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Status and distribution of the Eurasian lynx (*Lynx lynx* L.) in Slovenia in 2000–2004 and comparison with the years 1995–1999

Status in razširjenost risa (*Lynx lynx* L.) v Sloveniji med leti 2000–2004 in primerjava z obdobjem 1995–1999

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Keywords: Slovenia, *Lynx lynx*, SCALP, monitoring, distribution

Introduction

This report presents an analysis of recorded signs of lynx presence and spatial distribution of this species for the 2000 – 2004 period, as well as comparison with the 1995 – 1999 period. The lynx has been exterminated from most of Europe, including the area of Slovenia, around the year 1900. Kos (1928) reports that the last lynx in Slovenia was most probably killed in 1908. The attitudes of people towards this largest European cat have changed, and the results were the first reintroductions of the lynx to some European countries during the years 1970 – 1980. In 1973 the lynx was reintroduced to Slovenia, from where it soon spread to the neighbouring Croatia (Čop & Frković 1998). Started

simultaneously with the reintroduction was a research project studying its success and following the spread of the newly established population. The study was done by the Institute for Forestry and Wood Science from Ljubljana, and led by Mr. Janez Čop. Today, the Slovenian lynx reintroduction is considered to be among the most successful reintroductions in Europe. Its chronology is described in the report about the reintroduction project (Čop 1994).

In 1978, five years after the reintroduction, the competent ministry issued the first decision allowing an exceptional cull of the first five lynx. Each culled lynx had to undergo a veterinary examination at the Department of Veterinary Medicine of the Biotechnical Faculty in Ljubljana. Until the present day, a total of 139 lynx were legally culled, killed by traffic or found dead. Including Croatia, this number exceeds 300 (Kos & al. 2005, Frković 2003). A radiotelemetry study of lynx behaviour took place in Slovenia during the years 1994 and 1995. The project provided the first data about habitat utilization and social structure of the lynx population in the Dinaric high karst area, but it also opened some new questions, especially regarding the food ecology (Huber & al. 1995). The first report on the status of the lynx population in Slovenia and Croatia was produced within the framework of the SCALP project (***S**tatus and **C**onservation of the **A**lpine **L**ynx **P**opulation*) in 1995 (Čop & Frković 1998). The second report was produced in 2000 (Staniša & al. 2001) for the 1995 – 1999 period. The present, third report presents the results of the monitoring effort, and analyses developments in the Slovenian population during the 2000–2004 period.

In Slovenia the lynx enjoys a year-round protection and is listed among the rare and threatened animal species. Based on the data about the lynx population size, recorded signs of lynx presence, realization of cull in the previous period and damages to livestock, the competent ministry can issue a decision permitting exceptional cull of a certain number of lynx. The cull is spatially distributed into individual regions, and is limited to the hunting season, usually from October until the end of February. A new decision is issued for every calendar year. Based on the collected data, the competent ministry decided not to issue this decision on three occasions since 1995 – in 1997, 1999 and 2000. The Rules on Taking of Lynx from the Wild for 2004 for the first time took into account the recommendation of the SCALP group not to hunt the lynx in the Alps and in the pre-Alpine regions north of the Maribor–Ljubljana–Nova Gorica line.

Methods

In Slovenia, the status of the lynx population wasn't analyzed exclusively for the Alpine part of the country as is the case in the other SCALP reports. Data from the entire country was taken into account, as the events taking place in the lynx core area to the south of the country carry great importance for its spatial expansion into the Alps. To ensure comparability of the data with the other Alpine countries, we divided the population into: (1) the north-western sub-population, located west of the Jesenice–Ljubljana–Trieste motorway, and (2) the southern sub-population, located south of the Trieste–Ljubljana–Zagreb motorway (Figure 1).

All the collected data have been evaluated according to the unified SCALP system, providing for comparability of the data between countries. The data is divided into three categories based on their reliability:

- The first category (C1) includes all undisputable facts of lynx presence (shot animals, traffic and other mortality).
- The second category (C2) includes all recorded signs of lynx presence that have been verified by SFS (Slovenian Forest Service) lynx experts. This includes the data about damages to livestock, tracks, scats, losses of game animals attributable to the lynx, as well as other verified signs of lynx presence. This category also includes all the data collected by professional hunters in the special-purpose hunting reserves.
- The third category (C3) includes all other collected data that haven't been verified.

