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The Eurasian lynx in Continental Europe

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For joining the Friends of the Cat Group please contact Christine Breitenmoser at ch.breitenmoser@kora.ch

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Editors: Christine & Urs Breitenmoser
Co-chairs IUCN/SSC
Cat Specialist Group
KORA, Thunstrasse 31, 3074 Muri, Switzerland
Tel ++41(31) 951 70 40
<u.breitenmoser@kora.ch>
<ch.breitenmoser@kora.ch>

Cover Photo: Camera trap picture of two Eurasian lynx kittens in north-eastern Switzerland. 11 December 2014 (Photo KORA).

NOLWENN DROUET-HOGUET[1], DELPHINE CHENESSEAU[1], FLORIN KUNZ[2] AND FRIDOLIN ZIMMERMANN[2*]

Situation of the lynx in the Jura Mountains

The present report describes the situation of the Eurasian lynx *Lynx lynx* in the Jura Mountains Mts, shared by France and Switzerland. The species disappeared between the 17th and 20th century and recolonised its natural range from the 1970s following reintroduction in Switzerland. The current distribution in the region covers a total of 13,700 km², including 4,200 km² with "hard fact" evidence of reproduction (data of the biological year 2018/19). In France, the area of regular lynx presence is increasing and consolidates particularly in Franche-Comté region, while almost all suitable habitat is colonised in the Swiss Jura. Between 2004 and 2020, we documented sixteen dispersal movements to adjoining mountain ranges including the Alps (9), the Black Forest and the Schwäbische Alb (6), the Vosges Mts (1) and two to the Swiss Plateau. The Jura Mts could probably form a larger functioning meta-population with the adjoining Vosges-Palatinate Forest, the Black Forest and Schwäbische Alb, and the Alps, although difficult to achieve without reinforcement. The lynx population of the Jura Mts is likely threatened to various extents by traffic accidents, conflicts with human activities and persecution. Furthermore, coordinated health surveillance and genetic variability monitoring are needed to secure population viability.

The Eurasian lynx disappeared in France and Switzerland between the 17th and 20th centuries as a consequence of habitat degradation, direct persecution and the excessive reduction of wild ungulates. In the Jura Mts (Fig. 1), the last evidence reported on either side of the national border included a lynx killed in 1830 near Lignerolle (VD, Switzerland) and another lynx killed near Pontarlier (39, France) (in Breitenmoser et al. 2007). A capture in 1885 at the rim of the French Jura Mts is doubtful (historical review by Eiberle (1972), Herrenschmidt & Leger (1987) and (Schauenberg 1969) in Breitenmoser et al. (2007)). The species was reintroduced in Switzerland in the 1970s, where at least 8 to 10 individuals were released in 3 different sites (Breitenmoser et al. 1998, Breitenmoser & Baettig 1992). Shortly after their initial reintroduction in Switzerland, lynx naturally increased their range and started recolonising France by repopulating forests on the French side of the Jura Mts (Vandel & Stahl 2005). Reintroductions also occurred in the French Vosges Mts between 1983 and 1993 with the perspective of establishing a population there (Vandel et al. 2006). Some accidental or clandestine releases have also been made in the near German Palatinate Forest (Vandel & Wecker 1995). In France, the first observation dates back to October 1974 in the north-east of the department of Ain.

The aims of this report are to review 1) the census and survey technics implemented in France and Switzerland; and 2) the conservation status of the lynx in the Jura Mts with special focus on the conservation challenges and the conservation approaches.

Distribution, population size and trends

Census techniques and density

A stratified lynx monitoring is in place in both countries.

France: Monitoring started in 1998 based on a participative network involving 3,500 trained field experts who collect presence signs all year long. For each presence sign detected, a standardized form is filled out with all the technical criteria needed for further analysis. Data are further examined and validated by a professional agent from the OFB; only recorded signs of lynx that met the standardised criteria are retained (available at http://carmen.carmencarto.fr/38/Lynx.map#).

