LY17 report). However, there is a very slight increase in the number of recorded lynx: from 109 independent lynx in LY17 to 118 independent lynx in LY18 (λ = 1.08, 8.3 % 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 (λ = 1.03). The number of juveniles slightly increased from 62 juveniles to 66 juveniles (λ = 1.05). 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^2 in LY13 and 5500 km^2 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^2 to 13000 km^2. In 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 now are 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 migrating 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 stable part of the population structure. The number of families in LY17 and 18 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 unkown 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. Indeed, in the age class of subadult lynx this quantification is much more difficult than in the age class of adults or even impossible. 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, 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 109 independent lynx in LY17 45% were subadult (n=31) or most probable subadult (n=18). 47% (n=23) of these lynx, supposed to be subadults, were not recorded anymore in LY18. The total loss (including known/documented road mortality) in this age class was 51% (n=25).

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 mortality rate in adult lynx was 1% or 1.5%, respectively (Andrén et al. 2006, Schmidt-Posthaus et al. 2002). In our study, almost a quarter (22 %) of the adult lynx 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 more than 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 this part of the population increases to 28 %. These high losses explain the only marginal 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 on 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 assist and 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.

6. References

Andrén H., Linnell J. D., Liberg O., Ahlqvist P., Andersen R., Danell A. et al. (2002). Estimating total lynx (Lynx lynx) population size from censuses of family groups. Wildlife Biology, 8(1), 299-307.

Andrén H., Linnell J., Liberg O., Andersen R., Danell A, Karlsson J., Odden J. Moa P. Ahlqvist P. Kvam T. Franzén R, Segerstöm P. (2006). Survival rates and causes of mortality in Eurasian lynx (*Lynx lynx*) in multi-use landscapes. Biol Conserv 131:23-32., 299-307.

Kramer-Schadt S. (2004). Wohin läuft der Luchs in Bayern? Lebensraum, Ausbreitungswege und Populationdynamik anhand eines Simulationsmodells. In: Wölfl M., Leibl F., Wagner M. (Ed.): Naturschutz in Niederbayern, Luchsmanagement in Europa. Heft 4, 11/2004.

Krojerová J., Turbaková B. (2020). The analysis of genetic samples of Eurasian lynx (Lynx lynx) for the needs of the 3Lynx project carried out under CENTRAL EUROPE Interreg programme. 3Lynx project report (internal), 24 pp.

Minarikova T., Wölfl S., Belotti E., Engleder T., Gahbauer M., Volfová J., Bufka L., et al. (2019). Lynx Monitoring Report for Bohemian-Bavarian-Austrian lynx population for Lynx year 2017. 17 pp. Report prepared within the 3Lynx Project, funded by INTERREG Central Europe.

Molinari-Jobin A., Molinari P., Breitenmoser-Würsten C., Wölfl M., Stanisa C., Fasel M., Stahl P., Vandel J.-M., Rotelli L., Kaczensky P., Huber T., Adamic M., Koren I., Breitenmoser U.(2003). The Pan-Alpine Conservation Strategy for the Lynx. Council of Europe Publishing. Nature and Environment, No. 130.

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, 266-273.

Poledníková K., Bufka L., Wölfl S., Wölfl M., Engleder T., Gahbauer M., Heurich M., Schwaiger M., Mináriková T., Poledník L., Belotti E., Strnad M., Červený J. (2015). Demography and Population viability analysis of the Bohemian-Bavarian-Austrian lynx population. 37 pp. Project Report of the Trans Lynx Project.

Romportl, D. (2015). Habitat and dispersal models. 11pp. Project Report of the Trans Lynx Project.

Romportl D., Andreas M., Bufka L., Chumanová E., Strnad M. (2010). Habitat Models for Focal Species of Large Mammals. In: Anděl P., Mináriková T., Andreas M. (2010). Protection of landscape connectivity for large mammals. Evernia, Liberec.

Rudolph B.-U., Fetz R. (2008). Konzept zur Erhaltung und Wiederherstellung von bedeutsamen Wildtierkorridoren an Bundesfernstraßen in Bayern. Hrsg.: Bayerisches Landesamt fuİr Umwelt. ISBN 978-3-940009-91-3 (Online-Version).

Reinhardt I., Kaczensky P., Knauer F., Rauer G., Kluth G., Wölfl S., Huckschlag D. & Wotschikowsky U. (2015). Monitoring von Wolf, Luchs und Bär in Deutschland. BfN-Skripten 413.

Schadt, S (1998). Ein Habitat- und Ausbreitungsmodell für den Luchs. Diplomarbeit Technische Universität München, 102 Seiten.

Schadt S., Revilla E., Wiegand T., Knauer F., Kaczensky P., Breitenmoser U. et al. (2002). Assessing the suitability of central European landscapes for the reintroduction of Eurasian lynx. Journal of Applied Ecology,39(2), 18.

Schmidt-Posthaus H., Breitenmoser-Würsten C., Posthaus H. Bacciarini L., Breitenmoser U. (2002). Causes of mortality in reintroduced Eurasian lynx in Switzerland. Journal of Wildlife Diseases, 38(1), pp 84-92.

Wölfl M., Bufka L.,Cervený J., Koubek P., Heurich M., Habel H., Huber T., PoostW. (2001). Distribution and status of lynx in the border region between Czech Republic, Germany and Austria. Acta theriologica, 46(2), 181-194.

Wölfl S., Mináriková T., Poledník L., Bufka L., Wölfl M., Engleder T. et al. (2015a). Status and distribution of the transboundary lynx population of Czech Republic, Bavaria and Austria in the lynx year 2013. 22 pp. Project Report of the Trans Lynx Project.

Wölfl S., Mináriková T., Poledník L., Bufka L., Wölfl M., Engleder T. et al. (2015b). Status and distribution of the transboundary lynx population of Czech Republic, Bavaria and Austria in the lynx year 2014. 12 pp. Project Report of the Trans Lynx Project.