Distribution trend of the Eurasian lynx Lynx lynx populations in France

Jean-Michel VANDEL Philippe STAHL

Office national de la chasse et de la faune sauvage Montfort – F-01330 Birieux (France)

Vandel J.-M. & Stahl P. 2005. — Distribution trend of the Eurasian lynx Lynx lynx populations in France. Mammalia 69 (2) : 145-158.

ABSTRACT

The changes in the distribution of the lynx populations in France were analysed with 3,760 data gathered between 1974 and 2002. Maps were drawn for successive three-year periods on a fixed 3 km \times 3 km grid. Lynx were assumed "present" in every 3×3 km grid with one or several data, as well as in the eight surrounding grids, *i.e.* in a total area of 81 km². In 2000-2002, the total and permanent lynx range covered, respectively, 8,622 km² and 5,823 km² in the French Jura mountains (11,500 km² and at least 6,000 km² for the whole French and Swiss Jura Massif). Almost all forested mountain massifs are already occupied by lynx in that region. The total and permanent lynx range covered 3,159 km² and 1,962 km² in the Vosges Massif. This small range and still precarious status of the population 20 years after the first lynx re-introductions, should be related to the high mortality rate of the released lynx and low number of founders. Exchanges between the Jura and the Vosges lynx populations could however be expected in the near future. The total lynx range covered 4,365 km² in the Alps but no permanent area of presence was noticed. The regular increase in the number of islets of presence and the progressive colonization from the north towards the extreme south of the Alps suggested an insufficient observation pressure rather than the absence of any established population in the French Alps. In the future, the status of these three reintroduced populations should probably be comforted by exchanges between the Jura and the Vosges mountains and the Jura and the northern Alps.

RÉSUMÉ

L'évolution de la distribution des populations de lynx en France a été étudiée à partir de 3 760 données récoltées entre 1974 et 2002. Les cartes ont été dressées par périodes de trois ans sur un maillage fixe de 3×3 km. Les lynx ont été considérés présents dans chaque maille contenant une ou plusieurs données ainsi que dans les 8 mailles voisines, soit 81 km² au total. En 2000-

Lynx, distribution trend in France, conservation.

KEY WORDS

2002, les aires de présence totale et permanente du lynx couvraient respectivement 8 622 km² et 5 823 km² dans le Massif Jurassien français (11 500 km² et au minimum 6 000 km² pour l'ensemble du Massif Jurassien français et suisse). La quasi-totalité des massifs forestiers de montagne sont déjà occupés par l'espèce dans cette région. Les aires de présence totale et permanente couvraient 3 159 km² et 1 962 km² dans le Massif Vosgien. La petitesse de l'aire de présence, 20 ans après les premiers lâchers, et le statut encore précaire de la population sont à relier à la forte mortalité subie par les individus lâchés et au très petit nombre d'individus fondateurs. Des jonctions avec le Jura sont néanmoins probables dans un avenir proche. Dans les Alpes, l'aire de présence totale couvrait 4 365 km² en 2000-2002. Aucune aire de présence permanente n'a été identifiée. L'accroissement régulier du nombre de zones de présence et la progression régulière de l'espèce jusqu'à l'extrême sud du massif suggèrent néanmoins qu'il existe une population en voie d'établissement mais que la pression d'observation a été trop faible pour le montrer. À l'avenir, le statut de ces trois populations réintroduites devrait sans doute continuer à s'améliorer grâce au développement des échanges entre les Vosges et le Jura et entre le Jura et les Alpes du Nord.

MOTS CLÉS Lynx, répartition en France, conservation.