Since 2011, intense camera trapping sessions have also taken place in a large part of the Jura Mts in order to estimate local population densities. Based on spatial capture-recapture (SCR), data analyses revealed variations in lynx densities (SE) across French Jura counties ranging from 0.24 (0.02) to 0.91 (0.03) lynx per 100 km² (Gimenez et al. 2019).

Switzerland: Monitoring is conducted throughout the country since 1995. Observations (e.g. dead lynx, photos taken by chance, e.g. with

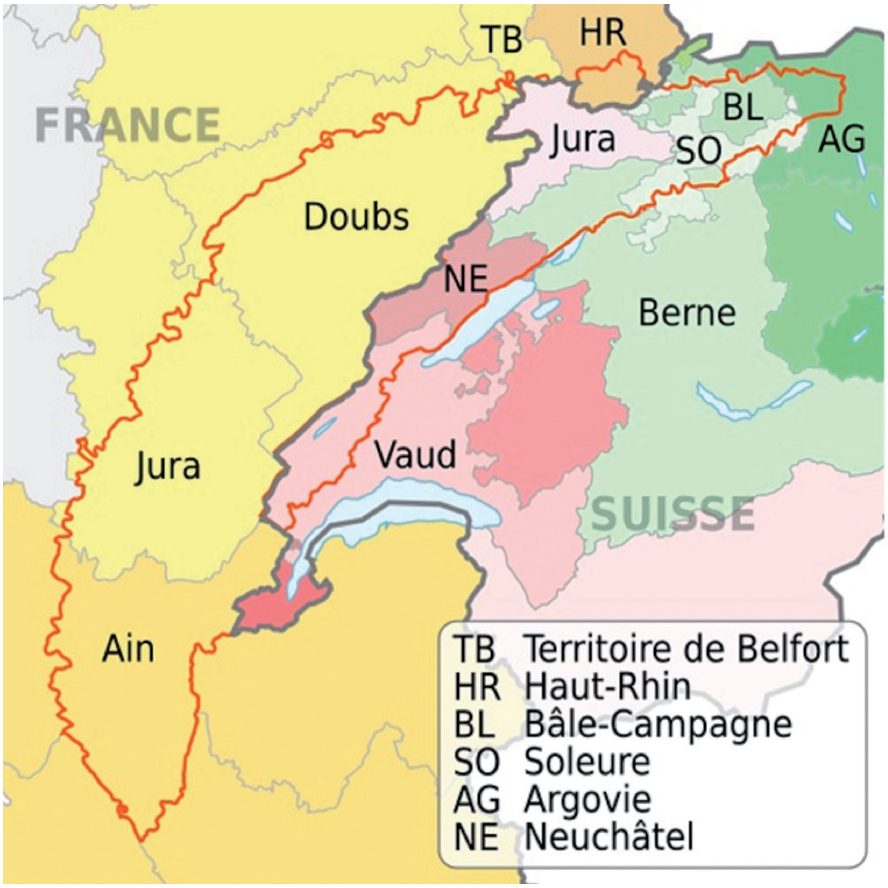

Fig. 1. Map of the Jura Mts with departments on the French side and cantons on the Swiss side (Sémhur 2019 / Wikimedia Commons).

