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Abstract: The population size and distribution of a target species are one of the most important features in conservation biology. By knowing these parameters, an effective management for conservation can be applied in the range countries of their distribution. This is particularly relevant for the smallest and long term isolated autochthonous populations of the Eurasian lynx in Europe. In 1941, zoologist Ivan Bureš was the first one to acknowledge the Balkan lynx with a subspecies status *Lynx lynx balcanicus* (Bureš, 1941). This subspecies has never been recognized by wider scientific public, even though morphometric and genetic analysis imply sub species status. The topic has become even more alarming with a recent dramatic decline and probability of extinction in the near future. The objective of this work was to assess the distribution and the conservation status of the Balkan lynx, to compare its historic and present distribution and to outline the main threats to its survival. The main data sets used in this study are the baseline survey questionnaire performed in the study area (western Macedonia and eastern Albania), literature data and the results from the camera trapping activities in both courtiers. The conservation status of the Balkan lynx was acquired using the offline system of the IUCN. The Area of Occupancy as the main information for the distribution range was obtained combining the data from the baseline survey and the confirmed presence of the Balkan lynx by various methods. Population size was calculated using the Area of Occupancy and the mean density of the Balkan lynx inside the Mavrovo NP attained from the systematic camera trapping session in 2010. The results show a decline in the population according to the Baseline Survey. The pessimistic scenario for the population size of the Balkan lynx is pointing to only 20 to 44 mature individuals. These individuals are distributed mainly in the western part of Macedonia and eastern Albania. No firm evidence occurs from the north (Kosovo and Montenegro). The minimum Area of Occupancy for the Balkan lynx is about 4,000]20,000 km2. According to the IUCN Red List criteria, the conservation status of this taxon is Critically Endangered (CR (C2a(i,ii)D). Urgent measures have to be taken in order to save the Balkan lynx. Recently a group of scientists jointly started a recovery project called "Balkan Lynx Recovery Programme" in order to stop the further decline of the population and to secure its survival.

UNIVERSITY OF MONTENEGRO

FACULTY OF NATURAL SCIENCES

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STATSU AND DISTRIBUTION OF THE BALKAN LYNX (*Lynx lynx martinoi* MIRIĆ, 1978) AND ITS PREY

PODGORICA, 2012

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NOTE

Original title of this work was “Status and distribution of the Balkan lynx (*Lynx lynx martinoi* Mirić, 1978) and its prey”. However, during the 6 years research of its population, genetic analysis and in consultations with the experts from the International Code for Zoological Nomenclature, as well as taxonomists responsible for the cat family (Felidae), it was agreed that the valid name for the Balkan lynx is *Lynx lynx balcanicus*, and not *Lynx lynx martinoi*, as it was for the first time quoted in the title accepted by the scientific committee of the Faculty of Natural Sciences in Montenegro.

Due to the administrative obstruction, the title of this thesis remained the same, while the taxon in the subject is treated as *Lynx lynx balcanicus*.

Preface

The world's biodiversity is facing a difficult period. Europe hosts most of the world's developed countries where the awareness for nature protection is thought to be on the high level. Yet, Europe is a home of over an 850 million people and the demand for living space is increasing. Sharing space and coexisting with large carnivores on the other hand, makes the matter even more challenging due to their need for big home ranges and specific diet, often causing a conflict with the people. The massive extinction of the predators in Europe started with the modern age, and the invention of the gunpowder. By the end of the nineteenth century, wolf, brown bear and Eurasian lynx were exterminated from most of the western and central European countries. Small and fragmented populations remained in the Balkans. This is particularly true for the Balkan lynx as it is currently believed to be a critically endangered autochthonous subspecies.

The interest in both the taxonomic and conservation status of the Balkan lynx started in the 1940's, when it was described for the first time as a separate subspecies by the Bulgarian zoologist Ivan Bureš (*Lynx lynx balcanicus* Bureš, 1941) and later on by Gjorge Mirić (*Lynx lynx martinoi* Mirić, 1978). Even so, the taxonomic position of the Balkan lynx is still not officially recognized. From the conservation point of view, the Balkan lynx suffered a severe bottleneck in the 1930's, after which the Yugoslavian authorities granted it a legal protection in 1949. The population soon started to recover and by the 1980 it reached 280 individuals (Mirić, 1981). The period after the split of Yugoslavia in 1991 was a nuisance for wildlife. Poaching, habitat degradation and depletion of the prey base brought the lynx back to the verge of extinction. Civil unrest, economic instability and poverty hindered any conservation action in that time. Only in 2000, a group of experts gathered and discussed the strategy for its recovery. Then again, in 2001, the conflict between the ethnic groups in South Serbia, Kosovo and Macedonia postponed the conservation actions for another 5 years. In 2006, the Balkan Lynx Recovery Programme was launched as a pilot project in Macedonia and Albania with the intention to be extended onto the two northern neighbouring countries: Kosovo and Montenegro. The activities in the project were focused on building capacity for a long term conservation programme, assessing the conservation status of the Balkan lynx, raising the public awareness towards wildlife in the two countries in general and towards the Balkan lynx in particular and establishing new protected areas for a better protection.

At present, the Balkan lynx distribution is most probably limited to the south-west Balkans in the border regions between Macedonia and Albania. Mavrovo National Park represents the only known stronghold of today's population, since it is the only area where reproduction has been confirmed and the ground protection is on the satisfactory level. Whether this population still represents a source population or has already become a sink population, we are still not certain. Challenging as it is, we are not only risking a loss of a certain feature in the ecological niche in the Balkans, we are also facing a loss of a genetically distinct unit which the Balkan lynx is believed to be (Breitenmoser-Würsten & Obexer-Ruff, 2003; Gugolz *et al.*, 2008).

Hopefully, this thesis will once again demonstrate the critical position in which the Balkan lynx is now and will justify the emergent efforts needed for its conservation.

Sažetak

Veličina populacije i rasprostranjenost ciljnih vrsta su jedne od najvažnih osobina u konzervacionoj biologii. Znajući ove parametre, može se primeniti efikasno vođenje zaštite u okviru zemljama njihove distribucije. Ovo je posebno relevantno za najmanju i dugoročno izolovanu autohtonu populaciju evroazijskiog risa u Evropi. 1941. godine, zoolog Ivan Bureš je bio prvi koji je balkanskom risu dao status podvrste - *Lynx lynx balcanicus* (Bureš, 1941). Ova podvrsta nikada nije bila priznata od strane šire naučne javnosti, iako su morfometrijske i genetske analize implicirale na to. Tema je postala još alarmantnija sa nedavnim dramatičnim padom populacije i velikim rizikom od izumiranja ove podvrste u bliskoj budućnosti.

