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Distribution and status of lynx in the border region between Czech Republic, Germany and Austria

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This paper summarizes available information concerning the presence of the Eurasian lynx *Lynx lynx* Linneaus, 1758 in the Šumava Mountains and adjacent areas along the common border of Czech Republic, Germany and Austria. Our data give an overview of the lynx population occupying the border region between the three countries from 1990 to 1999. We estimated population size using radiotracking data. From 1990 to 1998, population increased from under 20 to nearly 70 resident animals. During this time, reproduction increased as well, with a maximum of 55 kittens observed in the rearing period of 1998 to 1999. Mortality data indicated that illegal hunting was widespread. Our paper discusses possible links with other lynx populations and describes the legal status of lynx in the three different countries. Current management approaches are outlined and steps toward a long-term conservation plan for the population are proposed.

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Key words: *Lynx lynx*, distribution, status, management, Šumava mountains, Czech Republic, Germany, Austria

Introduction

During the 19th century, Eurasian lynx *Lynx lynx* Linneaus, 1758 were extirpated in the Šumava region. The last records of lynx killed are 1846 near Zwiesel, Germany (Sperber 1974), 1902 in Carinthia, Austria (Festetics 1981) and 1894 in the Czech Republic (Vodák 1974). For the first 70 years of the 20th century, sporadic observations in the region (eg near Zwiesel; J. Paternoster, pers. comm.) were usually interpreted as dispersing animals born in the Carpathian Mountains of Slovakia (Červený *et al.* 1996). In the early 1970s, lynx were re-introduced in

Bavaria. The exact number of animals released is still not known, but probably ranged from 5 to more than 10 individuals (Festetics 1981). From 1982 to 1989, a total of 17 lynx were released on the Czech side of the Šumava Mountains (Červený and Bufka 1996). The current status of lynx is described in detail for the Czech region of the population (Anděra and Červený 1994, Červený and Bufka 1996, Bufka 1997). For Germany approximate population estimates also exist (Kiener and Strunz 1996, Poost 1997, 1998, Schödl 1996, Wölfl 1996, 1997, 1998a, 1999). Detailed information is lacking for the Austrian part of the population (Breitenmoser and Breitenmoser-Würsten 1990, Huber 1995, 1996). In spite of all available information on the national level, the complete picture of the population of lynx in Europe is still unclear. To date each country has focused on its own territory, more or less neglecting an international view of the lynx population.

Our study attempts to fill this gap by combining information about lynx from all three countries. First, we map the international distribution of lynx in the Šumava region and adjacent areas of the Czech Republic, Germany and Austria. By processing all available data for the last decade we document and compare the status of lynx in the three different countries, focusing on population parameters (eg reproduction and mortality), population trends, legal status and current management of lynx. Second, we discuss possible improvements in international communication and coordination to set the stage for an international management of the central European lynx population.

Study area

The study area centers around the Šumava Mountains (Fig. 1). They consist of an extensive mountain chain approximately 120 km long and 20 km wide, situated along the border between Bohemia (Šumava Mountains), Bavaria (Inner Bavarian Forest) and Upper Austria (Mühlviertel). Two

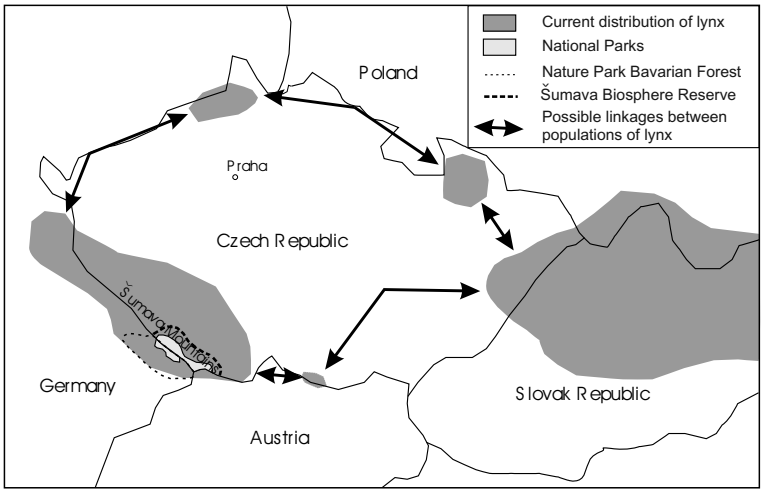


Fig. 1. Study area and possible linkages between lynx populations in central Europe.