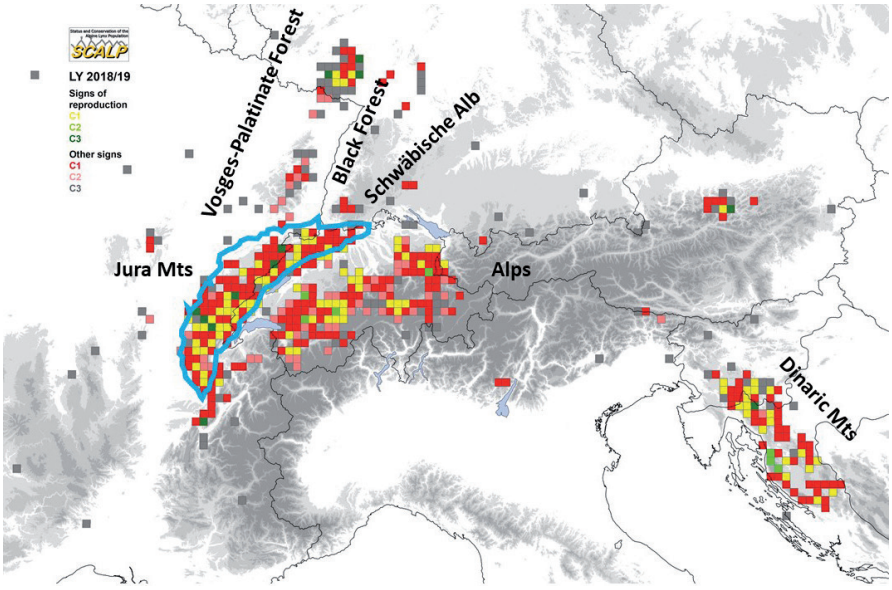

Fig. 2. Observed lynx distribution in the Jura Mts (blue outline), and the adjoining mountain ranges Vosges-Palatinate Forest, Black Forest, Schwäbische Alb, Alps and Dinaric Mts based on a 10 x 10 km grid (SCALP 2018/2019).

a pocket camera) and during the opportunistic camera-trapping, killed wild preys and livestock, tracks and sightings) are gathered year-round at the national and (sub)compartment level by the state game-wardens, hunters, naturalists and the general public and classified in three categories following the SCALP criteria (see Molinari-Jobin et al. 2003 and Molinari-Jobin et al. 2021 for details), and are published online (https://www.koracenter.ch/).

At a smaller scale, at the level of the lynx sub-compartments, the number and density of lynx are estimated by means of photographic capture-recapture models every two to four years. In the Jura Mts sessions were conducted every three years since winter 2006/07 in the reference area northern Jura Mts (882 km^2; Kunz et al. 2019) and since winter 2008/09 in the reference area southern Jura Mts (949 km^2; Zimmermann et al. 2018). Densities (SE) varied between 1.59 (0.6) and 2.55 (0.33) lynx/100 km^2 suitable habitat in the reference area northern Jura and between 1.2 (0.25) and 3.61 (0.85) in the reference area southern Jura. Additional information regarding data types, collection and organisation of the lynx monitoring in Switzerland can be found in Zimmermann (2019). We note that the density estimates are not comparable between France and Switzerland as the approach to estimate the densities differ (spatial vs. non-spatial model, state space or half mean maximum distance moved vs. fixed reference area) (see Gimenez et al. 2019 and Zimmermann et al. 2018 for details on the methodological differences).

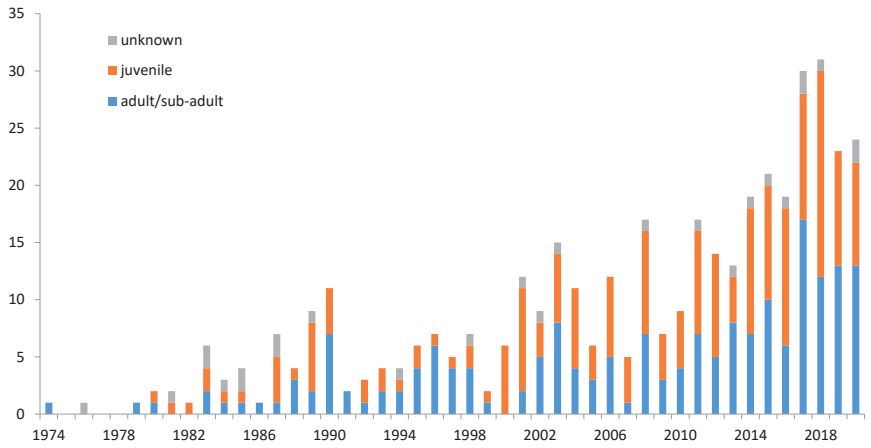

Fig. 3. Evolution of the number of lynx found dead, young orphanes removed from the population and lynx captured in the frame of translocation programs each year (classified according to the age categories: juveniles, sub-adults/adults, unknown) in the Jura Mts. (N= 413).