Cilj ovog rada je da se proceni distribucija i konzervacijski status balkanskog risa, da se uporedi njegova istorijska i danjašna distribucija i da se iznesu glavne pretnje njegovog opstanka. Osnovni skup podataka koji se koristi u ovoj studiji obuhvata upitnik osnovnog istraživanja u oblasti zapadne Makedonije i istočne Albanije, podatke iz literature i rezultate aktivnosti foto-zamki u obe zemlje. Konzervacijski status balkanskog risa je dobijen korišćenjem oflajn sistema IUCN-a. Kao glavna informacija o distribuciji risa, područje rasprostranjenosti (Area of Occupancy - AOO) je dobijena kombinacijom podataka iz osnovnog istraživanja i potvrđenim prisustvom balkanskog risa uz pomoć različitih metoda. Veličina populacije je izračunata korišćenjem površine zauzetosti i srednje gustine populacije balkanskog risa u nacionalnom parku Mavrovo stečeni tokom sistematske sesije foto-zamki u 2010 godini. Prema osnovnom istraživanju rezultati pokazuju pad populacije. Pesimističan scenario za broj populacije balkanskog risa ukazuje na samo 20 do 44 odraslih jedinki. Ove jedinke su uglavnom rasprostranjene u zapadnom delu Makedonije i istočnoj Albaniji. Nema čvrstih dokaza koje dolaze sa severa (Kosovo i Crna Gora). Minimalno područje rasprostranjenosti (AOO_{min}) balkanskog risa je oko 4000 - 20000 km^2. Prema kriterijuma crvene liste IUCN-a, status zaštite ovog taksona je krajnje ugroženi (CR (C2a (I, II) D). Treba preduzeti hitne mere da bismo sačuvali balkanskog risa. Nedavno je grupa naučnika počela zajednički projekat pod nazivom "Program oporavka balkanskog risa" kako bi se zaustavilo dalje opadanje populacije i kako bi se obezbedio njegovi opstanak.

Ključne reči: Balkanski ris, *Lynx lynx balcanicus,* Makedonija, Albanija, veličina populacije, distribucija, istorijski pregled, IUCN procena.

Abstract

The population size and distribution of a target species are one of the most important features in conservation biology. By knowing these parameters, an effective management for conservation can be applied in the range countries of their distribution. This is particularly relevant for the smallest and long term isolated autochthonous populations of the Eurasian lynx in Europe. In 1941, zoologist Ivan Bureš was the first one to acknowledge the Balkan lynx with a subspecies status - *Lynx lynx balcanicus* (Bureš, 1941). This subspecies has never been recognized by wider scientific public, even though morphometric and genetic analysis imply sub species status. The topic has become even more alarming with a recent dramatic decline and probability of extinction in the near future.

The objective of this work was to assess the distribution and the conservation status of the Balkan lynx, to compare its historic and present distribution and to outline the main threats to its survival. The main data sets used in this study are the baseline survey questionnaire performed in the study area (western Macedonia and eastern Albania), literature data and the results from the camera-trapping activities in both courtiers. The conservation status of the Balkan lynx was acquired using the offline system of the IUCN. The Area of Occupancy as the main information for the distribution range was obtained combining the data from the baseline survey and the confirmed presence of the Balkan lynx by various methods. Population size was calculated using the Area of Occupancy and the mean density of the Balkan lynx inside the Mavrovo NP attained from the systematic camera-trapping session in 2010. The results show a decline in the population according to the Baseline Survey. The pessimistic scenario for the population size of the Balkan lynx is pointing to only 20 to 44 mature individuals. These individuals are distributed mainly in the western part of Macedonia and eastern Albania. No firm evidence occurs from the north (Kosovo and Montenegro). The minimum Area of Occupancy for the Balkan lynx is about 4,000-20,000 km^2. According to the IUCN Red List criteria, the conservation status of this taxon is Critically Endangered (CR (C2a(i,ii)D)). Urgent measures have to be taken in order to save the Balkan lynx. Recently a group of scientists jointly started a recovery project called “Balkan Lynx Recovery Programme” in order to stop the further decline of the population and to secure its survival.

Key words: Balkan lynx, *Lynx lynx balcanicus,* Macedonia, Albania, population size, distribution, historical review, IUCN assessment.

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1. Introduction

In the south-west of the Balkan Peninsula, in the mountains forming the border between Albania and Macedonia and spreading north into Kosovo and Montenegro, a small and long-term isolated autochthonous population of Eurasian lynx *Lynx lynx* has survived to the present. The critical conservation status of this population was repeatedly recognised (Kratochvil *et al*., 1968b, Festetics, 1980, Breitenmoser and Breitenmoser-Würsten, 1990), but the political situation in the range countries was not in favour of a conservation project. Only recently, a group of scientists and conservationists launched the Balkan Lynx Recovery Programme (hereafter referred to as BLRP) (Breitenmoser *et al*. 2008). The project started in 2006 as a partnership between NGOs from both countries that are believed to share most of the Balkan lynx population – Macedonia and Albania, as well as expert guidance from Switzerland, Germany and Norway.

A total number of nine subspecies are suggested for the Eurasian lynx (*Lynx lynx*) (von Arx *et al*., 2004). Three out of those nine are distributed in Europe. The nominal form (*Lynx lynx lynx*) ranges throughout the northern parts of the continent, whereas the Carpathian lynx (*Lynx lynx carpathicus*) can be found in most of the suitable habitats on the Carpathian mountain arc. The population of the Balkan lynx (*Lynx lynx balcanicus*) today is isolated, surviving in the south-western parts of the Balkans. The Bulgarian zoologist Ivan Bureš (1886-1980) was the first one who proposed that the Balkan lynx should be classified into a subspecies, suggesting *Lynx lynx balcanicus* as a possible name (Bureš, 1941). Later on, Serbian mammologist Gjorge Mirić (1919-1994) gave precise and detailed descriptions of the Balkan lynx, taking the measurements of the skull as an essential parameter for comparison. Mirić gave a different subspecies name to the Balkan lynx - *Lynx lynx martinoi* (Mirić, 1978). Preliminary genetic analyses (Breitenmoser-Würsten & Obexer-Ruff, 2003; Gugolz *et al.*, 2008) confirm the distinctiveness of the Balkan lynx, but it is not yet clear whether the molecular-genetic differences of *Lynx lynx* populations in Europe justify the distinction of subspecies (conclusions from the International Exploratory Workshop "Genetic status and conservation management of reintroduced and small autochthonous Eurasian lynx *Lynx lynx* populations in Europe", Saanen, Switzerland, 24–27 October 2011). This question cannot be answered in this work, but the importance of the survival of the Balkan lynx goes far beyond its taxonomic status. Considering the autochthonous character of this population, the Balkan lynx should be considered an Evolutionary Significant Unit (see chapter 4.3), hence making the BLRP of high conservation importance.

The two countries in which the study area was chosen is with reference to the literature for Balkan lynx distribution. In the 1970s, Mirić's intensive investigation on the Balkan lynx distribution (Mirić, 1973; 1974; 1977) resulted in his monograph "The lynx populations of the Balkan Peninsula" (Mirić, 1981) in which detailed findings on Balkan lynx presence has been reported from the former Yugoslavian countries. Various authors also investigated the presence of the Balkan lynx through interviews with the local inhabitants (Micevski, 1997; Grubač, 2000, 2002), but perhaps the most thorough enquiry involving local experts was the one organized in 2000 (Breitenmoser-Würsten & Breitenmoser, 2001). In this study, experts in the field of zoology expressed their state of knowledge on the presence/absence, trend, population number and main threats of the Balkan lynx. They concluded that the last population of the Balkan lynx is in the remote areas of western Macedonia and eastern Albania. No firm evidence of the lynx appears from Montenegro and south-west Serbia (Paunović *et al*., 2001) or from Greece (Panayotopoulou, 2001). According to the report published by von Arx *et al*. (2004), Balkan lynx still occurs in the mountains along the Albanian-Macedonian

border. Therefore it was concluded that the start of the conservation programme would be focused on the two bordering countries (Fig. 1 and 2).