national parks, the Šumava (680 km^2) and the Bavarian Forest National Park (230 km^2) form the center of a large protected area. They are surrounded by two landscape protected areas (Šumava Biosphere Reserve 790 km^2, Bavarian Nature Park 2680 km^2). The summit of the Arber reaches an elevation of 1457 m above sea level. Forest cover is more than 90%, and human population density is low (20 inhabitants/km^2). For our analyses we included the foothills and adjacent mountain ranges namely, the Šumava Foothills, the Blanský Les, the Novohradske hory, the Outer Bavarian Forest, the Český Les, the Fichtelgebirge, and the Slavkovský Les. In these areas, forest cover varies from 60 to 80%, and human density reaches 100 inhabitants/km^2. The climate is continental with some maritime influence from the west. Mean temperature in the center of the study area is 3.5 to 6.5°C, with an annual precipitation varying from 2500 mm (west) to 400 mm (east). Permanent snow cover lasts up to 7 months. Other large predators such as wolf *Canis lupus* and brown bear *Ursus arctos* are not present in the area. Main prey species for the lynx are roe deer *Capreolus capreolus*. Other ungulate species such as red deer *Cervus elaphus*, wild boar *Sus scrofa*, and mufflon *Ovis ammon* also occur in the area.

Methods

Data sources and quality

We collected data for the Czech Republic by reviewing available literature, unpublished records of questionnaires distributed to various regional hunting grounds, results of snow tracking and incidental sightings, tracks, killed prey or lynx found dead (for detailed description see Červený and Bufka 1996, Bufka 1997, Červený *et al*. 1997). In Austria only incidental findings were recorded (W. Proksch, pers. comm.). In Germany incidental findings were gathered (Poost 1996, Wölfl 1996, 1997, Habel 1997). Since 1994 data have been collected using snow tracking and questionnaires as well (for details refer to Poost 1996, Heurich 1997, Kiener 1997).

When approaching our data set, we have to take into consideration several aspects linked with the process of data gathering and public relation work in the region. First, only few of the data were verified. We estimate verification of data to be about 30% in Czech Republic, 30% in Germany and about 20% in Austria. Especially data gathered by questionnaires generally could not be verified. Second, in the beginning of the nineties only minimal efforts were made to gather data. Only few people knew of lynx presence, and even fewer could recognize field signs of lynx. Coupled with more intense public information, data were collected on a larger scale during the next few years. For example, the questionnairies sent to hunters in Czech Republic since 1994 covered more districts each year. Therefore, our data likely overestimate the rate of increase of the lynx population. Moreover, data flow is dependent on other variables. The main problem with our data set is that it is not possible to measure the searching effort. Therefore, it is difficult to relate data quality to any population trends because we lack any index linking the amount of data to searching effort (for example, numbers of tracks found per km trackline searched, numbers of lynx observed per hour observation time). That is why a change in the yearly amount of data is not necessarily linked with a change in population numbers but may be related to other factors as well. For example, weather conditions, especially snow cover and snow conditions, strongly influence our findings of lynx presence. Additionally, the motivation level of people living in the area to cooperate with researchers is changing. This depends on factors such as mutual trust or hunting practice on roe deer. Lastly, the effort researchers make to procure data varies over space and time. In Austria, for example, a network for systematically gathering lynx information has only recently been installed. In spite of the shortcomings stated above our data are the best available. Because most of the data were not classified into different reliability categories, a splitting into different quality groups was not feasible.