Distribution

A lynx distribution map for the whole of the Jura Mts for the biological year 2018/19 was produced following the SCALP framework (Fig. 2). Based on 10x10-km grid cells, the total distribution in the Jura Mts was 13,700 km^2, comprising 4,200 km^2 with "hard fact" evidence of reproduction. The population size is estimated to be around 150 independent individuals (but needs to be taken with precaution regarding the variation in density across areas).

Trends by countries

France: The area of regular lynx presence – based on a biennial period and 10x10 grid cells – has been increasing, from 6,800 km^2 in 2017 to 7,300 km^2 in 2018 (OFB 2021 for updates), and consolidates particularly in Franche-Comté, with a notable increase in the Doubs.

Switzerland: Almost all suitable lynx habitat (2,700 km^2) in the Jura Mts is colonised by the species. The population size has increased from about 30 to 75 independent lynx between 2010 and 2018 (KORA, unpubl. data).

Mortality trends

Mortality data has been recorded in Switzerland since the beginning of the lynx reintroduction. There is an increasing trend since the first records in the 1980s (Fig. 3), which is not surprising as both the range and the lynx numbers increased over the years.

Transboundary movements and connectivity

Between 2004 and 2020, we were able to document eighteen dispersal movements by means of camera trapping and telemetry including some long-distance dispersal to adjoining mountain ranges and the Swiss Plateau (Table 1, Fig. 4). Nine lynx (R67, B232, F39_049, TALO, F01_049, B656, F01_053, F01_059, 2117) dispersed to the Alps, six (B328, FRIEDL, B430, B618, LIAS, TONI) to the Black Forest and the Schwäbische Alb (M. Herdtfelder, pers. comm.), one lynx (BINGO) dispersed to the Vosges Mts (Hurstel & Laurent 2016) and two (B288, B296) to the Swiss Plateau. Two of them turned back (B430, F01_053) and settled in the region where

Table 1. Lynx that dispersed in the last decades from the Jura to adjacent mountains ranges and the Swiss Plateau documented by means of camera trapping and telemetry. Name, sex, last observation in the Jura Mts (month/year), destination, first detection at destination (month/year), distance travelled (sum of distances between consecutive locations from the first location to the last location), reproduced (yes/no/?).

Name	Sex	Last observation in the Jura Mts	Destination	First detection at destination	Distance travelled (km)	Reproduced
R67 [a]	?	02/2004	Swiss Central Alps	03/2006	75	?
B296 [a]	m	01/2011	Swiss Plateau	08/2012	60	yes
B288 [a]	f	01/2011	Swiss Plateau	08/2012	25	yes
B232 [a]	m	02/2011	North-eastern Swiss Alps	02/2012	240	?
B328 [a]	m	10/2012	Black Forest	03/2013	70	no
F39_049 [a]	?	12/2012	Chartreuse (Alps)	10/2013	154	?
TALO [b]	m	05/2013	Haute Savoie (Alps)	05/2014	70	?
FRIEDL [a]	m	05/2014	Black Forest	04/2015	130	no
BINGO [a]	m	06/2014	Vosges	03/2015	178	?
B430 [a,c]	m	09/2014	Black Forest	02/2015	200	no
F01_049 [a]	?	03/2015	Savoie (Alps)	03/2016	57	?
B618 [a]	m	06/2015	Schwäbische Alb	06/2015	185	no
B656 [a]	?	12/2016	Chartreuse (Alps)	06/2017	85	?
LIAS [a]	m	02/2017	Schwäbische Alb	02/2017	290	no
F01_053 [a, c]	m	06/2017	Chartreuse (Alps)	12/2017	130	?
TONI [a]	m	05/2019	Black Forest	12/2019	97	no
F01_059 [a]	f	01/2020	Savoie (Alps)	02/2020	9	?
2117 [a]	?	02/2020	Haute Savoie (Alps)	05/2020	27	?