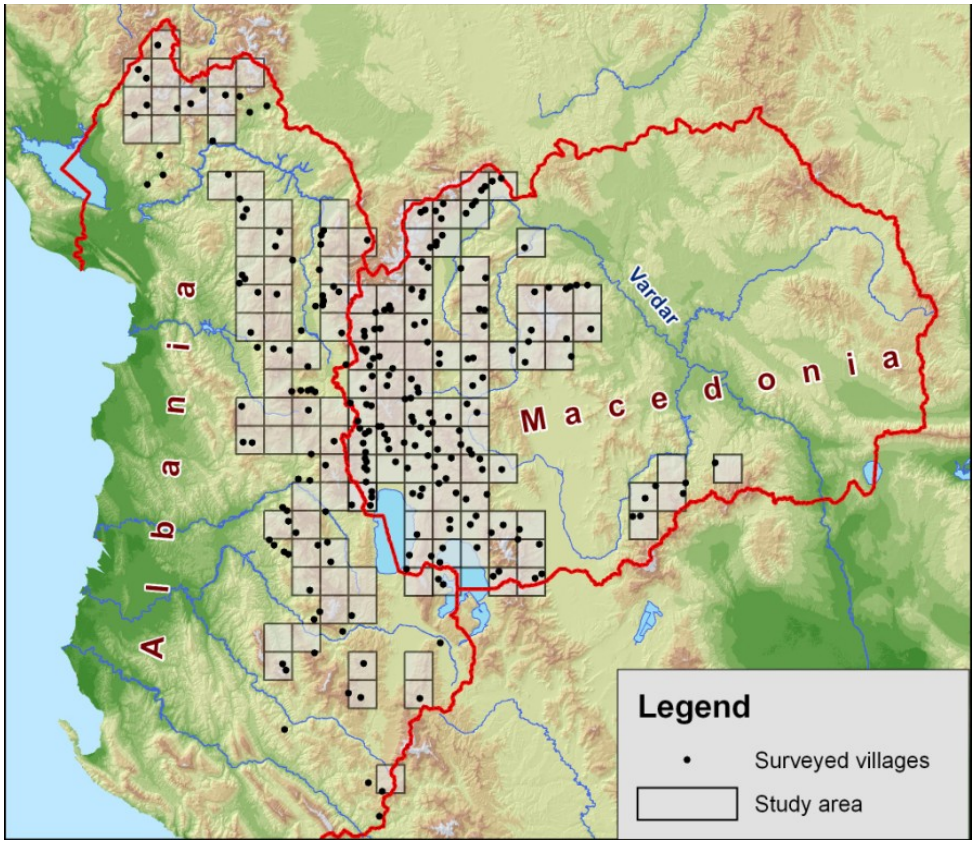


Fig. 1 Grid cells within the study area and inquired villages.

The activities in the project are organized according to the following basic goals: (1) to assess the conservation status of the Balkan lynx population, and to secure its survival in the trans-boundary areas of the region through (2) furthering protected areas and (3) securing its coexistence with the local communities. (1) As a first step, an overview of the Balkan lynx distribution, trend, status and perceived ecology and biology was needed. This was gained by compiling *Local ecological knowledge* (LEK). LEK refers to ecology as natural science and includes a person's general knowledge of nature and more specifically local knowledge (Yli-Pelkonen & Kohl, 2005). Local peoples' knowledge on abundance and distribution of species is gained through individuals' observation in their lifetime. It is a commonly used method for qualitative estimates of presence and abundance of species, as well as quantitative assessment on population trend (Anadon *et al.* 2009). Performed in a systematic way, LEK can lead to valuable clues for a long-term conservation programme. Overview of the distribution and status of the Balkan lynx was gained using LEK as a preparatory method for establishing a solid monitoring programme. Across the entire potential distribution area in both countries a questionnaire (Appendix I) was used to compile local peoples' knowledge. This **Baseline Survey** marked the beginning of the BLRP. Knowledge gathering is time consuming task which requires team work of several people. Human capacity in the project was achieved through trainings of young researchers for this long-term programme. Indeed, BLRP aims also to create partnership and commitment between the stakeholders for nature conservation activities in the region.

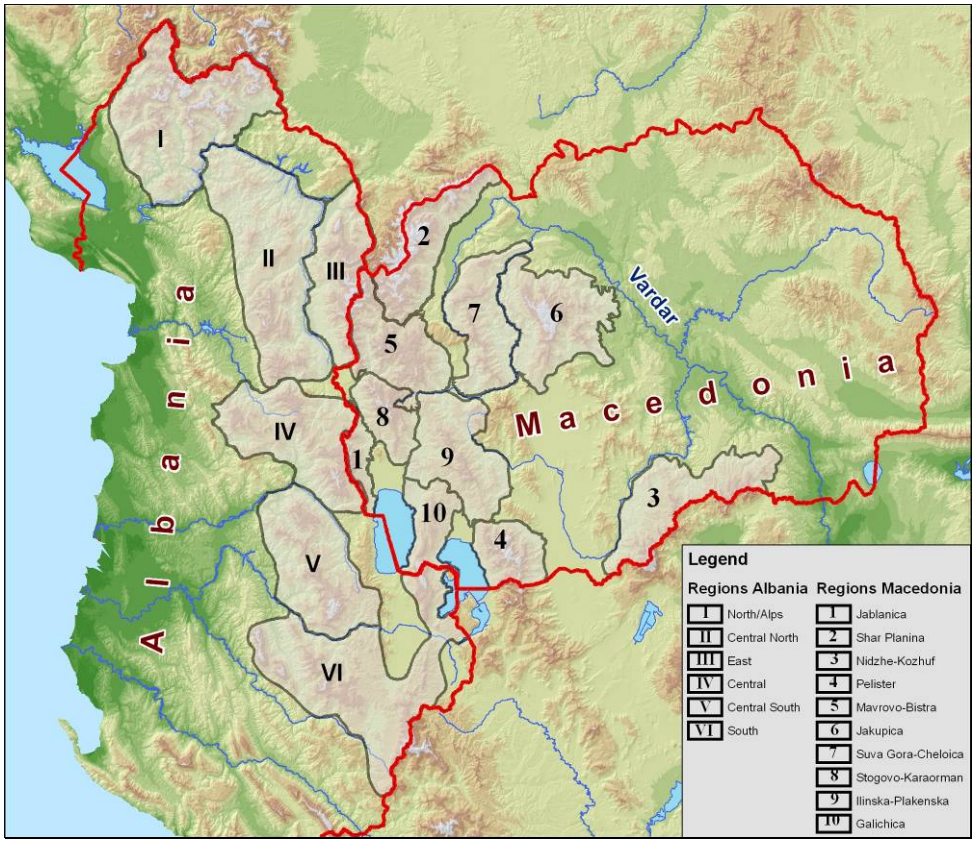


Fig. 2 The study area divided in regions.

(2) Most of the activities within the project were carried out in the border regions in western Macedonia and eastern Albania, because in the past decades, access to this region was limited and thus protected to a certain degree. Today, these areas are part of the wider European initiative called the European Green Belt (www.europeangreenbelt.org). The Green Belt covers mostly bordering regions belonging to the countries which during the Cold War were separated between Eastern and Western European Bloc hence forming the “Iron Curtain”. Almost the entire Macedonian border (except in the north) and the whole Albanian terrestrial border belong to the Green Belt. However, the most important areas for the Balkan lynx are western Macedonia and eastern Albania, where most of the activities from the BLRP were undertaken. One of the goals of the project is to create a number of protected areas in three mountain ranges in each country (Fig. 3).