Data plotting and processing

For plotting data in the Czech Republic, we used the RFME grid system with a square size of approximately 11.2 by 12 km (Červený *et al*. 1997). For Germany and Austria, data were transcribed into 10 × 10 km squares according to the Gauß-Krüger-grid system. For estimating population trends the period was divided into yearly intervals from 1990 to 1998. For each interval and square, lynx

Table 1. Radiotracked lynx in the Šumava Biosphere Reserve, Czech Republic (1996–2000). MCP – Minimum Convex Polygon Area Method (Mohr 1947).

Sex	Surveillance (month/year)	Age	Home Range Size (MCP)	Number of locations	Fate
Male	2/96	adult	–	19	dead
Male	2/96	adult	–	21	dead
Male	2/97–12/97	adult	494 km^2	151	transmitter failure
Male	2/97–6/98	subadult	394 km^2	84	unknown
Male	2/98–4/98	adult	–	47	unknown
Female	3/99–3/00	adult	307 km^2	235	transmitter failure
Female	3/99–11/99	subadult	–	232	unknown

presence intensity was classified to one of the three categories: (1) irregular occurrence (IRO) when < 5 observations were reported in a 12-month period, (2) regular occurrence (REO) with ≥ 5 observations in a 12-month period, and (3) confirmed reproduction (COR) when data indicated presence of female(s) with kitten(s) within a rectangle/square.

Along the overlap of the different grid systems (the border region between the Czech Republic and Germany or Austria, respectively) some adjustments were made; as a rule, stronger evidence was plotted on top of weaker evidence (eg COR on top of REO, REO on top of IRO). Furthermore, if a rectangle/square exceeded the border more than half its size and no data were recorded in the neighbouring country, we used only half-sized rectangles/squares for grafic presentation. However, for the evaluation of data, these half-sized rectangles/squares were not taken into account.

For estimating lynx population size we used radiotracking data from the Šumava National Park and the Czech Academy of Sciences. Since 1996, a total of 7 lynx were caught in boxtraps and fitted with radiocollars (Table 1). Additionally, estimates of snowtracking data from Šumava National Park were used which estimated 2.3 lynx per 100 km^2, including subadults (Bufka 1997). For evaluation of recruitment we considered the yearly reproductional cycle of lynx (May to April, years 1989–1990 to 1998–1999) and plotted all COR information for these 10 intervals into the grid system. For number of kittens per rectangle/square we used the maximum observed young during the breeding cycle in one square. To document the mortality in the population, we simply summed all known casualities.