[a]Camera-trapping, [b]telemetry, [c]turned back and settled in the region where they were first observed

they were first observed. Eleven individuals were males, two were females and five were of unknown gender. So far only the two lynx (B288 and B296) that dispersed to the Swiss Plateau reproduced with certainty. These dispersals to adjacent mountain ranges show that the Jura Mts could probably form a larger meta-population with the adjoining populations of the Vosges-Palatinate Forest, Black Forest, Schwäbische Alb and Alps, once all these mountain ranges are settled by lynx. However, we believe that the establishment of a functioning population especially in the Black Forest, Schwäbische Alb and in the French Alps (except for the Chartreuse) will be difficult to be achieved without further reinforcement, especially with female lynx.

Livestock depredation

Domestic prey in the Jura Mts is primary sheep *Ovis aries* (Vandel & Stahl 1998a, Angst et al. 2000, Stahl et al. 2001a). Flocks are mainly available in the lower parts of the Jura Mts along the northern rim, where they are kept in fenced parks. On the Swiss side the number of sheep is low and flocks are unevenly distributed. Most sheep are kept in small pastures nearby houses. Sheep farming is especially important in the northern Jura in the Clos du Doubs in the canton of Jura, where the only significant losses occurred so far (Fig. 5).

Depredation caused significant public conflicts especially in the French Jura Mts, although the number of sheep killed by lynx is low compared with wolf depredation. In France damages to livestock peaked at the end of the 1980s and 1990s–2000s (max = 410 victims in 1989; Fig. 6). Since the 2000s, damages have dropped to a lower level and varied between 40 and 182 livestock compensated as killed by lynx per year. On the Swiss side, damages to livestock varied between 0 and 48 per year (Fig. 6) and occur mainly in the northern Swiss Jura Mts (Fig. 5).

Threats and priorities

There are several main threats for the Jura lynx population. Traffic accidents represent a major source of mortality (Fig. 7), although this assumption is to be weighted with the fact that road kills have a high chance to be found and reported compared to other causes of death (e.g. illegal killing, diseases). In response to this threat, a predictive tool to estimate the impact of different road management actions on the lynx population viability is under development with a Land Transport Infrastructures, Ecosystems and Landscape project implemented by CEFE/CNRS, CEREMA, CROC and OFB (The ERC-Lynx project: https://sites.google.com/view/erclynx). In addition, conflicts with hunters and with livestock breeders to a lesser extent still represent an important challenge for lynx conservation in the Jura Mts as reported elsewhere (Breitenmoser et al. 2000). Illegal killing is likely to be underestimated and reaffirms the needs to be prevented and persecuted by developing a coherent strategy and guidelines to deal with wildlife crime, e.g. raising awareness among all stakeholders, establish a network of wildlife forensic experts, strengthening scene investigation, and prosecution of illegal activities through