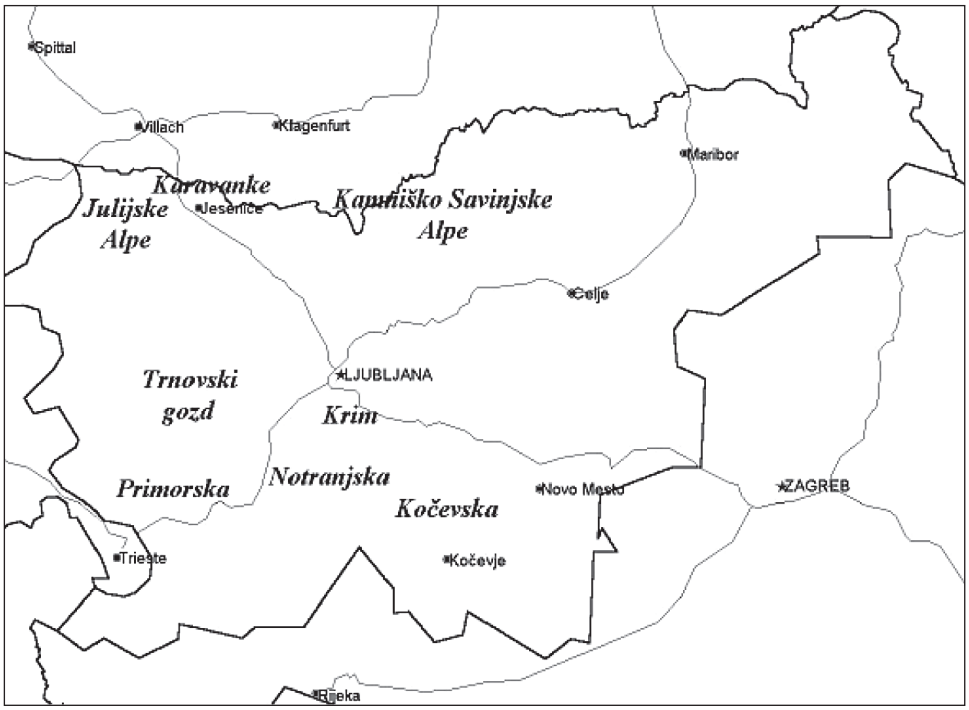


Fig. 1: Map of Slovenia showing some of the places mentioned in this report.

The data about the lynx in Slovenia is collected using different approaches:

(1) Ever since the reintroduction in 1973, the data about all verified mortality (traffic, found dead) and cull of the lynx is collected over the entire area of Slovenia.
(2) Since 1976, all losses of game animals are recorded in hunting statistics (required by the Hunting Laws of 1976 and 2004).
(3) Since 1986 in the Medved Kočevje Hunting Reserve, renamed Special Purpose Hunting Reserve Medved (LPN Medved) in 2004, and since 1991 in the Jelen Snežnik Hunting Reserve (today Special Purpose Hunting Reserve Jelen Snežnik or LPN Jelen Snežnik), all observed signs of lynx presence are recorded in a grid of squares. The size of the grid cell is 1×1 km. The total size of both areas is 73,000 hectares. A similar system is being used to record lynx presence in the Triglav National Park (Special Purpose Hunting Reserve Triglav or LPN Triglav) over the total area of 58,000 hectares.
(4) In 1996, monitoring was organized in North-western Slovenia where all observations in the area of 220,000 hectares are recorded with their geographic coordinates.
(5) In 1998 the Slovenian Forest Service started a monitoring based on a grid of forest sections in Notranjska, Kočevska and Primorska regions, where lynx presence is the strongest. The data are collected by district foresters and have a better than 1 km^2 spatial precision. In the areas where the lynx are not permanently present, the presence data are recorded through the SFS, Department of Forest Wildlife and Hunting. These data are usually categorized C3.
(6) Since 1996, SFS records all data about lynx damages to livestock using a unified methodology. The data are categorized C2.

Estimation of the lynx population size and its spatial distribution in Slovenia is based on data obtained from all six data sources. During the 2000 – 2004 period, geographic coordinates have also been recorded for all the collected data with a better than 1 km^2 spatial precision.

To describe temporal trends of lynx mortality, monitoring data from the special-purpose hunting reserves and damages to livestock, we used a fourth degree polynomial or the logarithmic curve, respectively. The population range of the lynx was described using the fixed Kernel method, using the areas that included 95%, 75% and 50% of the monitoring data points. This was done independently for the 1995 – 1999 and 2000 – 2004 periods. For determination of the population range, only the C1 and C2 data should be considered; however, we also used the C3 data. The reason is that the spatial locations of the C3 data are usually in the areas where the C2 data are also present, and the population range doesn't change significantly if the C3 data are excluded. The data that are spatially located into the 1×1 km grid have been randomly dispersed within the corresponding grid cell.

Results

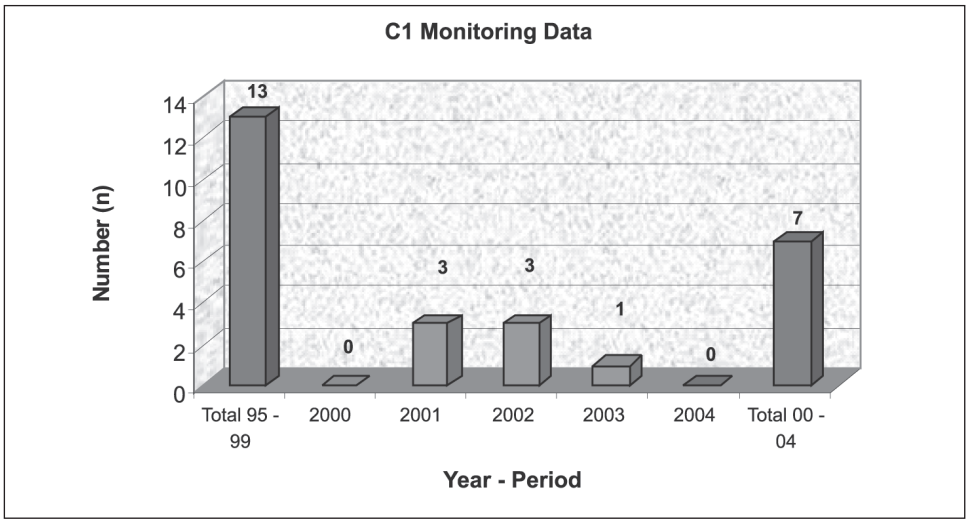
Monitoring and dynamics of the population size

In the 2000 – 2004 period, 908 data points were collected using the SCALP methodology, which is an 80% increase compared to the 1995 – 1999 period, when the number of collected data points was 505 (Table 1). The increase in the number of data points is mainly a product of better organization of the monitoring effort during the last five year period. Nonetheless, we can observe the majority of the increase in the southern subpopulation (factor 2.40), while the number of data points collected in the north-western subpopulation is, compared to the previous period, somewhat lower (factor 0.89). The largest part of the increase was in the last two years of the period. We can also see a statistically significant change in the data quality between both five-year periods (Table 1). This is observed for all the data ($p = 0.000$), as well as for the data from the southern ($p = 0.000$) and the northern subpopulation ($p = 0.009$).