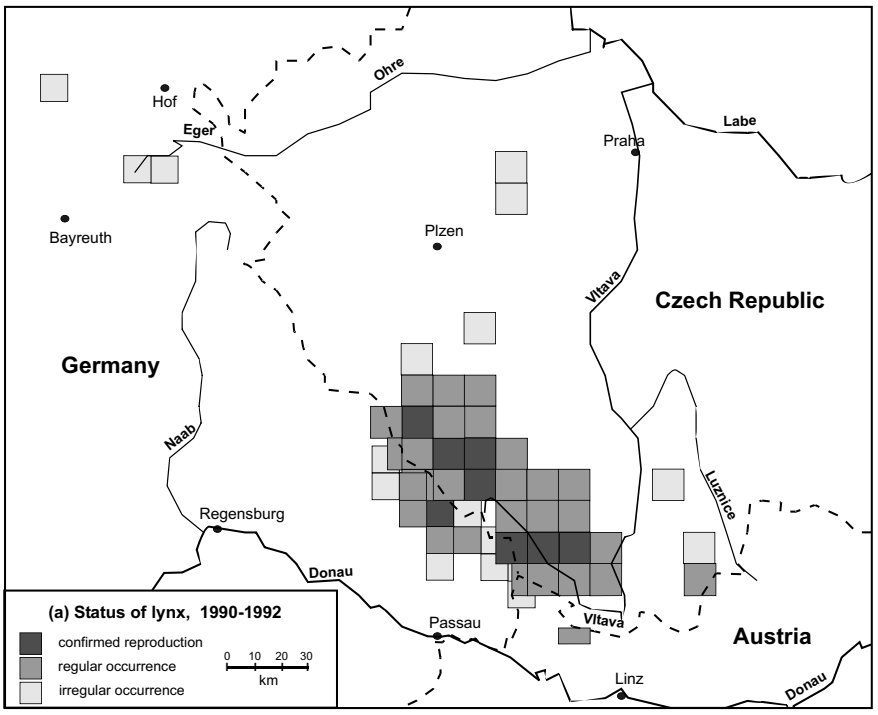
Results and discussion

Number and quality of data

Data collected throughout the past decade steadily increased in all three countries suggesting an increasing lynx population (Table 2). The data of lynx occurrence in southwestern Czech Republic were collected mainly from the territory of the Šumava National Park and Landscape Protected Area in the period 1990–1992 (Fig. 2a). In 1993, more intensive surveys (snowtracking in adjacent areas, questionare distribution in all districts in the western and southern Bohemia) had been started in order to provide more information about the total lynx distribution within the whole southwest Bohemia. Also, the research intensity in the Šumava Mts Region increased and the snowtracking was standardized (regular intervals, standardized routes). This means that the increase in amount of data in 1993 was due not only to the increase of the lynx population but also

Table 2. Data of lynx presence in the Šumava Mts gathered in the Czech Republic, Germany and Austria (1989–1999). Other – eg lynx found dead. [a] – data for January–April 1999.