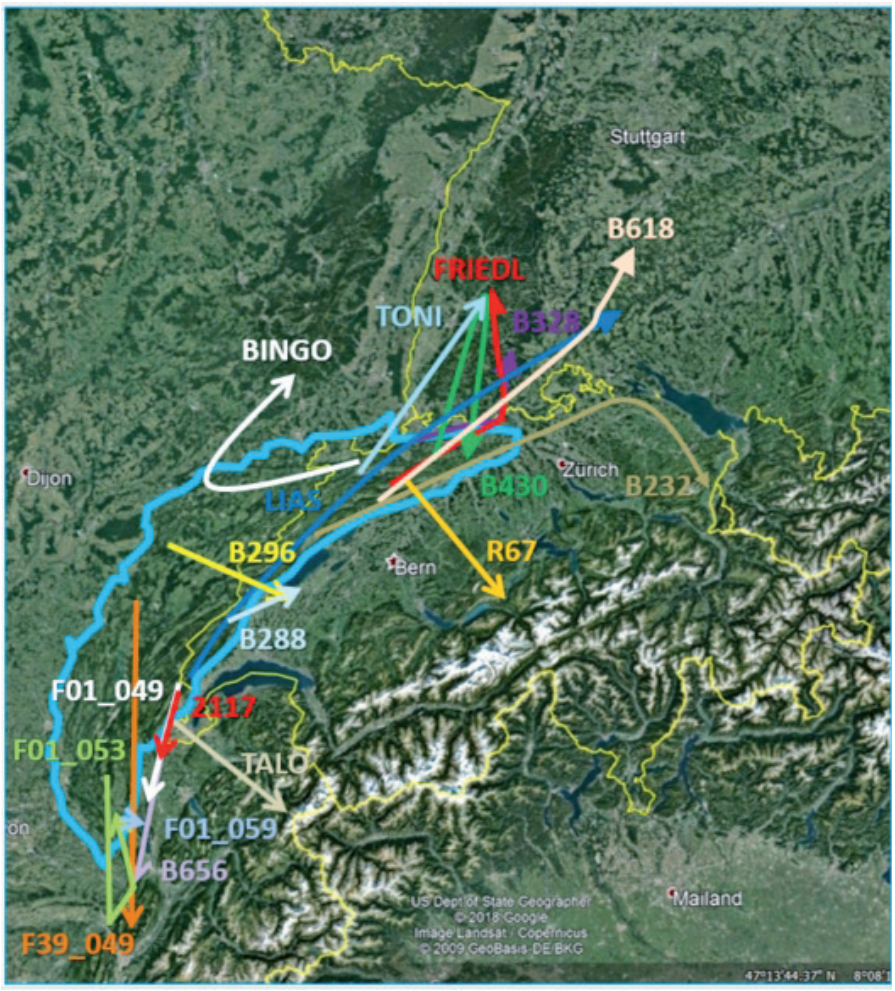

Fig. 4. Lynx that dispersed from the Jura Mts to adjoining mountain ranges and the Swiss Plateau documented by means of camera trapping and telemetry (details in Table 1).

law enforcement. Although no major epizootic outbreak has been experienced until now, cases of diseases such as feline immunodeficiency virus (FIV) and feline leukaemia virus (FeLV) detected in the northern Swiss Jura Mts (Ryser-Degiorgis et al. 2021) could threaten the Jura population, which stresses the importance of a coordinated health monitoring between France and Switzerland.

Finally, population viability requires securing a demographically and genetically healthy population. Heterozygosity, allele frequencies and gene flow between the population in the Jura Mts and adjoining ranges is not well understood and calls for further investigations.