INTRODUCTION

The Eurasian lynx Lynx lynx became extinct or rare in many regions of western Europe during the 19th and 20th century (Kratochvil 1968, Breitenmoser & Breitenmoser-Würsten 1990, Stahl & Vandel 1998a). This dramatic regression which began in the Middle Ages was attributed to the combined action of the fragmentation of forested habitats in connection with agricultural development, to the increasing rarity of wild ungulates and human persecution (Breitenmoser 1998). In France, the last captures occurred at the beginning of the 17th century in the Alsace and Vosges regions (Herrenschmidt & Léger 1987), at the end of the 19th century in the Jura and the Massif Central (Herrenschmidt & Léger 1987) and at the beginning of the 20th century in the Alps (Lavauden 1930, Schauenberg 1969, Saint Girons 1973). In the Pyrenees, the last captures would go back to 1917 (Lavauden 1930) or to 1930-40 (Couturier 1954).

Today, the lynx is present again in France in the Alps, Jura and Vosges. The French alpine and Jura populations have their origins in the reintroductions made in Switzerland in the 70's. The exact number of individuals released in Switzerland was not known because unofficial reintroductions have been made in addition to the official ones. Certain estimates affirm the release of 8-10 individuals in the Swiss Jura and of at least 14 individuals in the Swiss Alps (Breitenmoser, Breitenmoser-Würsten & Capt 1998). In the Vosges, the return of the species was due to the release of 21 individuals (12 males and 9 females) between 1983 and 1993 in France. This project was made under the aegis of the French Authorities (Herrenschmidt 1990, Stahl et al. 2000). Unofficial releases of lynx may also have occurred in the nearby German Pfälzerwald region in the early 90's (Vandel & Wecker 1995).

To evaluate the conservation status of the reintroduced lynx population, 20-30 years after the first releases, a basic understanding of their distribution and population fragmentation was needed on a national or regional scale. In this paper, we describe the recent change and present distribution of these re-introduced populations and discuss the future prospects of the lynx with respect to its conservation in France.

METHODS

DATA COLLECTION

From 1974 to 1989, no standardized methodology was applied to collect information on the presence of the lynx. We used two sources of data: (1) records accumulated until 1984 by Christian Kempf, biologist in charge of the Lynx programme; (2) record cards that had been filled in by agents of ONCFS, the French National Hunting and Wildlife Agency, between 1985 and 1989, under the direction of Véronique Herrenschmidt. During this period, most records were from naturalists, foresters and hunters, who incidentally were aware of the presence of the lynx.

From 1990 to 2002, data were collected by the lynx expert networks (Vandel & Stahl 1996) which were set up by ONCFS at the request of the Ministry of Environment to monitor lynx populations. Each network – one in each administrative unit called "département" in France had 30 to 50 trained lynx experts, most of whom were nature conservation professionals or wellinformed naturalists or hunters. The data were centralized by the local administration before being transmitted to ONCFS. The members of the lynx networks established the presence of lynx by three types of information: (1) sightings; (2) signs of presence (footprints or tracks, remains of wild ungulates, lynx carcasses, scats and hairs); (3) attacks on domestic animals. The last ones, of course, only allow to detect the presence of lynx in livestock rearing areas. Scats and hairs were most often rejected because they were not checked by molecular analysis. They represented only 3.7% of the data. For the other types of information, detailed criteria of recognition were defined and standard field-note card established for each type of lynx sign (Vandel et al. 1996). The data were classified as "confirmed presence" when a proof was given (photograph for a sighting, photograph or plaster cast for a footprint or a track, detailed examination and description of bites on the skin of the necks of wild or domestic preys with a precise description of how they had been consumed, lynx corpse) or when a visual

observation was made by a member of the network himself. The data were classified as "probable" when the description was precise and wholly characteristic of a lynx sign or sighting, but not corroborated by material proof. Data were classified "unreliable" and rejected when the information provided was neither sufficiently precise nor typical of a lynx.