Year	Czech Republik					Germany					Austria					Total				
	Sight	Tracks	Kills	Other	Total	Sight	Tracks	Kills	Other	Total	Sight	Tracks	Kills	Other	Total	Sight	Tracks	Kills	Other	Total
1989	12	30	1	–	43	–	–	2	–	2	1	–	–	–	1	13	30	3	–	46
1990	12	34	7	–	53	6	13	3	–	22	–	–	–	–	–	18	47	10	–	75
1991	9	57	1	2	69	9	16	16	–	41	–	–	2	–	2	18	73	17	2	110
1992	14	34	12	6	66	5	24	9	–	38	–	1	–	–	1	19	59	21	6	105
1993	54	56	258	5	373	13	33	24	–	70	2	1	–	–	3	69	90	282	5	446
1994	157	98	284	7	546	35	86	44	–	165	1	4	1	–	6	193	188	329	7	717
1995	120	201	316	6	643	51	185	59	2	297	–	3	6	–	9	171	389	381	8	949
1996	230	209	364	8	811	66	157	42	4	269	10	–	9	–	19	306	366	415	12	1099
1997	225	223	322	3	773	63	196	24	9	292	4	20	10	–	34	292	439	528	12	1271
1998	319	322	341	8	990	41	113	30	11	195	4	22	3	–	29	364	457	374	19	1214
1999[a]	13	44	16	1	74	18	60	20	5	103	1	9	2	–	12	32	113	38	6	189
Total	1165	1308	1922	46	4441	307	883	273	31	1494	23	60	33	–	116	1495	2251	2398	77	6221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(a) Status of lynx, 1990-1992
confirmed reproduction
regular occurrence
irregular occurrence
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km
Passau
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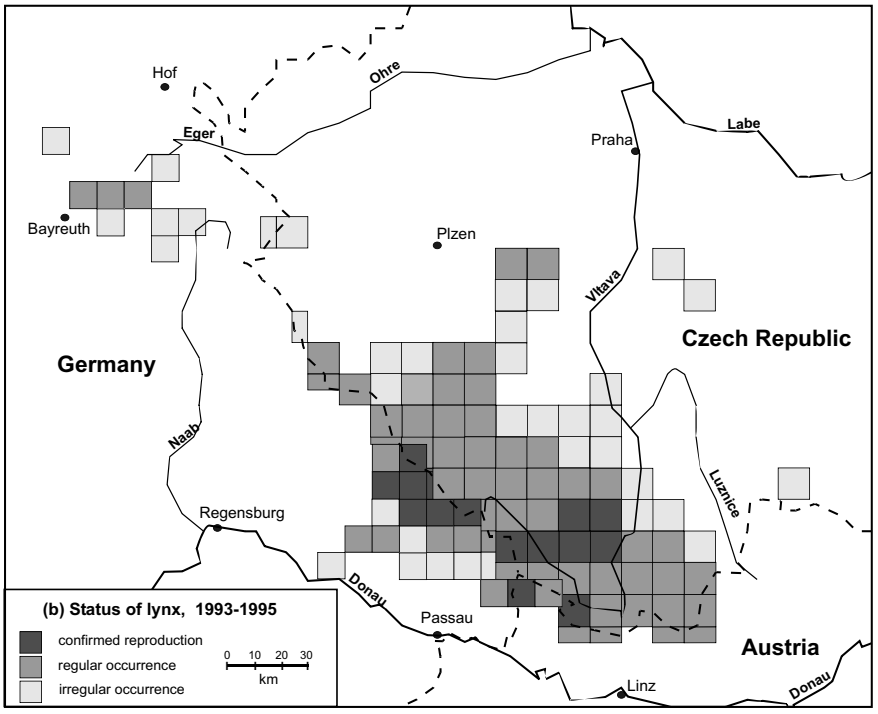
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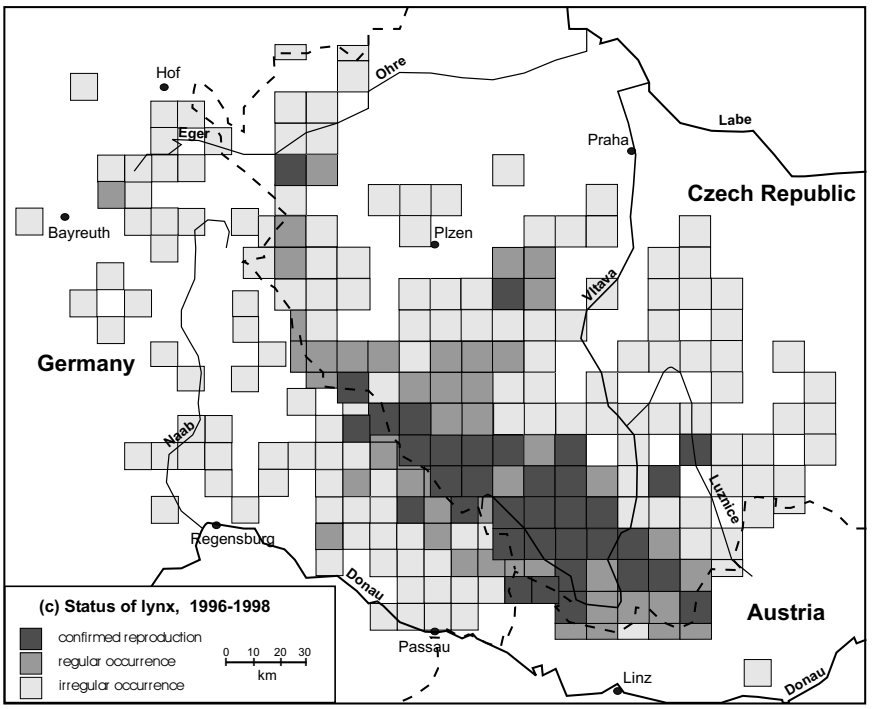

Fig. 2. Changes of the status of lynx in the border region between Czech Republic, Germany and Austria during the three periods: 1990–1992 (a), 1993–1995 (b), 1996–1998 (c).

attributable to increased research. In Germany, the amount of data slowly increased during the early 1990s. With the beginning of systematic tracking surveys in 1994 numbers of data more than doubled within each of the next 2 years (Table 2, Fig. 2b, c). The reason for the decrease in data in 1998 is not clear (see below). In Austria only accidental findings were recorded up to 1996. In this region, people become familiar with the reseachers' interest in lynx data and started gathering data in a more standardized way.

Square categories

Tables 3 and 4 contain the yearly classification of lynx occurence on a national and international scale. They clearly show the steady rise in the numbers of squares with lynx, which is logically linked to enlargement of area covered by lynx. From 1990 to 1998, the area where lynx data were reported increased sixfold (Table 3). In the past 3 years the area of increase slowly levelled off. The increase in 1998 again can mainly be explained by an information campaign in Bavaria which yielded about 20 new IRO grids in the region "Oberpfalz" (Wölfl 1998b; Fig. 2c).