Conclusions

We see several challenges and opportunities for the long-term conservation of this lynx population. In recent years, the Jura population was a source population and served for reintroduction or restocking programs. Between 2003 and 2020, 20 lynx (12 females and 8 males) were captured in the Swiss Jura Mts and released in different mountain ranges in the frame of reintroduction and restocking programs (see Molinari et al. 2021 for details): northeastern Switzerland (Alps), Kalkalpen (Alps), Tarvisiano (Alps), and Palatinate Forest. While such translocations are a good opportunity as they enable to found new populations or reinforce existing ones, they are also a challenge for the Jura population. Given that only healthy young individuals, which should not be too closely related if translocated to the same area, qualify for translocation programs, this could have an impact on the genetic status of the Jura population, especially if the population size is decreasing and there are growing demands for individuals for reintroduction/restocking programs in the coming years. This calls for a genetic transboundary monitoring of the Jura population. The species has colonised almost all suitable habitat, hence there is only a tiny scope for a further increase of the population. The Jura population, which is currently listed as Endangered (EN under Criterion D) will always remain below 250 mature individuals. This is far from the size of a long-term secure population considering genetic aspects and stochastic events. The long-term genetic viability could be achieved if the Jura population was part of a larger meta-population allowing the exchange of individuals between populations, which seems visionary but not illusionary, given the recent records of long-distance movements between adjacent mountain ranges. However, lynx first need to colonise neighbouring mountain ranges with improved connectivity or translocations. The conservation of the lynx in the Jura Mts requests coordinated monitoring, management and applied research. In Switzerland, the lynx management is achieved through the Swiss Lynx Concept (FOEN 2016) which is based on four main pillars: 1) lynx conservation as a main goal, 2) damage prevention, 3) damage compensation and 4) intervention regulation. In France, a National Action Plan is in the process of elaboration, which focuses on increasing monitoring efforts, reducing human-related mortality, reducing conflicts with humans and improving communication and awareness. In the future special emphasis should be given to transboundary convergent methods and cooperation.

At the population level the Office Français de la Biodiversité and the Foundation KORA recently stepped up their collaboration whereas at the meta-population level a cross-border cooperation has been initiated at the Franco-German-Swiss Conference of the Upper Rhine (Upper Rhine Conference; Krebühl et al. 2021).

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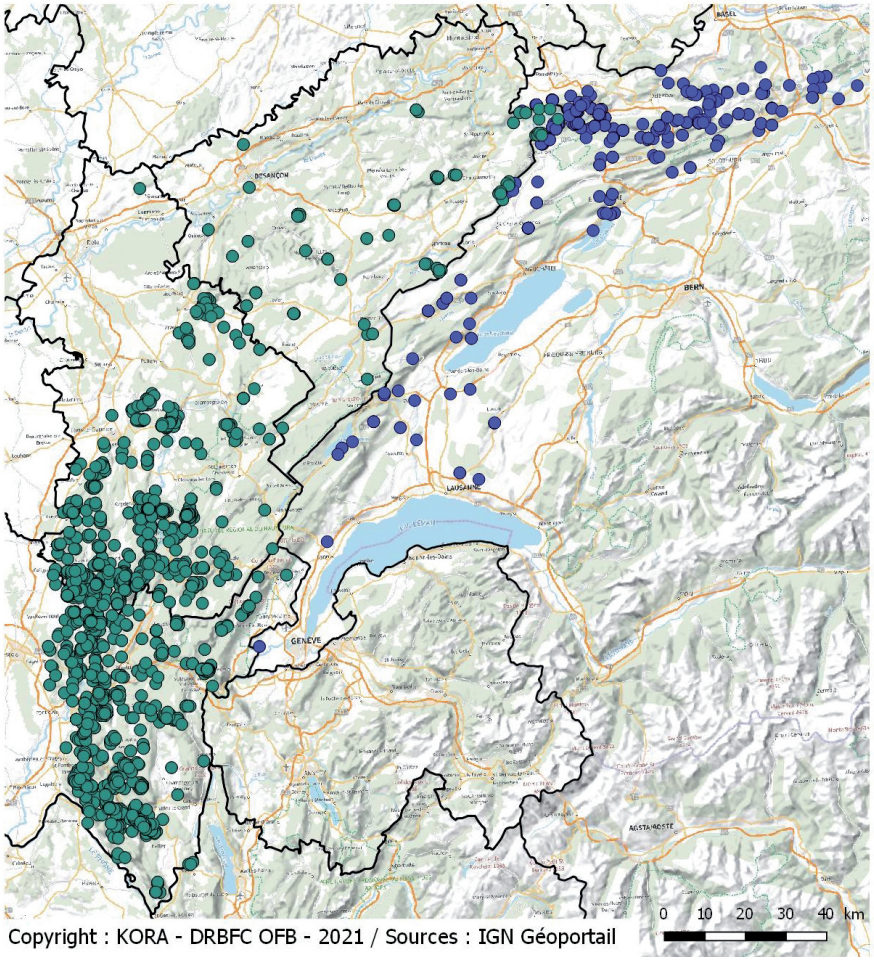