SPATIAL ANALYSIS

The objective was to differentiate the sectors where the species is settled (breeding areas or permanent presence of the species) from those where has a rather vague status (recent or only occasional presence). The data were plotted on a fixed quadrangular 3×3 km grid. The lynx was assumed "present" in every 3×3 km grid in which one or several data had been assembled, as well as in the eight surrounding grids, *i.e.* in a total area of 81 km² per data. Relatively to telemetry data analysed with the minimum convex polygon method (Mohr 1947), this grid method leads to slightly underestimated values of the occupied range (Vandel 2001). Indeed, this surface area (81 km²) corresponds to almost half or one-third of the average home range size of a lynx in the Alps or the Jura (Breitenmoser et al. 1993, Stahl et al. 2002, Vandel et al. in prep.).

Maps were drawn for three-year periods. Confirmed and probable data were accumulated over three years to smooth certain inter-annual irregularities of the distribution due to the relative rarity of the data. The permanence of lynx presence in each grid was then measured by superposing the maps drawn for these successive three-year periods. Two categories were distinguished:

 permanent presence: proof of breeding noted during the period of 2000-2002, or presence of the species recorded in 2000-2002 and in at least two of the preceding periods;

- recent or irregular presence: presence noted for the first time in the period of 2000-2002 but not in the four preceding periods or presence noted with interruptions longer than one period.

The data on the presence of lynx in Switzerland in the period 1999-2002 were given by KORA (Coordinated research projects for the conservation and management of carnivores in Switzerland). These were from lynx found dead, killed or captured, observed by a third party or by game wardens, and of cases of predation on livestock. A map was drawn from these data following the same spatial analysis.

RESULTS

DATA COLLECTED

The presence of the lynx in France was analyzed from 3,760 data (Table 1): 58% were classified as confirmed and 42% as probable; 78% of them were collected in the Jura Massif (n = 2.914), 16% in the Vosges Massif (n = 616) and 6% in the Alpine Massif (n = 230). The predation events on domestic livestock represent 8% of the data collected in the Vosges Massif, 14% in the Alpine Massif and 57% in the Jura Massif. These data often are redundant with other lynx signs. On average, the area of presence identified by the sole attacks on domestic animals represents 2% of the total lynx range in the Vosges Massif, 17% in the Alpine Massif and 17% in the Jura Massif. The other most frequent lynx signs were sightings (n = 112, 49%) and tracks (n = 32, 14%) in the Alpine Massif, sightings (n = 535, 18%) and wild prey (n = 329, 11%) in the Jura Massif, and sightings (n = 272, 44%), tracks (n = 128, 21%) and wild preys (n = 85, 14%) in the Vosges Massif.

DISTRIBUTION OF THE LYNX IN THE JURA MASSIF Since the first observation of the lynx in 1974 on the border of Switzerland, the lynx range has never stopped increasing (Fig. 1). It expanded from 81 km² in 1973-1975 to 8622 km² in 2000-2002. Already by the late 80's, the lynx occupied all mountainous forest massifs situated south of the city of Lons-le-Saunier. This continuous area extended up to the Rhône river towards the south. From east to west, it stretched from the High Jura chain along the Swiss border to the Bresse plain (Fig. 2). During the following decade (1990-1999) and until 2002, the regular presence of the lynx throughout these forested mountains was confirmed. To the north, a marked extension of the range progressively occurred in the direction of the city of Besançon (Loue Valley, Moidons and Joue Forests). To the north-east, along the border with Switzerland, in the Doubs and Haut-Rhin *département* in the Alsatian Jura, lynx presence, although already quite long established in 2000-2002, remained rare (Fig. 2). In this region, the lynx presence was only noticed along a narrow 25- to 50-km wide stretch of land and has never resulted in a continuous and permanent range.

Reproduction proofs were collected regularly as of 1982-84 in the Jura Massif. They covered 2,727 km² in the last period, *i.e.* 32% of the total lynx range (Fig. 1). The permanent lynx range covered 5,823 km² in 2000-2002 in the French part of the Jura Massif, *i.e.* almost all mountainous forest massifs situated in the Ain and Jura *départements* (Fig. 3). On the whole Swiss side of

TABLE 1. - Number and type of data collected on the presence of the lynx in the Vosges, Jura and Alps between 1974 and 2002.