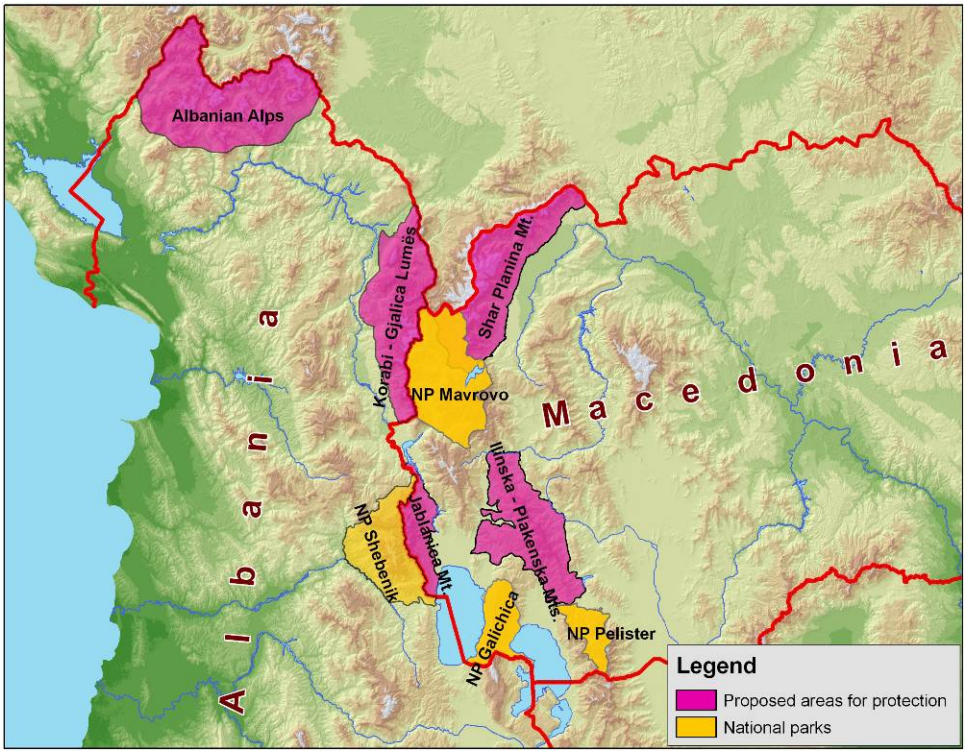


Fig. 3 Proposed protected area system (purple areas) in Macedonia and Albania. Yellow regions represent the National Parks in Macedonia and the newly proclaimed Shebenik NP in Albania after the star of the BLRP project.

(3) Finally, human attitude towards all three large carnivores (bear, wolf and lynx) living in the two countries was assessed with the thorough Human Dimension survey carried out in what is known as the Balkan lynx distribution area.

The aim of this work corresponds to the first goal of the project: to assess the distribution and conservation status of the Balkan lynx population. As a second priority, I have compared the present and the historic distribution of the Balkan lynx. The method and the results part in the presented work will be organized according to the three main objectives of this thesis:

1. Summarise the historic distribution of the Balkan lynx and decline of the population based on a literature review;
2. Survey the present status of the population (distribution and population size) based on the local ecological knowledge;
3. Assess the conservation status of the Balkan lynx according to the IUCN Red List criteria.

As a conclusion, I have made recommendations for urgent conservation measures and further research.

2. Methods

2.1 Study area

The study area within Albania and Macedonia was selected taking into account the already known biology and ecology of the Eurasian lynx. Unsuitable areas for lynx such as plains, big-river valleys, ravines, non-forested and low-elevation hillsides were excluded from the survey. In Macedonia, mountains west of river Vardar were taken as most relevant (Fig. 1 and 2). In Albania, all the mountains in the northern and eastern part of the country, bordering with Montenegro, Kosovo, Macedonia and Greece belong into the survey area. The study area was designated using a 10x10 km grid map (100 km^2) of the countries (Fig. 1).

2.2 Literature reviews and historic decline of the Balkan lynx population

All available publications on the Balkan lynx distribution, historic declines and historical distribution maps were reviewed and are presented in the results and Appendices.

Parts of the threats towards the Balkan lynx survival are taken directly from the literature data. In order to evaluate the threats obtained from the literature, and to be able to predict the future possible cause of extinction, I have only taken the most recent published data (from the year 2000 onwards) where threats for Balkan lynx survival are revealed: Grubač, (2000 and 2002); Breitenmoser-Würsten & Breitenmoser, (2001); Bego, (2002); von Arx *et al*., (2004) and Ivanov *et al.*, (2008).

2.3 Present status of the Balkan lynx based on the LEK

2.3.1 Baseline Survey

The main aim of the Baseline Survey was to assess the distribution and relative abundance of lynx and other large carnivores, in addition to potential prey species (wild ungulates, lagomorphs and tetranoids) by means of interview techniques. The selection of the investigated area for the Baseline Survey (Fig. 1) and the question form were developed together with all partners in the BLRP. A total of 73 grid cells were selected for western Macedonia and 63 for eastern Albania and in each cell at least one village was visited. Each of the grid cells represents a survey category in which a certain number of respondents (sample) were interviewed. The questionnaire included 13 wildlife species and 50 questions divided into six categories (Appendix I). The first group of questions was related to the presence, abundance and trend of the targeted species over a period of the past 5 years from when the questionnaire was made. The second group is related to the conflicts between people and large carnivores and the human attitudes towards them. Socio-economic aspects of the villages are addressed in the third group of questions, while some detail information on livestock breeding and damage compensation system are asked in the fourth group of questions. The fifth and the sixth group of questions deal with general information on the person interviewed and the village in which

he/she lives. For the purpose of this thesis, only the first group of questions will be considered. Particularly, distribution pattern and trends are outlined only for the lynx, as well as its main prey species (roe deer, chamois and brown hare), under the 'Results' chapter (Assessment of the conservation status). The sample design focussed on people relevant for the study: hunters, game wardens, foresters, livestock breeders, beekeepers, farmers, veterinarians, naturalists but also owners of cafeteria or markets as well as a random sample of informants which did not fall in one of the mentioned profiles (Tab. 1).

Table 1. Number of completed questionnaires per profile of the interviewees and per country during the Baseline Survey.

	Profile	**Macedonia**	**Albania**
1	hunter	195	48
2	livestock breeder	86	22
3	farmer	43	53
4	naturalist	24	/
5	forester	22	26
6	shop owner	16	24
7	game warden	13	/
8	veterinarian	8	9
9	beekeeper	5	/
10	other	141	138
	TOTAL	**553**	**320**

The interviewing technique was face-to-face and the questionnaire was completed at the time of interviewing in order to avoid misinterpretation of data. For better interpretation of the results (analyses and comparison), the study area (eastern Albania and western Macedonia) was divided into several topographical and/or political regions (separated by mountains, big rivers and state borders) (Fig. 2; Tab. 2).

Table 2. Baseline Survey's investigated area in Macedonia and Albania divided by regions. In each region, number of completed questionnaires is presented.

Macedonia		**No. of questionnaires**	**Albania**		**No. of questionnaires**
1	Jablanica	51	I	North-Alps	47
2	Shar Planina	77	II	Central North	71
3	Nidze-Kozhuf	21	III	East	57
4	Pelister	43	IV	Central	75

5	Mavrovo-Bistra	91	V	Central South	44
6	Jakupica	34	VI	South	26
7	Suva Gora-Cheloica	33			
8	Stogovo-Karaorman	45			
9	Ilinska-Plakenska	109			
10	Galichica	49			
	TOTAL	**553**			**320**

Verified lynx findings (stuffed animals, lynx pelts, museum specimens, photographs of lynx and camera-trapping photos) fall into a separate category called Balkan lynx 'Hard facts'. I used the 'Hard facts' to determinate lynx presence in the area where the 'fact' comes from, as well as to present the Balkan lynx losses (stuffed animals or pelts) throughout the time. This way one can estimate the known losses in the past and predict to a certain level the expected mortality in the population dynamics for the future. 'Hard facts' data are classified taking the definitions from the SCALP initiative (Status and Conservation of the Alpine Lynx Population), which is an ongoing programme aiming to coordinate the lynx monitoring and the conservation activities in the Alps (Molinari-Jobin, A. *et al*., 2003). Three criteria were developed by the SCALP expert group in order to standardise the interpretation of the monitoring data:

Category 1 (C1) represent the 'Hard facts', e.g. all reports of lynx killed or found dead, photographs of lynx, samples confirmed by molecular-genetic analyses, as well as young orphaned lynx caught in the wild and put into captivity.