The area with irregular occurrence of lynx nearly tripled in 1996 and is still increasing (Table 4). Considering the assumption that the IRO squares mainly

Table 3. Numbers of squares of different categories and total area covered by lynx in the Czech Republic, Germany and Austria (1990 to 1998). IRO – irregular occurrence, REO – regular occurrence, COR – confirmed reproduction, * – area per square: 134.4 km^2 in Czech Republik, 100 km^2 in Germany and Austria.

Year	Czech Republik			Germany			Austria			Sum of squares	Area* (km^2)
	IRO	REO	COR	IRO	REO	COR	IRO	REO	COR		
1990	2	13	3	7	1	2	–	–	–	28	3419
1991	7	18	2	4	2	1	2	–	–	36	4529
1992	1	19	7	5	4	1	1	–	–	38	4729
1993	9	25	11	4	2	2	2	–	–	55	7248
1994	–	32	10	11	3	2	–	–	2	60	7445
1995	15	37	7	9	10	6	–	1	1	86	10630
1996	51	31	16	19	12	9	–	1	1	140	17371
1997	43	31	18	26	9	5	1	–	2	135	16665
1998	41	26	30	45	7	3	–	–	2	154	18737

represent subadult lynx or 'floaters' looking for suitable habitat we assume that the Šumava lynx population is still a source population which is saturated in its center. Therefore, most subadults are forced to leave (Zimmermann 1998). However, familiarization of lynx presence by its prey species (Breitenmoser and Haller 1993) or decrease of prey availability because of high human-induced hunting pressure on ungulates could have caused an expansion of individual home range sizes. Therefore, the size of total area covered by lynx would have increased as well.

For population estimation we assumed that maximal lynx density is one adult lynx per 100 km^2 (Breitenmoser *et al.* 1993). This assumption was confirmed by the wide roaming movements of radiotracked lynx in the Šumava Biosphere Reserve

Table 4. Numbers of squares of different categories (1990 to 1998) combined for all three countries. Adjustments (overlap of grid systems, omitting half-sized squares) included. IRO – irregular occurrence, REO – regular occurrence, COR – confirmed reproduction.

Year	IRO	REO	COR	REO+COR
1990	8	13	5	18
1991	12	21	3	24
1992	6	24	8	32
1993	13	28	13	41
1994	10	36	15	51
1995	25	47	14	61
1996	69	43	26	69
1997	69	41	25	66
1998	86	33	35	68

(Table 1) and the snowtracking data of the Šumava National Park (Bufka 1997). As square size in the Czech Republic were 134.4 km^2 and not 100 km^2 as in Germany or Austria (see Methods), by accumulating numbers of squares to get the population estimate we intentionally underrated our population size to compensate for areas within the grid system not suitable for lynx (eg cities, lakes). If we assume that one grid of the REO and COR category (100 to 134.4 km^2) roughly equals one adult territorial lynx (eg Breitenmoser *et al.* 1993, Jędrzejewski *et al.* 1996, Schmidt *et al.* 1997, Czech Lynx Project, unpubl.) we estimate population size for the last 3 years at about 70 resident animals between Austria and Saxony. As more and more grids yield data on reproduction (especially in the Czech Republic) the number of REO squares is slowly decreasing. This indicates the occupation of more and more prime habitat, and once a territority is established animals begin reproducing.

Reproduction and mortality

Data on reproduction steadily rose during the 10-year period and show a levelling off during the last three breeding seasons at about 30 reproductional units (Table 5). However, on a national scale data show different trends: the increase of reproduction in the Czech Republic in 1998/1999 is nearly compensated by the sharp decline in Germany. Known mortality within the population averages 5 animals per year (Table 6). However, it is likely that natural and human-induced mortality (especially poaching) is underestimated. In spite of the heavy losses, the population still seems to increase slowly. One might infer that mortality is still lower than recruitment.