	Alpine Massif	Jura Massif	Vosges Massif	Total
Predation on livestock (sheep, goats)	32	1646	48	1726
Footprints and tracks	32	206	128	366
Scats and hairs	1	7	20	28
Lynx captured or found dead	8	73	9	90
Sightings	112	535	272	919
Predation on wild prey (Roe deer, chamois, red deer)	21	329	85	435
Data with several types of indices	24	118	54	196
Total	230	2914	616	3760

the Jura Massif, observations were made on about $3,000 \text{ km}^2$. The total surface area colonized by the Lynx throughout the whole French and Swiss Jura Massif thus covered about $11,500 \text{ km}^2$. The permanent presence of the species has only been identified at least in half of this area $(5,823 \text{ km}^2)$.

VOSGES MASSIF

The lynx range developed around the reintroduction sites and increased from 1,872 km² in 1988-1990 to 3,159 km² in 2000-02 (Fig. 1). Before 1988, the data were too rare to allow any analysis. As early as in 1988-1990, a small continuous area of occurrence covered the forested massifs on the Alsatian side of the southern Vosges mountains in the Haut-Rhin *département* and in the south of the Bas-Rhin département (Fig. 2). During subsequent periods, this area extended to the north, up to the city of Saverne, gaining the major part of the forested mountains of the Alsatian slope of the Vosges. In the most northern part of the Vosges Massif along the German border, information were collected at regular intervals between 1989 and 1996. Afterwards, the data became rare in spite of the training of new field lynx experts and of a higher observation pressure. In the Pfälzerwald Massif, i.e. the forested expansion of the northern part of the Vosges Massif in Germany, the presence of the lynx had been certified in the course of the first half of the 90's. Notably, two female lynx with a familiar behaviour had been captured at that time (Vandel & Wecker 1995). Subsequently, as in France, less data had been collected in spite of the implementation in 2000 of a systematic survey of lynx signs of presence by the German authorities (Huckschlag, pers. comm.).

Towards the west and the south of the Vosges Massif, isolated data were collected in the Vosges and Haute-Saône *départements*, up to 60 km away from the first foothills of the Vosges Massif. To the south, on the fringe of the Vosges Massif, lynx signs of presence were discovered alongside two main undivided stretches of forests. The first one, bordering on the Vosges and Haute-Saône *départements*, continued all the way up to the north-west of the city of Vesoul (Fig. 2). The sec-



Fig. 1. — Changes in the total lynx range and in the area where breeding indices had been recorded in France from 1974 to 2002.

ond one was bordering on the Haute-Saône and Doubs *départements*, and stretched all the way to the far ends of the Jura *département*.

Throughout the Vosges Massif, the surface area on which breeding proofs had been collected increased regularly from 1988-90 to cover 810 km² in 2000-2002, *i.e.* 26% of the total range (Fig. 1). The permanent lynx range covered 1,962 km² in 2000-2002 (Fig. 3).



Fig. 2. – Changes in the distribution of the lynx in the Vosges, Jura and Alps Massifs from 1974 to 2002.





Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
Chablais and Faucigny	1					1	2		1	2	2	1	2	12
Vuache and Salève		3		1			3			1	2	2	2	14
Glières and Aravis								1	2	2		3		8
Chamonix and Beaufortin valleys	2		1		3			5	2	1	1		3	18
Bauges	1		•		0		1	•	-	2	•		2	6
Chartreuse and	•									-			-	Ũ
Epine chains	8		1		1		2		2	2	6	8	10	40
Maurienne Valley						2		2	1	2	2	5	16	30
Oisan Valley				1	1	1	1	5	1			1	1	12
Vercors and Diois	1	2				1		3	1	3	2			13
Briançon and Queyras regions								3		1	1	1		6
Devoluy, Beauchêne, Valgaudemard and Valbonnais				1	1	1	1	1		2	2	2	2	13
Mongoo Embrunaio					1		1	1		2	2	2	2	10
and Ubaye											1	2	1	4
Haut Verdon and Canjuers							1				2	3	2	8
Haut-Var								1		2		1		4

TABLE 2. — Number of occurrence of lynx signs of presence in different Alpine regions between 1990 and 2002. The regions are shown on Figure 4.