Category 2 (C2) incorporate all records of livestock killed, wild prey remains, tracks and scats reported and confirmed by trained people (e.g. game-wardens) and people who attended special courses. These records are mostly an objective proof of lynx presence.

Category 3 (C3) include all unconfirmed wild prey remains, scats and tracks reported by the general public as well as all sightings and vocalisations, e.g. signs that cannot be verified.

In the presented work I have included the 'Hard facts' data (C1) and verified data on lynx kills, tracks and scats (C2) in the presence/distribution assessment of the Balkan lynx.

During the project, additional reports from local inhabitants were continually recorded and represent a substantial portion of the research. These records are in the form of lynx observations, tracks, scats, domestic animals killed by lynx, indications of dead/killed lynx and people attacked by lynx. The results are presented separately from those from the Baseline Survey questionnaire (Appendix I) and are called 'Chance observations' (Category 3 data). All of these results are contributing to the distribution pattern of the Balkan lynx for Macedonia and Albania obtained from the LEK.

2.3.2 Calculation of distribution area

The results of the Balkan lynx distribution in this work were assessed for a period of 5 years, from September 2006 till September 2011. Three data-sets were used in order to obtain the most accurate distribution pattern: Baseline Survey questionnaire data (C3); 'hard-facts' findings (C1), plus the C2 data gathered from the project; and other not verified reports on observed lynx, lynx tracks,

scats and lynx kills - 'chance observations' (C3). The presence of predator and prey species was assessed according to the number of positive answers per grid cell. Each grid cell within the Baseline Survey questionnaire with more than 50 % positive answers indicates good evidence for presence. Less than 50 % indicates scarce presence. Evidence for scarce presence was added to the previous results as a potential area of the lynx, outside the most probable area of distribution. No positive answers indicate that the species is not present. I estimated the **Minimum Grid Range** (MGR_{min}) of the Balkan lynx by counting the number of grid cells with more than 50% positive answers per 100 km². The **Maximum Grid Range** (MGR_{max}) is the number of grid cells with at least one positive answer per 100 km². The polygon for Balkan lynx distribution according to the findings from the Baseline Survey is shaped considering the natural and anthropogenic boundaries in the landscape (plains, big rivers, towns, high mountain pastures etc.). I used the Corine Landcover (www.eea.europa.eu/publications/COR0-landcover) system and followed the forest areas or patches inside or closely outside the cells. In cases with some grid cells when the natural or anthropogenic border was not clearly defined, or could not be established, the forested areas according to the Corine Landcover was most important feature to follow. In order to represent the whole potential range of the Balkan lynx, its distribution range was extended into the three neighbouring countries in the north (Kosovo, Montenegro and Serbia (south-western part)), referring to the most recent research (Grubač, 2000 and 2002) and expert opinion (Paunović *et al*., 2001). Grubač's research is based on interviews with local people and these data are considered Category 3. This way, I have outlined the present Balkan lynx distribution with an area calculation for both: **Area of Occupancy** (AOO) and **Extent of Occurrence** (EOO). While the AOO is a very detailed range of likely and possible distribution pattern of the Balkan lynx, the EOO is the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of the Balkan lynx, excluding cases of vagrancy. The EOO can be measured using the Minimum Convex Polygon (MCP) – the smallest polygon in which no internal angels exceeds 180° and which contains all the sites of occurrence. The EOO are also sites which haven't been searched for (or at least not in a near past), but contain known appropriate habitat for lynx presence (IUCN, 2008). I have come up with two different values for AOO and EOO depending on the data taken for their calculation. The **Minimum Area of Occupancy** (AOO_{min}) was obtained taking only the Category 1 and 2 data for Macedonia and Albania later than year 2000 as an adjusted polygon. The **Maximum Area of Occupancy** (AOO_{max}) was calculated taken the Category 1, 2 and 3 data for Macedonia and Albania later than the year 2000; C3 data for Montenegro and Kosovo were taken from the recent literature and the MGR_{max} as an adjusted polygon. Considering the two different values obtained for the AOO, the MCP for EOO was also calculated with two different values. The **Minimum Extent of Occurrence** (EOO_{min}) is the MCP including all AOO_{min} polygons, while the **Maximum Extent of Occurrence** (EOO_{max}) is the MCP including all AOO_{max} polygons. The area calculations for both, AOO and EOO are computed in the GIS ArcMap software.

For the distribution data acquired beyond the Baseline Survey questionnaire (Category 1, 2 and 3 – Chance Observations), I have come up with three time periods: before 1990, between 1990 and 2000 and after 2000. This separation was made considering the political situation/development in both countries in order to see whether there is a correlation between a certain period and the distribution of the Balkan lynx. The period before 1990 is considered a time with long-term established political regimes in both Albania and Macedonia being a Federal Republic of Yugoslavia, where nature-protection laws were different from the present ones. The period of 1990-2000 is a transition period for Albania and Kosovo with social unrest, civil wars in Albania and reduced law enforcement. The period after 2000 is considered a time with increased political stability and law

enforcement. It is also in a co-ordinance with the IUCN Red List assessment time span (10 years or 3 generations, whichever is longer).

2.3.3 Estimation of the population density and size

The population size estimation presented in this work was obtained considering two data-sets: camera-trapping in a reference area and Baseline Survey data on Balkan lynx distribution.

Camera-trapping is a widely used method for monitoring elusive and rare species. It is an excellent tool to detect presence-absence of species in an area, as well as to make quantitative estimations of the populations of certain species where each individual is easily recognizable. It is very useful and recommended for a species which have certain individual pattern on their fur, like the spotted cats do (Karanth, 1995). During the research period (2006-2011), four camera-trapping sessions have been completed in Macedonia and two in Albania (Fig. 4 and Tab. 3). For the purpose of this thesis, the results from the two systematic sessions completed in Mavrovo National Park will be taken as a reference for Balkan lynx density.