Table 1: The number of the collected data about lynx presence by reliability.

Category	Southern Subpop.		North-western Subpop.		Total	
	1995–1999	2000–2004	1995–1999	2000–2004	1995–1999	2000–2004
C1	12	7	1	0	13	7
C2	230	674	77	93	307	767
C3	61	48	124	86	185	134
Total	303	729	202	179	505	908

There were 7 lynx taken from the population (reliability C1) in the last five-year period, which is almost a one-half decrease compared to the previous period (13 animals). The largest cull in the last period was in 2001 and 2002, with three animals removed each year (Table 2, Graph 1). The planned cull for the 1995 – 1999 period was 15 animals, of which 13, or 87%, were actually taken. During the 2000 – 2004 period the planned cull was 10 animals, of which 7 (70 %) were taken. The planned culls have been reduced from one period to the next, and even those were not realized (Table 2). The recorded lynx cull data shows a decreasing trend since 1990, and is approaching zero (Graph 2).

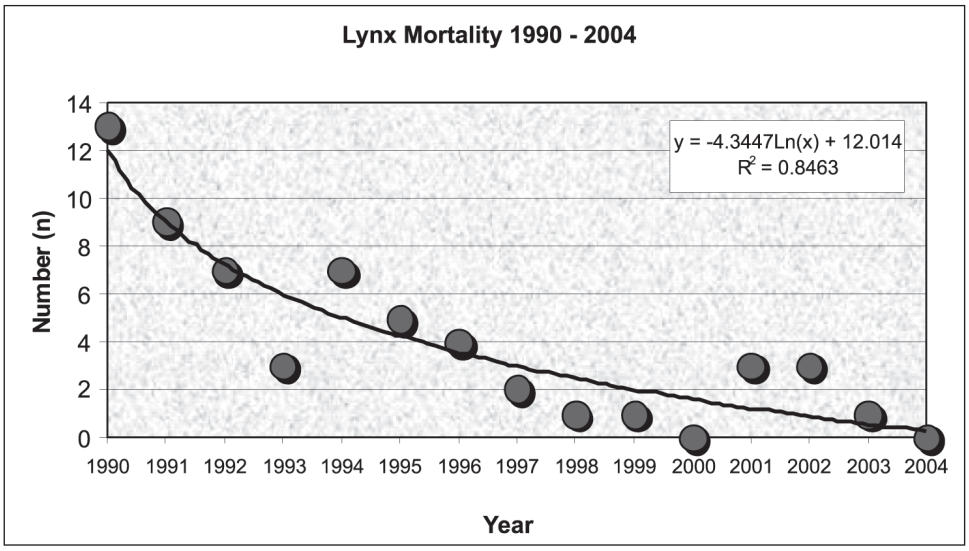


Graph 1: The dynamics of C1 monitoring data.

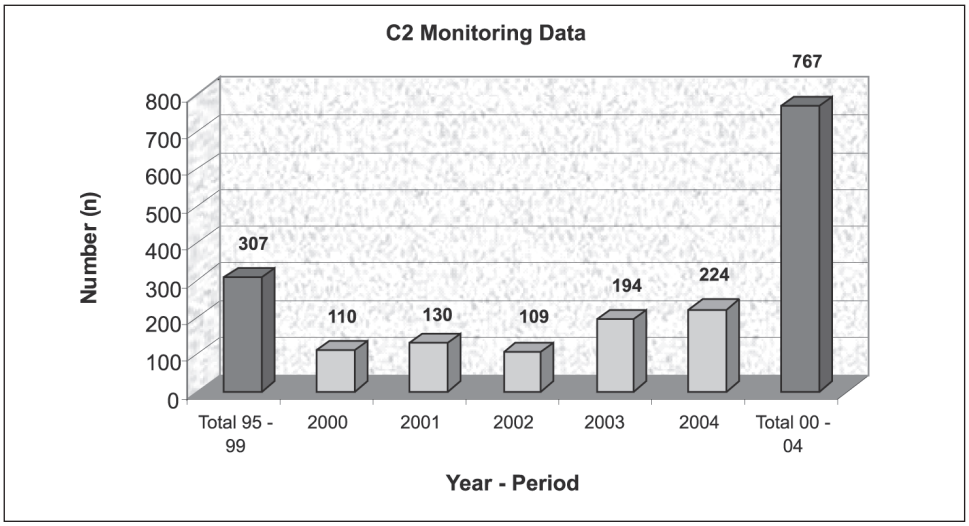
Table 2: Planned cull, realized cull, and other verified mortality of lynx in Slovenia.