ALPINE MASSIF

The first data on the presence of the lynx in the French Alps were from 1982-1984. They were collected in the Haute Savoie *département* (Fig. 2). Previously, in 1976, the remains of a lynx had been found in the Isère *département*, but these were from one of the two males that had been released in the "Grand Paradis" Park in Italy. There had been no follow-up of their presence because of the cessation of the programme and the absence of any other nearby population.

The lynx range increased from 261 km^2 in 1982-1984 to 4365 km² in 2000-2002 (Fig. 1). The distribution of the data showed a progressive colonization of the French Alps, from the north towards the extreme south of the French Alps (Fig. 2). The lynx started to advance in the Chablais region in 1982-1984, then successively progressed towards the northern part of the Alpine forelands (Chablais, Faucigny, Bauges, Chartreuse, Vercors) until 1988-1990, and to the inner valleys of the northern part of the Alps (Beaufortin, Maurienne). The lynx then reached the southern Alps, *i.e.* the Haute Provence *département* in 1994-1996, the Alpes-Maritimes *département* in 1997-1999 and the Var *département* in 2000-2002.

In spite of an increase in the number of islets of presence with the passing years, not a single uninterrupted and vast range has appeared. Proofs of reproduction were rare (Fig. 1). They have mainly been collected in the Haute Savoie *département* and along the confines with the Jura Massif in the Savoie *département*. According to our criteria, the presence of the lynx in the French Alps may only be considered permanent in an extremely reduced area (Fig. 3), which represented 5.5% of the total lynx range in 2000-2002. Although the lynx presence was irregular at the scale of a 3×3 km grid, a certain regularity of the lynx's presence was noticed at the level of mountainous geographic entities (Table 2). In the valley of Chamonix, in the Chablais-Faucigny, Bauges, Chartreuse and Vercors massifs for example, data have been collected at regular intervals since 1990 (Fig. 4).



FIG. 3. - Present status of the lynx in France.



Fig. 4. – Alpine massifs with lynx signs of presence between 1990 and 2002.

DISCUSSION

In the last two decades, three lynx populations have developed in France, in the Vosges, the Jura and the Alps. The dates of appearance of the lynx in these regions, like the axes of dispersal, have been a good reflection of the history of the lynx reintroductions. In the Jura, lynx expanded from two regions in the High Jura close to Switzerland where in the 70's unofficial and official reintroductions had been made (Breitenmoser et al. 1998). In the Alps, lynx expansion was in a north-south direction, beginning in the Chablais region near the Swiss border before continuing further to the south. This coincides with releases that had been made in the Swiss Alps in the 70's. In the Vosges, lynx started to re-establish themselves on the Alsatian slope of the southern Vosges Massif, around the reintroduction sites that had been used as of 1983.

Today the lynx population with the most precarious status is to be found in the Vosges Massif. Applying density estimates of about 1.0 lynx per 100 km² found in the Jura mountains (Breitenmoser et al. 1993), the numbers of sedentary adults could be about thirty for the total lynx range and only 20 individuals for the lynx permanent range. Multiple proofs of reproduction have been noticed in the Vosges Massif. If needed, these are proofs that the lynx have met the necessary conditions to breed and survive, notably prey available in abundance and a sufficient quietness for female to reproduce and raise their young. The small population size thus should rather be related to the low number of individuals that survived among the released lynx and therefore to the low number of founders (Vandel et al. in prep.). Although 21 individuals (12 males et 9 females) were released, only four females and six males had a chance to survive and reproduce because of illegal killing, natural mortality or familiar behavior (Herrenschmidt 1990, Vandel 1995, Stahl et al. 2000).