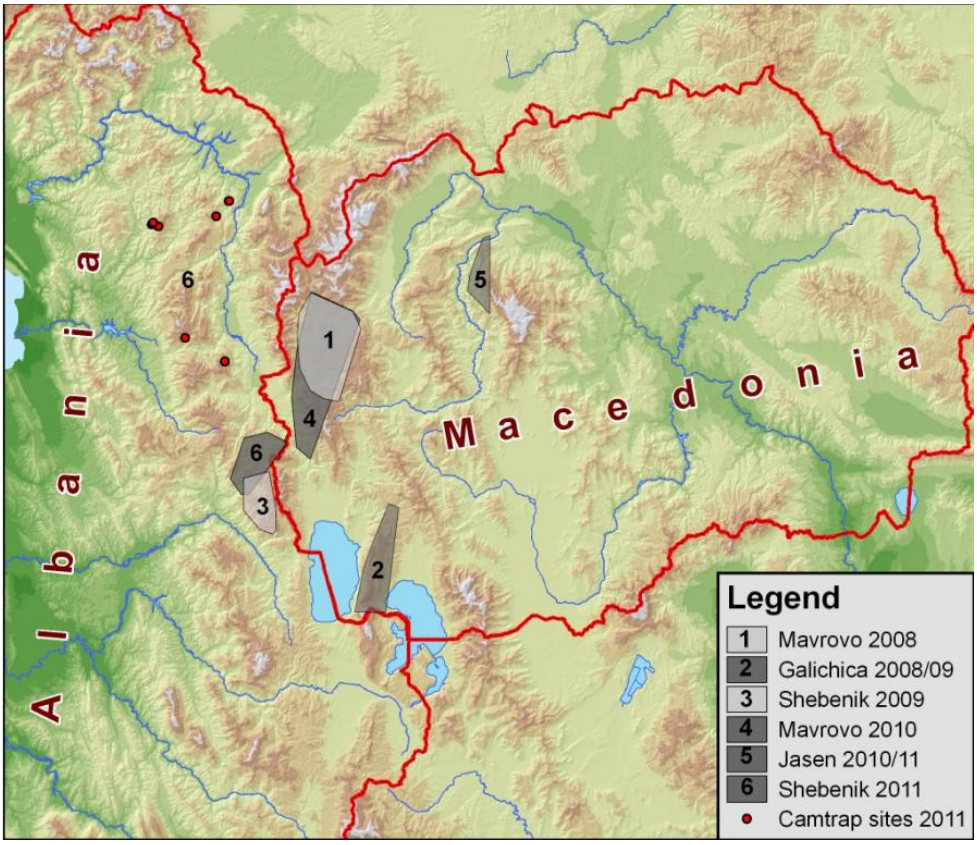


Fig. 4 Conducted camera-trapping sessions in the study area. Gray areas represent Minimum Convex Polygons of the camera-trapping sites. Red dots are camera-sites outside the main bulk during the 2011 Shebenik NP session.

Table 3. Camera-trapping sessions in Macedonia and Albania. For each session the following information was recorded: the year when the sessions were conducted, number of potential and actual (realized) trapping nights, duration of the session, number of sites, number of sites where lynx was photograph (positive sites) and total number of photographed lynx per session.

Region	Study area	Year	No. of potential trapping nights	No. of realized trapping nights	Duration (days)	No. of sites	No. of lynx-positive sites	No. of lynx photos
Mavrovo-Bistra; Stogovo-Karaorman	Mavrovo NP	2008	1920	1800	60	32	9	29
Galichica	Galichica NP and surroundings	2008-2009	952	894	56	17	0	0
Central	Shebenik NP	2009	1558	901	41	38	0	0
Mavrovo-Bistra; Stogovo-Karaorman; Jablanica	Mavrovo NP and surroundings	2010	2400	2130	60	40	10	24
Jakupica; Suva Gora-Cheloica	Jasen protected area	2010-2011	1200	1180	60	20	2	2
Central; Central-North	Shebenik NP and surroundings	2011	2471	1735	180	42	1	1

By knowing the population density (number of lynx individuals per 100 km^2) in the investigated area (Mavrovo NP), I have extrapolated the data over the whole distribution range of the Balkan lynx using the simple equation: $\frac{X * Y}{100}$, where X is the **minimum** or **maximum** area of the Area of Occupancy (AOO_{min} or AOO_{max}, respectively; see above) and Y is the population density taken from the camera-trapping findings, in order to calculate the population size. According to IUCN (2008), AOO is a useful proxy for the population size, because there is generally a positive correlation between AOO and population size.

The camera-trapping results were also used for calibration of the distribution pattern of the Baseline Survey data, by confirming the presence of the Balkan lynx in, until recently, doubtful areas and for a better calculation of the Area of Occupancy and Extent of Occurrence during the IUCN Red List assessment. Camera-trapping data are 'hard-facts' data of their own.

The results obtained from the above-mentioned methods were used to give explanation to the two possible scenarios:

- Pessimistic scenario: Taking the standard deviation of the population density into account; the lowest, highest and the mean value of the population density gained from the camera-trapping in the reference-core area will be extrapolated into the **minimum value** of the Area of Occupancy (AOO_{min}) of the Balkan lynx. These results reveal the frame of the population number for its minimum range of distribution.
- Optimistic scenario: Taking the standard deviation of the population density into account; the lowest, highest and the mean value of the population density gained from the camera-trapping in the reference-core area will be extrapolated into the **maximum value** of the Area of Occupancy (AOO_{max}) of the Balkan lynx. These results reveal the frame of the population number for its maximum range of distribution.

2.4 Assessment of the conservation status

The IUCN Red List assessment (Appendix V) was carried out using the Species Information Service toolkit (online available at: https//sis.iucnsis.org). The toolkit helps the assessor as accurately as possible assess the red list category of a species. The results for the assessment of the conservation status are discussed in three main directions: population status (area and size of the population), population development and threats.

The population density is taken from the camera-trapping session in Mavrovo NP in 2010. The distribution range of the Balkan lynx is calculated according to the requirement of the IUCN Red List assessment. Main features for the distribution are the Area of Occupancy AOO and Extent of Occurrence EOO, which are obtained by the above mentioned methods.

The population trend of the Balkan lynx was assessed by asking each interviewee during the Baseline Survey questionnaire for the population dynamics during the last 5 years per grid cell. When more than 75 % of interviewees answered that the population is increasing, decreasing or stable in any one grid cell, then this was interpreted as strong evidence for the population trend. When 50 – 75 % of interviewees had same judgment for the trend in any one grid cell, this was interpreted as a weak evidence for population trend. If less than 50 % of interviewees gave the same response regarding trend for any one grid cell, the trend was considered non-assessable. Trend was also assessed inside the Mavrovo National Park taking into account the camera-trapping results for lynx density. I used the trend as the tendency for the Balkan lynx population inside the Mavrovo NP to discuss the possible threat of decline in the population. I also used the Balkan lynx trend in the process of the IUCN Red List assessment.

Threats obtained from the Baseline Survey are also part of the IUCN assessment. Baseline Survey questions are taking into consideration the persecution of the lynx – as a direct threat (Appendix I - Question 1.6) and the presence/absence and negative trend of its main prey, as an indirect one. The following species were considered as main prey of the Balkan lynx: roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*) and the brown hare (*Lepus europaeus*), due to literature reviews (Breitenmoser & Haller, 1987; Jobin *et al.*, 2000) and a radio-telemetry study in Macedonia - showing the consumption rate of one radio-tagged individual to be 64% roe deer, 24% chamois and 12% brown hare (Melovski *et al*, 2010). Cases of poached lynx individuals were classified in three periods: before 1990, between 1990 and 2000 and after 2000 (see subchapter “Calculation of the distribution area” in this chapter).

3. Results

3.1 Literature reviews and historic decline of the Balkan lynx population

In his publications on the prehistoric and historic distribution of the lynx on the Balkans (Mirić 1974; 1981), Mirić never mentioned the lynx' actual subspecific status. Where the actual border between the Balkan and Carpathian lynx was, if needed there was a border, we simply do not know. We also speculate on the possible mixture between these two subspecies in the plains south of the Danube River and the Balkan Mountains in Serbia and Bulgaria (Fig. 5 and 6). The same is true for the north-west part of the Balkans at the very beginning of the Dinaric Mountain range and the eastern parts of the Alps. According to Mirić (1981), the lynx that lived in the Balkans was distributed all over the peninsula in the Middle Ages. Evidences for this presence are represented by the numerous toponyms with the name "lynx" (Ris – in Slavic languages) in the Balkans.