Evidence of immigration/emmigration

So far, there has been no proof of immigration from other lynx populations. However, recent data indicate increasing lynx presence in the Labe Sandstone

Table 5. Number of squares with evidence of lynx reproduction, sum of maximal kitten number observed and mean kitten number per square (1989 to 1999, all three countries combined).

Breeding season (May–April)	Czech Republic	Germany	Austria	Sum	Sum of max kitten number observed	Mean kitten number per square
1989/90	1	1	–	2	2	1
1990/91	2	1	–	3	7	2.33
1991/92	3	–	–	3	7	2.33
1992/93	8	2	–	10	19	1.90
1993/94	10	2	–	12	22	1.83
1994/95	11	3	2	16	36	2.25
1995/96	11	10	–	21	43	2.05
1996/97	22	9	1	32	52	1.63
1997/98	23	6	1	30	54	1.80
1998/99	29	1	2	32	55	1.72

Table 6. Causes of mortality among lynx found dead (between 1990 to 1998, all three countries combined).

Year	Traffic	Poaching	Other	Unknown	Sum
1990	–	–	–	–	–
1991	1	–	1	–	2
1992	–	4	1	1	6
1993	–	5	–	–	5
1994	–	6	–	–	6
1995	1	5	–	–	6
1996	1	5	–	3	9
1997	–	3	1	–	4
1998	–	7	–	–	7
Sum	3	35	3	4	45

Area, Krušné Hory and northern Moravia, which could mean a possible connection to the Slovakian lynx population (Riebe 1994, Červený *et al.* 1997). Also there is no evidence that lynx move back and forth between the Šumava and the Alpine population, apart from sporadic lynx occurrence in Austria (H. Augustin, pers. comm.). The Alpine lynx population probably does not serve as a source population as it did not expand during the last decade (Breitenmoser 1998). As stated above, the Šumava lynx population is still considered to be a source population. Surviving juveniles might be forced to leave the area in order to search for vacant territories. This is demonstrated by the emmigration of a subadult radiotracked male which wandered over 200 km within 10 months and was finally located between Plzeň and Praha, about 100 km northeast of its capture place (Table 1). Similar observations were made in Germany where isolated lynx presence was reported in 1995–1996 in the valley of the Altmühl, about 80 km west of the nearest known lynx occurrence. A connection with other lynx populations in Slovakia or even in the Alps seems possible (Fig. 1).

Legal situation

According to the nature conservation legislation of the Czech Republic, the lynx is an especially protected species, listed as strongly endangered. Moreover, it is listed in the Red Data Book as a rare species (Baruš *et al.* 1989). According to hunting laws it is categorized as a game animal with hunting season (January––February) only with special permission from the Ministry of Environment of the Czech Republic. However, since the implementation of this status no application for special permission has been made. We believe that concerning lynx hunting, hunters regard the implemented option on legal shooting as far too complicated and prefer to poach animals. According to the German hunting law, the lynx is a game species with year-round protection (Doerenkamp 1994). Additionally, it is listed in

the Red Data Book as threatened by extinction (Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen 1993). In Austria, lynx is included in the Austrian hunting law (Huber and Kaczensky 1998). In the different hunting laws of each district, the lynx is listed as a species with a season that is closed on a year-round basis.

Current management approaches

In the Czech Republic, a differential approach for management based on zoning of the whole territory was implemented in 1998 (Koubek *et al.* 1997). The "A" zone of strict protection of lynx without any regulation is represented almost by the areas used by resident lynx individuals and potential migrating corridors. Usually large parts of these zones have extra protected areas (protected landscape areas, national parks). The total area of this zone is about 11 700 km^2. The "B" zone is an area of the lynx occurrence with the possibility of regulation based on stated rules (see above). The "C" zone is the territory outside the area of an expected lynx occurrence with the possibility of hunting management without special limitation (only the hunting season followed from hunting law). Because of the assessed numbers and natural dispersal of the lynx, further reintroductions are not planned in the Czech Republic. The damages on livestock are proposed to be compensated for by the state. The bill concerning compensation for damages caused by extra protected species, including lynx, on livestock is pending approval in the Czech government. In Germany, a compensation fund for lynx damages on lifestock was implemented by non-governmental organisations in 1998. Additionally, a network of local people were trained in distinguishing kill signs of different predators (Wölfl 1998a, 1999, 2000). In 1998–1999, a total of 44 domestic animals were examined and 12 judged to be killed by lynx. Since July 1998 the Bavarian hunting association pays a compensation for roe deer, red deer and mufflon killed by lynx. At the end of October 1999, a total of 30 roe deer were jugded as killed by lynx.