The Vosges Massif is made up of two forested entities separated from one another at the latitude of Saverne by a local narrowing of the forested landscape, and by a cut made for the passage of highway 4 and the Marne and Rhine canal. Lynx signs of presence were collected between the highway and the canal. This demonstrated that these linear infrastructures allowed the species to pass. However, the progressive development of the lynx presence in the southern and central Vosges mountains, as well as the concomitant increasing rarity of the species in the northern part of the Vosges and in Pfälzerwald, support the hypothesis of a certain independence between these two entities. The possibility of the lynx regularly crossing these barriers is a rather unlikely hypothesis.

To the south of the Vosges mountains, lynx signs of presence were recently discovered. The presence of the lynx in these regions situated between the Vosges and Jura mountains shows the species has the capacity to cross in fragmented forested habitats in a flat open or hilly country, interrupted by large areas of mixed and livestock farming. This information does not demonstrate that there is a connection between the populations of lynx in the Jura and in the Vosges, but they suggest that eventually such a connection is possible if these populations are dynamic and saturated enough to incite subadults to seek a new territory. The few new indices of presence collected since 1997 in the forested and hilly habitats of the Haute-Saône département, suggest that between these two regions some exchanges may take place in the near future.

In the Jura Massif, the lynx has a favourable status. Its permanently present area covers at least 6,000 km² throughout France and Switzerland, almost all forested mountain massifs. By extrapolating to the whole Jura Massif, the density estimates obtained by radiotracking in the Swiss Jura (Breitenmoser et al. 1993), a population of about 115 individuals may be put forward for the period 2000-2002. About sixty sedentary adult individuals may be present in the area of permanent presence throughout France Jura. According to the habitat suitability models developed in the Swiss Jura (Breitenmoser et al. 2002), about 94% of the lynx potential habitat would already be occupied. Eventually, the expansion of this population seems to be possible towards the North. Given the recent progression of its range, it is highly probable that the species will be permanently present in

in the French Alps. As of the first half of the 90's,

the Besançon region in the near future, in continuity with the range already occupied in the Ain and Jura regions. Also, the presence of the species should be confirmed in Switzerland in the cantons of Soleur, Bâle campagne, and partially in Argovie. A more irregular presence may continue to be noted on the boundary with Switzerland in the Doubs *département*, where the forested habitat clearly seems to be less favourable to the species because of the presence of large open agricultural lands. South of the Jura mountains, the lynx distribution range extended towards the Alps beyond the Rhône river all the way to the Vuache mountains in the Haute Savoie département and as far as the Chartreuse Massif in the Isère département via the "Epine" mountain chain. Proofs of reproduction have been collected within these two extensions of the Jura range. This demonstrated that effective exchanges already exist between the Jura and northern Alps. They will probably continue in the future. Other connections with other massifs of the Alpine forelands have however not been brought to light.