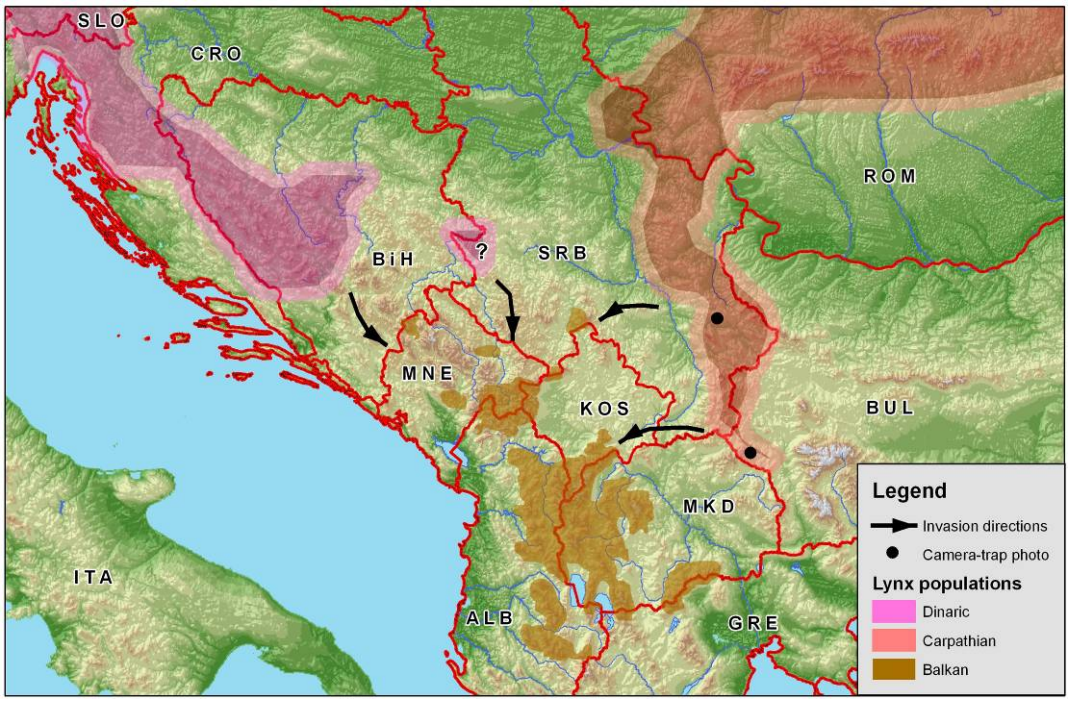


Fig. 5 Possible directions to Carpathian lynx invasion. From the eastern side (Stara Mt., Osogovo Mt. – red colour) and north-west (Dinarides – purple colour) according to von Arx *et al*., (2004). Dots are representing recent camera-trap findings from Serbia (Paunović pers. comm., 2010) and Bulgaria (Zlatanova *et al*., 2009). Question mark stands for assumed Dinaric lynx presence (Grubač, 2000).

Fig. 6 Balkan Peninsula with Danube River as its northern border. The hypothesis which we are fostering in this work is the north-west re-colonisation route of the Balkan lynx along the Dinaric arc and Eastern Alps with a Danube River as a natural border that separated the Carpathian lynx population. Downloaded from http://crazy-frankenstein.com/the-danube-river.html.

The first notes of lynx living in the Balkan Peninsula appeared already in the 17th and 18th century (Valvasor, 1689; Taube, 1777). In the 19th century lynx articles could be found in the hunting magazines as part of the hunting practices (Führer, 1896), as well as the fauna-checklists for certain countries (Ettinger, 1857; Freyer, 1842; Heldreich, 1878). Publications dedicated specifically to the lynx in that time were primarily questioning the presence and extinction awareness of lynx in the countries, all the way through Western, Central and Eastern Europe (Brusina, 1899; Draganović, 1897; Hristović, 1893; Obereigner, 1888). At the end of the 18th and beginning of the 19th century, the lynx was present everywhere in the forested areas in the mountains of the Balkans but had disappeared from the lowlands (Appendix II, Fig. 24, 25 and 26) (Mirić, 1981; Čop, 1988). After the rapid increase of the human population in 19th and 20th, the considerable exploitation of the forest and the massive annihilation of the large carnivores and herbivores, the lynx distribution shrank considerably compared to the previous times. By the end of the 19th and the first half of the 20th century, the lynx that lived on the Balkans was extirpated from most of the former-Yugoslav republics and Bulgaria (Atanasov, 1968; Mirić, 1981), (Appendix II, Fig. 23).

Status assessments and reviews of the Eurasian lynx population with emphasis on the assumed Balkan subspecies existed in the 1960's as a requirement of the International Union for Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF). These were in the context of a larger Eurasian lynx assessment for Europe (Kratochvil *et al.*, 1968a, 1968b), in which the population size of the Balkan lynx is considered to be from 50 to 70 individuals, distributed in the territories of western Macedonia and Kosovo. Mirić (1963) reports that in 1955 about 30 lynx lived in Yugoslavia in the mountains surrounding the Methohia basin and west of the Vardar River in Macedonia. Several years later, Smit and Van Wijngaarden (1976), produced a report on the distribution, status, threats and conservation measures for the Eurasian lynx, including the population estimates for the Balkan lynx. The estimate in this report is however taken from

Kratochvil et al. 1968b. Status of the Eurasian lynx in Europe was again assessed in 1978 (Wotschikowsky, 1978) and 1979 (Kempf *et al*., 1979). Festetics (1980) estimated the Balkan lynx population to be 60 to 70 individuals in 1958, to 80 individuals in 1963. Mirić (1981) estimated a bottleneck in the Balkan lynx population, reaching its critical status of 15 to 20 individuals in the former Yugoslavia before the Second World War (1935-1940). According to this paper, in the following years the population started to recover due to its strict protection. In 1955-1964 the population only in Macedonia and Kosovo reached 70 individuals. By 1974 the Balkan lynx reappeared into Montenegro (around 10 individuals) while in Kosovo there were approximately 70 individuals and 120 in Macedonia. Taking the estimates from Albania (75 individuals) and Greece (5 individuals), the Balkan lynx population in that time reached 280 individuals spreading on approximately 6000 km^2.

In the beginning of the 1990's, on behalf of the Bern Convention, Breitenmoser & Breitenmoser-Würsten (1990) compiled a report on the status of the Eurasian lynx in all country members of the Council of Europe, by means of expert questionnaires. The same inquiry was repeated after five years but published in 2000 as the Action Plan for Conservation of the Eurasian lynx in Europe (Breitenmoser *et al.*, 2000). An updated version of the 1995 questionnaire was used in a second assessment by the experts from all European range countries in 2001 (von Arx *et al*, 2004) called the ELOIS – Eurasian Lynx Online Information System. The question form was changed and made more compatible with the standards used for the IUCN/SSC Species Information System (SIS). Experts from the Balkan countries thought that the number of the Balkan lynx did not exceed 100 mature individuals distributed along the Macedonian-Albanian border and stretching north to Kosovo. This report is also available online at www.kora.ch/en/proj/elois/online/index.html. The first review dedicated to the conservation needs of the Balkan lynx only, was carried out by Breitenmoser-Würsten & Breitenmoser in 2001, as a result of a meeting organized in Plitvice National Park (Croatia) in 2000. The review summarizes the knowledge on the status and distribution of the Balkan lynx, as well as the gaps in the knowledge of the most threatened lynx population in Europe. The conclusion of this review was that the Balkan lynx population had reached a critical state with an estimated number of 62 to 78 individuals in the region, or 30–35 in Macedonia (Hristovski, 2001), 20–25 in Albania (Bego, 2001), 12–18 in Kosovo (Grubač, 2000) and a few individuals in Montenegro (Paunović *et al*., 2001). Only sporadic occurrence are reported from Greece (Panayotopoulu, 2001) on the Greek-Macedonian border, while according to Zlatanova *et al.* (2001), no Balkan lynx is believed to remain in Bulgaria.