Year	Plan	Cull	Losses	Total Mortality
1995/96	5	4	1	5
1996/97	5	3	1	4
1997/98	0	0	2	2
1998/99	5	0	1	1
1999/00	0	0	1	1
Total 1995–1999	15	7	6	13
2000/01	0	0	0	0
2001/02	5	3	0	3
2002	3	3	0	3
2003	2	1	0	1
2004	2	0	0	0
Total 2000–2004	10	7	0	7

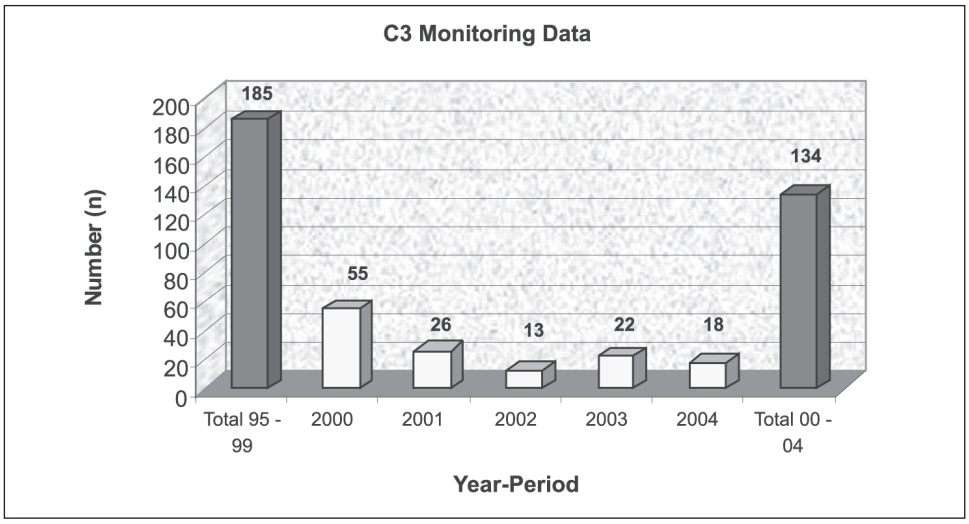
There is a large number of reliable C2 data about lynx presence. There are 767 such data points for the last period or 85% of all data points, while this number in the previous period was 307 or 60%. The number of C2 data has increased 2.5 times from one five-year period to the next. During the last five-year period, the number of these data grew (Graph 3). The trend with the C3 data is exactly the opposite. The numbers of these data are declining, both from one five-year period to the next, when the decrease was 30%, as well as from year to year (Graph 4). Besides the number of the data points itself the analysis of the categories of the collected data also shows an improvement in the lynx monitoring method during the 2000 – 2004 period.



Graph 2: The trend of lynx mortality in Slovenia from 1990 until 2004.

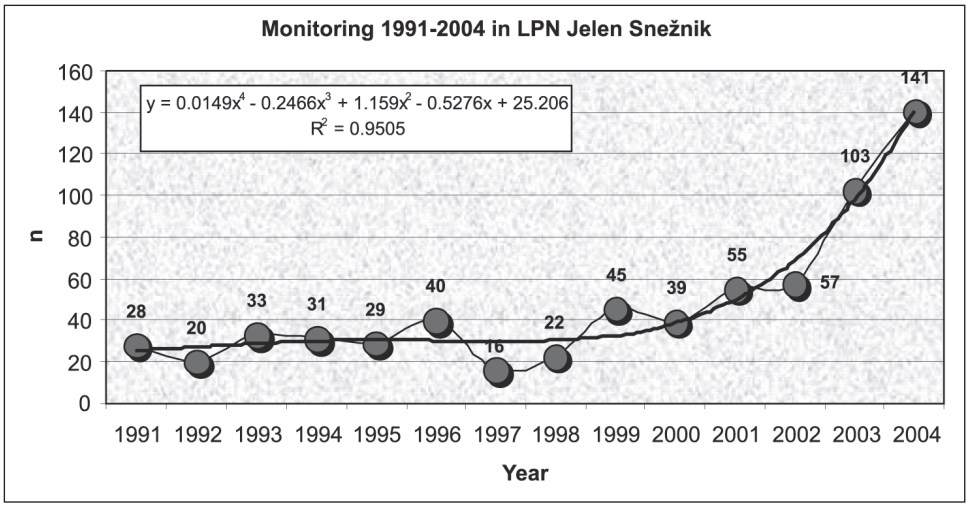


Graph 3: The dynamics of the C2 monitoring data.

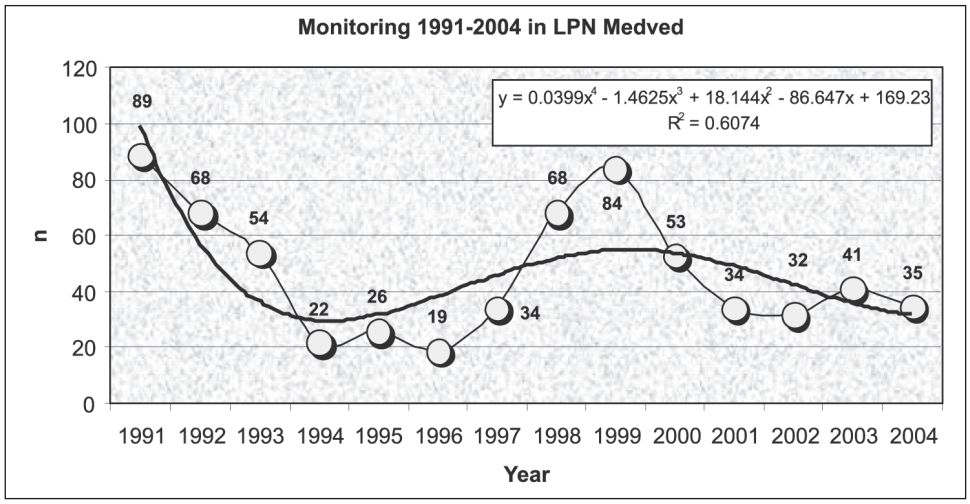


Graph 4: The dynamics of the C3 monitoring data.