In the Alpine Massif there are still many uncertainties about the present status of the lynx. The data collected over 20 years indubitably show the lynx's regular presence in several mountain massifs in the northern part of the Alps, and a progression towards the south over more than 300 km. Such a progression could only have taken place by a population that is producing young, and is pushing certain individuals to new territories. The paradoxical absence of any proofs of breeding and of any discovery of a corpse (Stahl & Vandel 1998b, Stahl & Vandel 1999) thus should rather be attributed to an insufficient observation pressure and/or the use of a methodology of spatial analysis of the data that is not adapted to alpine regions, rather than to the total absence of an established population. In the oriental part of the Swiss Alps, the lynx is present in a continuous area of about 10,000 km² (Zimmermann et al. 2002). The denseness of the data collected in the Swiss Alps contrasts with the fragmentation of the area of occurrence of the lynx in the French Alps. The observation pressure probably has been much higher in the Swiss than the KORA center had monitored lynx in the Swiss Alps by radiotracking. Surveillance of the presence of lynx was also improved by the installation of still-camera traps along the passages usually frequented by radiotracked lynx. In the French Alps, the probability to discover a lynx sign of presence is probably much lower because of the difficulties of prospecting linked to the mountain relief, the difficulty to penetrate in winter into forested habitats situated on a slope, and because of the low human density and little interest people are taking in this species in many regions. The methodology used in this work, which is based on the attribution of only 81 km² of "occurrence" for each lynx sign of presence, also probably leads to an important underestimation of the area of occurrence of the lynx when the probability to discover any lynx sign is very low. The connectivity between populations is, for felines, a key element for the dynamics and persistence of metapopulations in fragmented habitats (Ferreras 2001, Schadt 2002, Schadt et al. 2002). Although the potential habitat of the lynx in the alpine Arc is rather extensive (Zimmermann & Breitenmoser 2002), the connections between the massifs are difficult to assess in the northern Alps because of the existence of highly urbanized valleys, important axes of communication, and areas with very high mountains. In the future, it would thus be necessary to evaluate more precisely the habitat quality for the lynx in the north of the French Alps as well as the structural constraints of this habitat may represent for

Acknowledgements

We would like to thank the following people for their contribution to this study: the members of the lynx networks for their co-operation and intensive field work; Eric Marboutin for their constructive comments; Dr Simon Capt for the data of KORA (Coordinated research projects for the conservation and management of carnivores in Switzerland). This study was supported by the Ministry of Environment, nature and landscapes Directorate.

the development of a lynx population.

REFERENCES

- BREITENMOSER U. 1998. Large predators in the Alps: the fall and rise of man's competitors. *Biological Conservation* 83: 279-289.
- BREITENMOSER U. & BREITENMOSER-WÜRSTEN C. 1990. — Status, Conservation Needs and Re-Introduction of the Lynx Lynx lynx in Europe. Nature and Environment Series, No 45. Council of Europe, Strasbourg.
- BREITENMOSER U., KACZENSKY P., DÖTTERER M., BREITENMOSER-WÜRSTEN C., CAPT S., BERNHART F. & LIBEREK M. 1993. — Spatial organization and recruitment of Lynx (*Lynx lynx*) in a reintroduced population in the Swiss Jura Mountains. J. Zool., Lond. 231: 449-464.
- BREITENMOSER U., BREITENMOSER-WÜRSTEN C. & CAPT S. 1998. — Re-introduction and present status of the Lynx (*Lynx lynx*) in Switzerland. *Hystrix* 10 (1): 17-30.
- BREITENMOSER U., CAPT S., BREITENMOSER-WÜRSTEN C., ANGST C., ZIMMERMANN F. & MOLINARI-JOBIN A. 2002. — Le lynx dans le Jura, aperçu de l'état actuel des connaissances. KORA, Muri, 19 p.
- COUTURIER M. A. 1954. L'ours brun, Ursus arctos L., Grenoble, 907 p.
- FERRERAS P. 2001. Lanscape structure and asymetrical inter-patch connectivity in a metapopulation of the endangered Iberian Lynx. *Biological Conservation* 100: 125-136.
- HERRENSCHMIDT V. 1990. Le Lynx : un cas de réintroduction de superprédateur. *Rev. Ecol. (Terre Vie)*, Suppl. 5: 159-174.
- HERRENSCHMIDT V. & LÉGER F. 1987. Le Lynx, Lynx lynx (L.) dans le nord-est de la France. La colonisation du massif jurassien français et la réintroduction de l'espèce dans le massif vosgien. Premiers résultats. *Ciconia* 11: 131-151.
- KRATOCHVIL J. 1968. Survey of the distribution of populations of the genus *Lynx* in Europe. *Acta. sc. nat. Brno* 2: 5-12.
- LAVAUDEN L. 1930. *Essai sur l'histoire naturelle du Lynx*. Allier & fils, Grenoble, 108 p.
- MOHR C. O. 1947. Table of equivalent populations of North America small mammals. *Am. Mild. Nat.* 37: 223-249.
- SAINT GIRONS M. C. 1973. Les Mammifères de France et du Benelux (Faune marine exceptée). Doin, Paris, 481 p.
- SCHADT S. 2002. Scenarios Assessing the Viability of a Lynx Population in Germany. Lehrstuhl für Landschaftsökologie der Techischen Universität München, 96 p.
- SCHADT S., REVILLA E., WIEGAND T., KNAUER F., KACZENSKY P., BREITENMOSER U., BUFKA L.,