Perspectives

The ultimate goal to achieve is a long-term coexistence between man and lynx in the Šumava region. As a wide roaming species a healthy lynx population will never thrive solely within protected areas but requires large parts of human-used landscape as well. This fact should not be considered as a conservational constraint. To the contrary, it is necessary to encourage nature protection groups and scientists to establish fact-based discussions with land-user groups such as farmers and hunters.

For long-term lynx conservation, several actions should take place in the near future with the following goals:

(1) Educate skilled people to function as regional contacts. To be ever present, honest and qualified in cases of simple questions, unsettled fears and real damages seems to be the most important step towards mutual trust between the different interest groups. Honest and unbiased public relation work must be the key to

reduce human-induced mortality of large carnivores. For Germany this network of contact people has been recently enlarged to the whole lynx range and numbers more than 80 persons to date. In Austria a first education course was recently undertaken.

(2) Establish compensation funds for livestock. The funds in Germany still work on a NGO level but should be replaced by a state-based regulation. In the Czech Republic, parliament is currently discussing a model of governmental compensation. For Austria the first steps towards a compensation system are currently prepared. If necessary at all, compensation of game animals preyed upon by lynx should be covered within the local or regional hunting associations.

(3) Reduce competition for hunting ungulates between large carnivores and man by integrating sound and fact-based ungulate management into lynx conservation. In addition to monocausal vegetation-based inventories, reliable monitoring methods for ungulate species (especially roe deer) must be applied. The forestry-based decimation of herbivores, which currently takes place in most parts of Europe, contradicts conservation goals to reestablish large carnivores populations. Ungulates serve as main prey for lynx and wolves and these species will never establish minimum viable populations without the tolerance of human hunters. The current pressure placed on ungulates populations will definitely not increase the acceptance of large predators by hunters.

(4) Especially in the Czech Republic hunting rights have shifted from state--owned to privately owned hunting grounds after 1989. Currently it is proposed that the minimum size of a hunting ground should be decreased from 500 to 100 ha which would mean an increase of hunters in the area. In spite of hunting associations officially speaking out for the lynx (eg Landesjagdverband Bayern e.V. 1998) acceptance on the local level is still low. Under these circumstances survival of large predators is not likely without acceptance or at least tolerance of private hunters.

(5) On a scientific scale we must establish feasible methods for monitoring numbers and population trends of lynx. Radiotracking may be a solution but is limited to selected regions as it is too cost-intensive. Possibly a combination of radio- and snowtracking on a regional scale may yield some index calculations which could be useful for estimating lynx numbers in other areas as well. Data verification should be standardized and guaranteed to improve quality of accidentally found data.

(6) If we are able to reach a coexistence of man and lynx in the Šumava region, a connection to other lynx populations such as in Slovakia, Poland and the Alpine countries could secure a long-term perspective for the lynx in central Europe (Fig. 1). We must define, protect and improve migration corridors to guarantee gene flow between the populations. A fine-tuning of lynx hunting in source populations like in Slovakia would enforce the linkage between the different populations.

(7) Establish an international discussion and information exchange to guarantee a scientific platform of the Central European countries similar to the SCALP group

(Status and Conservation of the Alpine Lynx Population; Breitenmoser 1998). We suggest establishment of the CELTIC (Conservation of the European Lynx: Management and International Cooperation) to take further steps to identify countries and institutions for this platform. On this platform, management issues such as compensation payments, surveying techniques, defining and managing problem animals and the pro and cons of strictly regulated legal hunting could be addressed.

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