The dynamics of the collected monitoring data of all three categories is also shown separately for the two areas covered by both special-purpose hunting reserves (Graphs 5 and 6). In LPN Jelen Snežnik, the dynamics of both monitoring and the number of lynx was steady until the year 2000. After 2000, we can observe a sharp increase in the number of the recorded signs of lynx presence. In LPN Medved, the number of observations cyclically fluctuates with a ten-year period. The dynamics of the recorded data of lynx presence is currently decreasing. In both cases we're dealing with C2 quality data, recorded by professional hunters. The status of the lynx in LPN Medved is unchanged over the last five years, or even slightly declining. In LPN Jelen Snežnik the status is better, and is improving over the last few years.



Graph 5: Dynamics of the data collected within the framework of the monitoring in LPN Jelen Snežnik.



Graph 6: Dynamics of the data collected within the framework of the monitoring in LPN Medved.

Population range

Slovenia can be divided into four areas with regard to lynx presence (Figures 2 and 3). The first is the *southern area*, which mainly includes Notranjska and Kočevska regions. The other area is the *north-western area*, spreading west and north of the Jesenice-Ljubljana–Trieste line. These two areas represent more than 95% of the lynx range in Slovenia, and are treated as two subpopulations. The third area is the area of Kamnik–Savinja Alps (Kam.–Sav.). We're assuming occasional lynx presence in this area. The fourth area is Eastern and North–Eastern Slovenia, where the lynx are assumed absent. Although lynx presence has been recorded in this area, all the data are of C3 category. The described rough division of the population range in Slovenia into two subpopulations is valid both for the 2000–2004 period, as well as for the previous 1995 – 1999 period.

Table 3: The size of different areas of the lynx population range, in hectares.

Period	Area			Total
	S. Subpop	NW Subpop.	Kam. – Sav.	
1995–1999	266.200	298.800	17.000	582.000
2000–2004	351.200	255.900	19.900	627.000
Factor	1,32	0,86	1,17	1,08

The lynx population range spans over approximately 627,000 ha, which represents 31% of the total area of Slovenia. At around 582,000 hectares, the size of the population range was slightly smaller during the previous period. The total increase of the population range was approximately 8%.

The size of the area from which the southern subpopulation data have been detected (Table 3) has increased for 30%. There are once again data about lynx presence in the western part, the Vreščica and Slavnik areas. There were no data from these areas during the previous period. There has also been an increase in the number of lynx presence observations in the eastern part of the subpopulation, the Kočevski Rog area. During the 2000 – 2004 period, we have three locations where the density of the monitoring data was the highest (50% fixed Kernel): LPN Jelen, LPN Medved and in the vicinity of Ribnica. In the southern subpopulation the lynx is also present along the border with Croatia.

There was a 15% decrease in the size of the western subpopulation area (Table 3), mostly because of the lower number of observations from Nanos and the area around Idrija, while the number of data points from Trnovski Gozd remained the same as in the previous period. Both time periods compared, we can observe lynx presence more frequently in the areas around Cerkno and Bovec. The area where lynx presence is observed in Bohinj and Jelovica remains approximately the same. In the north-western subpopulation we find two higher data density areas (75% fixed Kernel) in the vicinity of Tolmin and Bovec. This is where the attacks of lynx on livestock were most frequent in this subpopulation. The north-western subpopulation reaches across the state border with Italy, from Kambersko all the way to the tri-border between Austria, Slovenia and Italy, and then across the Austrian border toward Kepa and Mojstrana.

The area of lynx presence in Kamnik–Savinja Alps is smaller, but has also increased slightly over the recent years. The largest numbers of observations are around Kamniška Bistrica and Solčava. C2 category of some of these data confirms permanent presence of lynx in this area as well, although these are probably just single animals.

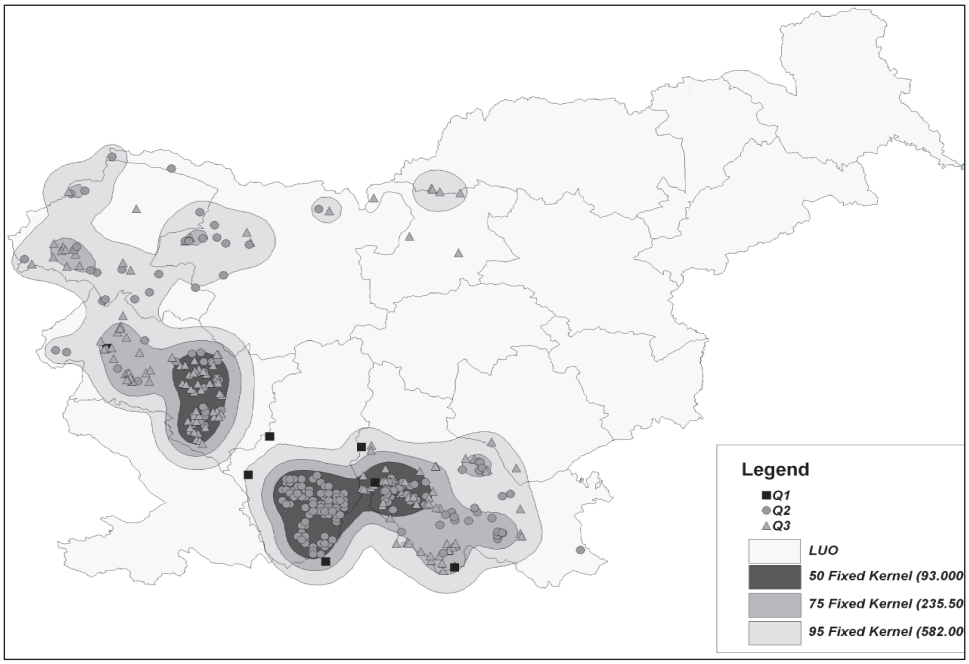


Figure 2: Lynx population range in Slovenia 1995 – 1999.