CERVENY J., KOUBEK P., HUBER T., STANISAS C. & TREPL L. 2002. — Assessing the suitability of central European landscapes for the reintroduction of Eurasian lynx. *Journal of Applied Ecology* 39: 189-203.

- SCHAUENBERG P. 1969. Le Lynx Lynx lynx (L.) en Suisse et dans les pays voisins. *Revue Suisse Zool.* 76: 257-287.
- STAHL P. & VANDEL J.-M. 1998a. Le Lynx Boréal Lynx lynx (Linné, 1758). Encyclopédie des carnivores de France N°19. SOCIÉTÉ FRANÇAISE POUR L'ÉTUDE ET LA PROTECTION DES MAMMIFÈRES (ed.), Muséum National d'Histoire Naturelle, Paris.
- STAHL P. & VANDEL J.-M. 1998b. Distribution and status of the Lynx in the French Alps. *Hystrix* 10: 3-16.
- STAHL P. & VANDEL J.-M. 1999. Mortalité et capture de lynx (*Lynx lynx*) en France (1974-1998). *Mammalia* 63: 49-59.
- STAHL P., VANDEL J.-M. & MIGOT P. 2000. La réintroduction du lynx dans le Massif vosgien. *Le Courrier de la Nature* 182: 25-27.
- STAHL P., VANDEL J.-M., RUETTE S., COAT L., COAT Y. & BALESTRA L. 2002. — Factors affecting lynx predation on sheep in the French Jura. *Journal of Applied Ecology* 39: 204-216.
- VANDEL J.-M. 1995. Le Lynx dans le massif vosgien, situation en 1994. Bull. Mens. Off. Nat. Chasse 202: 2-15.
- VANDEL J.-M. 2001. Répartition du lynx (Lynx lynx) en France (Massif alpin, jurassien et vosgien), méthodologie d'étude et statut actuel. École Pratique des Hautes Études, Laboratoire de Biogéographie et écologie des vertébrés, Diplôme, Montpellier, France, 88 p.
- VANDEL J.-M. & STAHL P. 1996. Surveillance des populations de Lynx en France : commentaires méthodologiques. *Bull. Mens. Off. Nat. Chasse* 215: 2-7.
- VANDEL J.-M. & WECKER F. 1995. Présence actuelle du Lynx (*Lynx lynx*) dans le massif des Vosges du Nord (France) et le Palatinat (Allemagne). *Ciconia* 19: 133-144.
- VANDEL J.-M., STAHL P. & MIGOT P. 1996. Dossier Lynx - Commission d'observation, commission de constatation de dommages, formation. Office national de la chasse et de la faune sauvage, Birieux.
- ZIMMERMANN F. & BREITENMOSER U. 2002. Potential distribution and population size of the Eurasian lynx (*Lynx lynx*) in the Jura mountains, Switzerland, *in* SCOTT J. M. *et al.* (eds), *Predicting Species Occurrence: Issues of Accuracy and Scale.* Covelo California, Island Press: 653-660.
- ZIMMERMANN F., WATTENWYL K. VON, RYSER A., MOLINARI-JOBIN A., BURRI A., BREITENMOSER U., BREITENMOSER-WURSTEN C. & ANGST C. 2002. *Monitoring Luchs in der Schweiz 2001.* KORA, Muri, 37 p.

Submitted on 1st February 2004; accepted on 20 February 2005.