Fig. 5. Distribution of livestock compensated as killed by lynx in the French Jura Mts (N = 4,343, 1984–2019, green dots) and in the Swiss Jura Mts, cantons of Bern, Baselland, Geneva, Jura, Neuchâtel, and Vaud (N = 496, 1973–2019, blue dots).

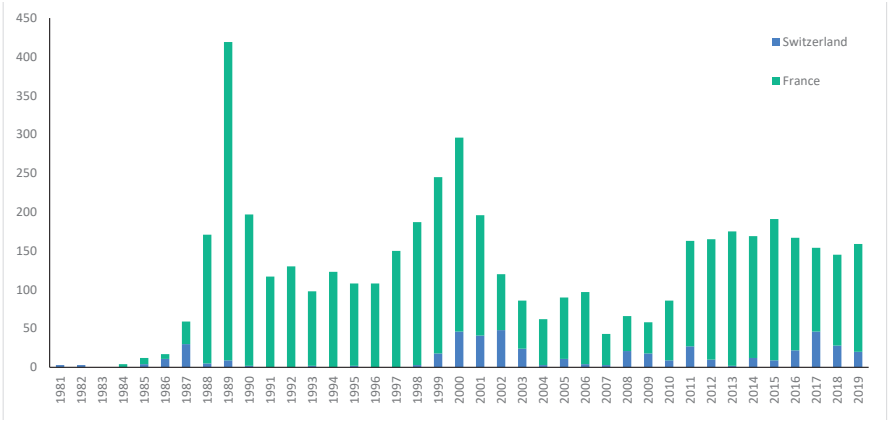

Fig. 6. Evolution of the number of livestock compensated as killed by lynx in the French Jura Mts (in green) since the 1980s (N = 4,343) and in the Swiss Jura Mts (in blue) since the reintroduction in the 1970s (N = 496).

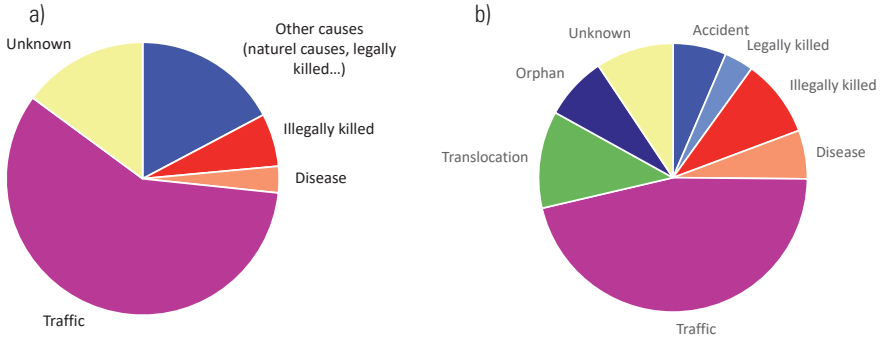

Fig. 7. Causes of death in: a) French Jura Mts (N=255, 1974–2020); b) Swiss Jura Mts (N=171, 1976–2020). In the Swiss Jura Mts, orphaned lynx removed from the wild and lynx captured in the frame of translocation projects were included in the causes of death.

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[1] Office Français pour la Biodiversité, Gières, France
<nolwenn.drouet-hoguet@ofb.gouv.fr>

[2] KORA – Carnivore Ecology & Wildlife Management, Muri, Switzerland
*<f.zimmermann@kora.ch>