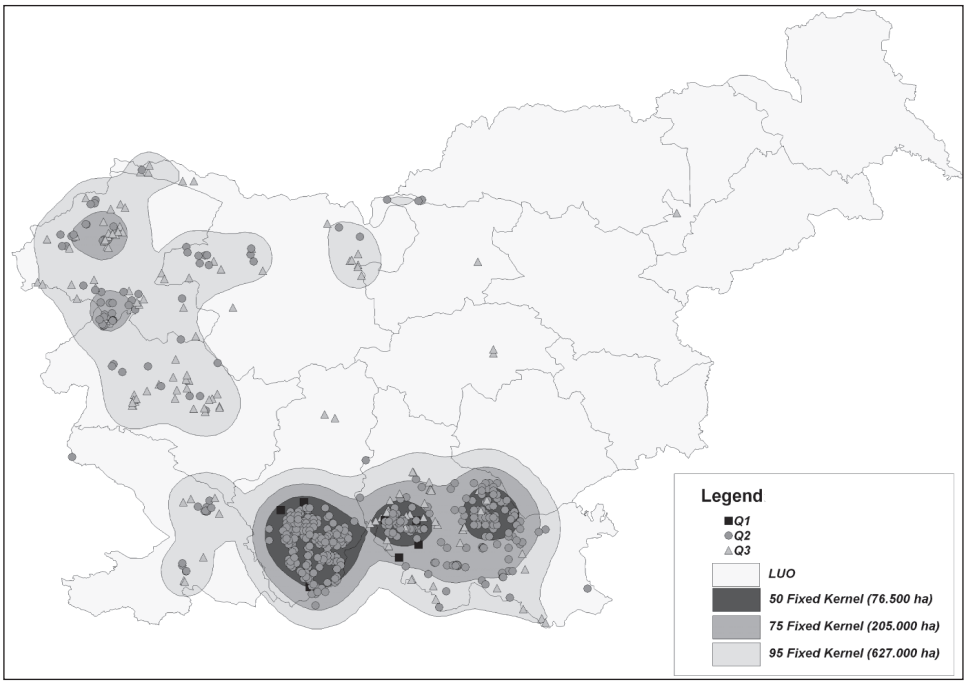


Fig. 3: Lynx population range in Slovenia 2000 – 2004.

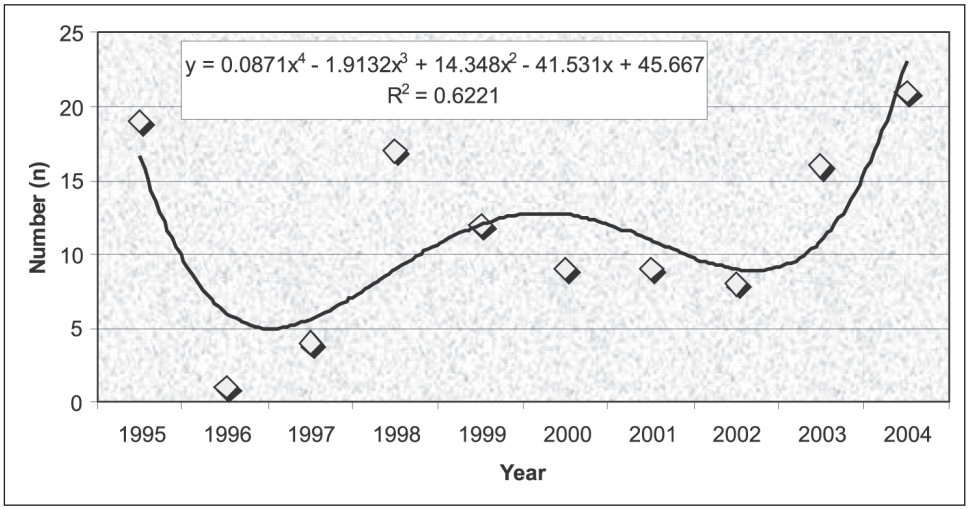
Damages to livestock

The damages caused by lynx to livestock represent a relatively small share of the large carnivore damages in Slovenia (which are also caused by wolves and bears). This share has been 10% in the 2000 – 2004 period, and 8% in the previous period. From one period to the next, the lynx damages have increased from 51,500 € to 71,500 €, an increase of 1.4 (Table 4). There is a very weak correlation ($R^2 = 0.4620$) with low statistical significance between the amount of damage and the number of damage cases, so we used the number of damage cases and not the monetary value of the damages for further analyses. A single damage case represents a single case of lynx appearance, while the monetary value of the damage depends on the number of killed animals, which varies from 1 and up to 10 or more. The total number of damage cases over the last five-year period was 122, which is a 1.7 factor increase compared to the previous five-year period, when there were 71 cases recorded. The number of damage cases in the southern subpopulation in the later period was 63, which is a 1.2 factor increase compared to the previous period (53 cases). In the north-western subpopulation the number of damage cases in the later period was 59, which is a 3.3 factor increase compared to the previous period when there were only 18 cases recorded. The increase in the number of attacks can also be attributed to an increase in the number of small livestock.

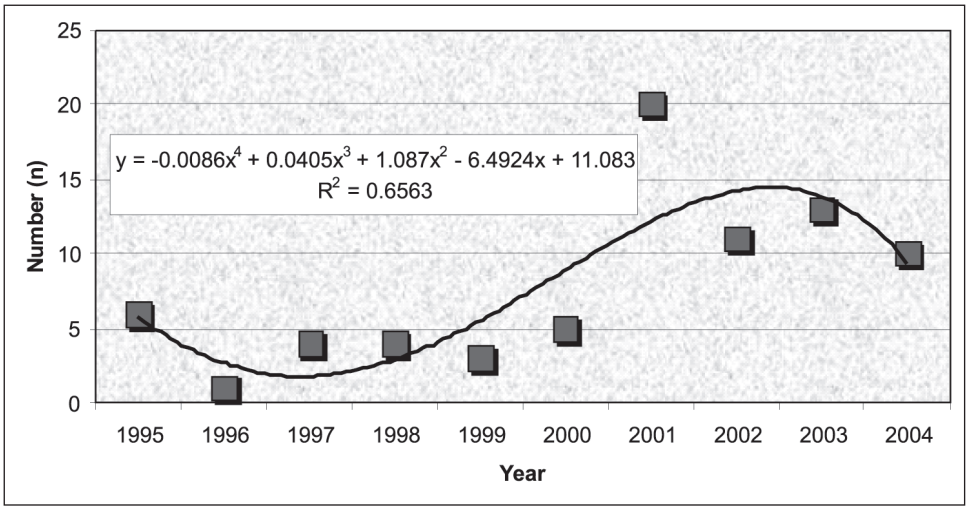
Table 4: Damages to livestock caused by the lynx.

Year	Number of damage cases			Damage	
	Total	S Subpop	NW Subpop.	SIT	€
1995	25	19	6	1,254,954	5,750
1996	2	1	1	93,000	400
1997	8	4	4	308,850	1,450
1998	21	17	4	2,449,400	35,800
1999	15	12	3	1,731,000	8,000
1995–1999	71	53	18	5,837,204	51,400
2000	14	9	5	2,159,000	9,600
2001	29	9	20	5,388,000	29,100
2002	19	8	11	2,975,000	13,400
2003	29	16	13	2,637,000	10,987
2004	31	21	10	2,024,500	8,435
2000–2004	122	63	59	15,183,500	71,522

The trends of the number of attacks (4th level polynomial) are fluctuating for both populations, which is especially true for the southern subpopulation. The number of attacks in the north-western subpopulation area is increasing over the years, with a slight decrease in 2004.



Graph 7: The dynamics of the number of attacks in the southern subpopulation.



Graph 8: The dynamics of the number of attacks in the north-western subpopulation.

Discussion

By continuation of the monitoring of signs of lynx presence, the number of the animals taken from the population and the number of lynx attacks on livestock during the last five-year period we have obtained data that enables a rough understanding of the development of the Slovenian lynx population.

(1) *The total number of monitoring data points* has increased significantly (Table 1). The number of reliable data C2 has also increased. This is certainly a result of better organization of the monitoring effort during the last five year period. The increase in the number of lynx presence data in the southern subpopulation can also be partly attributed to the presence of lynx in new areas over the last five years, as can be seen from the data showing lynx presence on Vremščica, Slavnik, and in the eastern part of Kočevski Rog. There is also a pronounced increase in the number of signs of lynx presence in the LPN Snežnik area. In the north-western subpopulation, the number of data collected over the last five-year period is lower compared to the previous period. However, this decrease is on account of a lower number of data from just a certain part of the area – Nanos and the Idrija region. Similarly to other areas, the numbers of data collected in the other parts of this area grew. The number of lynx on Nanos and the area around Idrija is probably not significantly lower than it was during the previous period. The decrease can be attributed to the monitoring effort, which will require a better organization in this area. In light of these facts, we cannot maintain that the number of lynx present in the western subpopulation during the last period was lower.

(2) *The data of recorded lynx mortality* show a negative trend, which approaches the asymptote of zero (Graph 2). We can see a similar trend in the number of animals planned for culling, however the cull plans were usually not reached (Table 2). Illegal killing, which is supposed to be quite significant, is often mentioned in this context. The cull is supposed to be additionally hindered by territoriality and low population density. However, interpretation of these facts warrants caution. For example, in the western subpopulation there were no lynx culled regardless of the issued cull permit, constant lynx presence, and numerous damages caused over a relatively small area. The fact that there was a cull permit makes poaching quite unlikely. The current lower lynx density as previosly period (1990–95) makes hunting of this species difficult as well.

(3) *Monitoring of lynx presence in the special-purpose hunting reserves* has been one of the main parameters showing the lynx population size trends. Reliable (C2) data, collected in an organized manner, and the trends calculated from them are assumed to be showing the actual status in the wild. The results were also verified with the managers of both hunting reserves. For LPN Medved they confirmed the trend (Graph 6) that the status of lynx in the hunting reserve over the last five years is generally unchanged, or recently even on a slight decrease. The status shown by the trend (Graph 5), a substantial increase in lynx presence in the hunting reserve, has similarly been confirmed for LPN Jelen Snežnik.

(4) *The size of lynx population range* has increased according to comparative analyses. There was an increase in the area of the southern subpopulation, while that of the north-western subpopulation has slightly decreased. For the north-western subpopulation, we should apply the reasoning used in the discussion of the number of observations from paragraph one. The number of observations and the size of the population range calculated from them are, of course, related. Had the monitoring in Nanos and Idrija areas been done more thoroughly, the calculated range wouldn't decrease. We should also exercise caution in interpretation of the increase of the population range of the southern subpopulation. The report for the 1995—1999 period (Staniša & al. 2001) showed the population range also in the areas where it was known that lynx were present, but monitoring data were missing. If those areas are compared, we can see that the range of the southern subpopulation also didn't change as drastically as we could conclude from our analysis. In any case, there is a significant shift of the range westward. Possible reasons for the shift are a somewhat lower number of roe deer and red deer, an increased number of wolves in the Kočevje area, diseases and problems in the population. If we take into consideration the findings of the 1995– 1999 report, there hasn't been a significant change of the lynx population range for the last 10 years.

(5) *Damage cases* of attacks on livestock and their dynamics are a fairly reliable indirect sign of lynx presence, although the number of attacks can be also caused by an increase in the number of attacks of a single lynx. The increase in the number of attacks shows an increase in the number of lynx over the last period. However, we must not neglect the fact that the higher number of the attacks depends also on an increased number of small livestock available, and on the inadequate protective measures used. The number of attacks in the north-western subpopulation is almost the same as in the southern, which also hints at the relative relation between the numbers of lynx in both subpopulations (Table 4). The increased numbers of attacks in the Tolmin and Bovec areas correlates also with the increased number of other signs of lynx presence in this area. On basis of this criterion we can assume that there are more lynx in the western subpopulation than five years ago.

We can summarize the findings from the paragraphs above into a table and use "–" to show deterioration, "+" for improvement and "0" for no change in the lynx population status. Deterioration is demonstrated only by the recorded lynx mortality. All other parameters show either no change or an improvement of population status. If we take into account the considerations from (2) about the difficulties of hunting for lynx, we can state with a certainty that the status of the lynx population in Slovenia didn't get any worse during the 2000 – 2004 period, and has probably remained unchanged.

Table 5: Status of the Slovenian lynx population (marked +, 0, –).

analysis category	S. subpop	W. subpop	total
(1) Total number of monitoring data.	+	0	+
(2) Lynx taken from the population.	–	–	–
(3) Lynx monitoring in the special purpose hunting reserves.	0 , +		
(4) Size of the population range.	0	0	0
(5) Number of damage cases.	+	+	+

How many lynx are there in Slovenia? The report for the 1995 – 1999 period (Staniša & al. 2001) estimates 40 to 50 lynx for the entire country, 30 to 40 in the southern subpopulation and about 10 in

the western subpopulation. Using the population range of approximately 650,000 ha and overlap of the lynx home ranges from different sources (Kos & al. 2004, Ragni 1998), we get to a similar number.

- western subpopulation 10 – 15 lynx
- southern subpopulation 20 – 35 lynx
- Slovenia – total 30 – 50 lynx

However, connectivity of an individual habitat patch should also be taken into consideration when estimating lynx spatial distribution. In this manner lynx territoriality also has a significant effect on evaluation of the available habitat. Using this additional valuation of habitat in Slovenia, we can assume existence of 9 to 15 suitable territories in the areas currently occupied by reproductive animals. In these territories, reproduction occurred over the last five years (Kos & al. 2004, Kos, unpublished data). Taking into account the structure inside individual territories, we can assume presence of 30 to 50 lynx in Slovenia.

In Slovenia, the numbers and spatial distribution of the collected data (Figure 3) allow differentiation of four different areas: (1) the southern part of the country – the southern subpopulation, spreading over the area south of the Trieste–Ljubljana–Zagreb motorway (Kočevska, Notranjska), is the area to which the lynx was first reintroduced and where its numbers are still the highest today, (2) the north-western part of the country with Julian Alps – north-western subpopulation, the area that lynx started to colonize in the mid eighties of the previous century, (3) Kamnik–Savinja Alps to the north and some other isolated areas where only a small number of lynx presence data were collected, and (4) the rest of Slovenia – North-Eastern and Eastern Slovenia, where the lynx is not present.

A potential migration obstacle separating the presence of lynx in Western and Southern Slovenia is the Jesenice–Ljubljana–Trieste motorway. However, considering that this motorway is crossed by bears without serious problems (KACZENSKY 2000), we can assume the same for the lynx (Adamič & al. 2000). To the west and to the north of these motorways there are no significant spatial obstacles that would obstruct the spatial expansion of the lynx into Italy and Austria. Expansion of the lynx population into these two countries, and consequent repopulation of the Alps through natural migration, depends mainly on management decisions implemented in the border regions.

The available data by themselves are a good enough basis for evaluation of the possibility of expansion of the lynx population into the Alps. The presence of lynx in the border area with Italy and Austria, especially around Tolmin and Bovec, is getting stronger and stronger. The population range has already expanded over the national border. We estimate that the outlooks for population expansion across the borders are currently good. The data from our monitoring should be additionally augmented by monitoring data from both neighbouring countries. However, better answers regarding capability of the lynx to expand from Southern to North-Western Slovenia and further into the Alps can be provided only by radiotelemetric studies. In the years 2004 to 2007, there is a plan to capture and radiotrack two lynx in the border area with Italy within the scope of an international Interreg project.

At the first conference of the SCALP group, in 1995, the Slovenian lynx population was evaluated as the most vital in the Alps, which was indicated by its fast spreading to the neighbouring Croatia and towards Italy and Austria (Čop & Frković 1998). Slovenia was always considered to be the core of the lynx population in the Eastern Alps. It is evident from this report that this role is currently still preserved.

Conclusions

(1) Lynx monitoring has intensified in the 2000 – 2004 period and has more high-quality data compared to the previous five-year period.
(2) The trend of removal of lynx from nature is falling and is approaching zero.
(3) The lynx range in Slovenia is separated into four areas, of which two are separate subpopulations (western and southern), one area represents isolated areas with occasional lynx presence (Kamnik–Savinja Alps), and the last is the area without lynx presence.

(4) The population range of the lynx remained in the 2000 – 2004 period of approximately the same size as in the previous five-year period.
(5) Compared to the previous five-year period, there was an increase in the number of attacks of lynx on small livestock in certain areas during the 2000 – 2004 period.
(6) The estimated number of lynx during 2000 – 2004 remains the same as in the previous period, from 30 to 50 animals. A slight increase is detected in the north-western subpopulation.
(7) The status of the lynx population in Slovenia remains stable.

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