3.2 Present status of the Balkan lynx based on the LEK

3.2.1 Baseline Survey

For the Baseline Survey questionnaire, 154 villages in Macedonia were visited and a total of 553 individuals interrogated from 10 different profiles plus random number of people who did not belong in one of the relevant profiles. Most of the interviewees were hunters (195) and random informants (145), while the veterinarians (8) and the beekeepers (5) were the categories containing the fewest people in sample size (Tab. 1). Balkan lynx presence (Fig. 7) was reported for the following regions: Shar Planina (region 2 in Fig. 2), Mavrovo-Bistra (5) and Stogovo-Karaorman Mts. (9). In addition, certain indications for lynx presence appear in the areas of Jablanica Mt. (its northern part) (1), Suva Gora-Cheloica (7) and Jakupica Mt. (6). These data are confirmed by new findings from the camera-trapping for lynx presence in those areas (see the paragraph below in this chapter). In a total

of 25 out of 73 grid cells, locals have indicated that lynx is present with more than 50% (good presence); in 36 grid cells the percentage is less than 50% (scarce presence); and in 12 grid cells, no interviewees answered positively for the presence of lynx (Fig. 7).

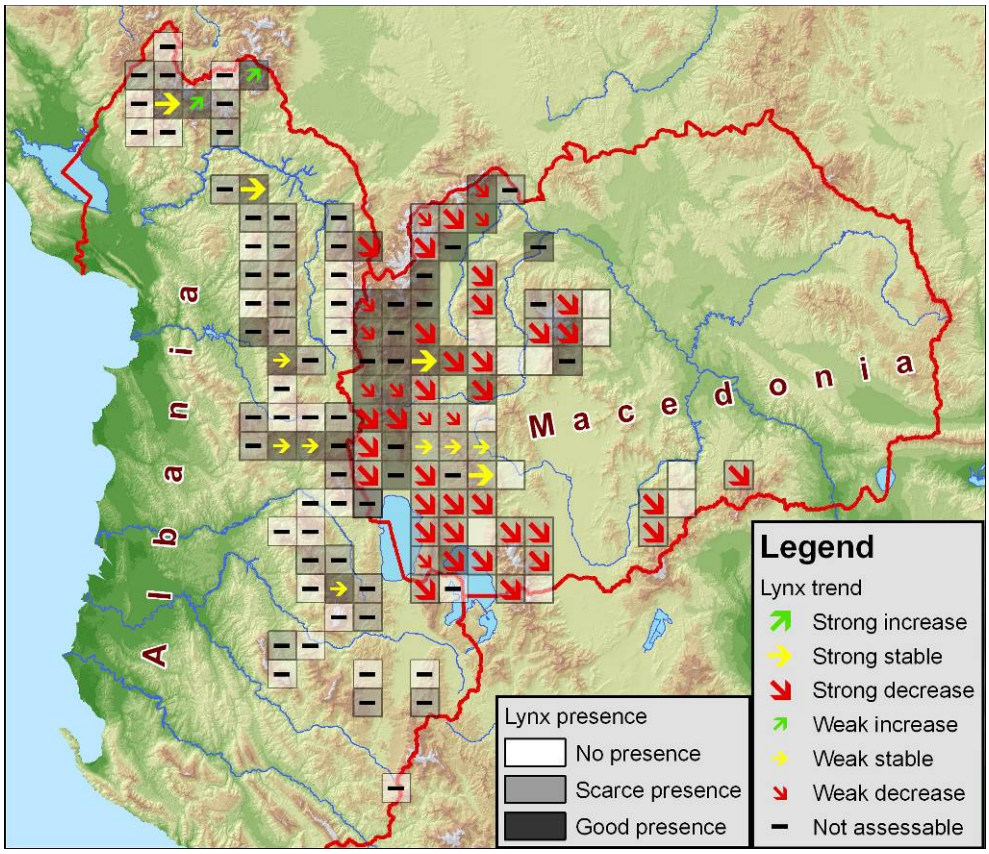


Fig. 7 Balkan lynx presence and trend in Albania and Macedonia.

In Albania, 320 questionnaires were completed in 104 villages. Most of the interviewees were random informants (138), farmers (53) and hunters (48), while veterinarians (9) were the category with the fewest people in the sample size (Tab. 1). Lynx presence was reported for the area of Eastern Albanian Alps (Prokletije Mountains) as well as Shebenik-Jablanica and Martanesh region. Region-wise, Balkan lynx is present in the Central (region IV in Fig. 2), Central-North (II) and North-Alps (I) regions (Fig. 7). Several grid cells with more than 50 % positive answers appeared in the Southern (VI), Central-South (V) and East (III) regions. There are 12 out of 63 grid cells with a good lynx presence. In total, in 26 grid cells there is a scarce lynx presence and in the remaining 25 grid cells, there was no positive answer for lynx presence (Fig. 7).

The 'hard facts' data in this work are gathered using three different methods within the BLRP: baseline survey, camera-trapping and radio-telemetry. During the Baseline Survey the proof for lynx existence in the study areas was gathered in the form of chance photos of living or dead individuals and verified stuffed lynx or lynx pelts. The Balkan lynx team managed to collect a total of 22 'hard facts' (Category 1 data) from Macedonia and Albania (Tab. 4) of this kind.

Table 4. Balkan lynx Category I (without the camera-trapping results) and II findings according to the SCALP criteria. The region of each recorded specimen is kept, together with the year and type of

record; fate of the documented animal; the SCALP criteria in which the data fall; when dead lynx is documented, ownership of the pelt or stuffed lynx was registered.

Region	**Year**	**Type**	**Fate**	**SCALP**	**Ownership** (in case of pelt or stuffed)	**Remarks**
Mavrovo-Bistra	?	stuffed	dead	I	exposed in a hotel in Mavrovo	subadult
Shar Planina	1990's	stuffed	dead	I	exposed in a cafeteria in v. Veshala, Shar Planina	juvenile
Mavrovo-Bistra	1999	photo	live	I	/	
Stogovo-Karaorman	2000 - 2001	pelt	dead	I	exposed in a restaurant in Skopje	
Central Region	2001	stuffed	dead	I	private owner	
Shar Planina	2002	pelt	dead	I	private owner	
Stogovo-Karaorman	2003	photo	live	I	/	2 juveniles
Central Region	2003	stuffed	dead	I	exposed in a restaurant in Librasht	
Ilinska-Plakenska	2004	stuffed	dead	I	private owner	subadult
Mavrovo-Bistra	2005	pelt	dead	I	private owner	
Central-North Region	2005	stuffed	dead	I	private owner	
Central Region	2005	stuffed	dead	I	private owner	
Suva Gora-Cheloica	2006	pelt	dead	I	private owner	
East Region	2006	pelt	dead	I	hunter in Kukes	
Central-north Region	2006	stuffed	dead	I	exposed in a restaurant in Fushe-Arrez, Puke	
Mavrovo-Bistra	2007	stuffed	dead	I	exposed in a restaurant in Zajas, Kichevo	
Jablanica	2007	stuffed	dead	I	?	juvenile
North-Alps	2007	stuffed	dead	I	exposed in a shop in Gomsique, Puke	juvenile
Mavrovo-Bistra	2008	photo	dead	I	private owner	subadult, just killed
Mavrovo-Bistra	2008	photo	live	I	/	juvenile - trapped and released
North-Alps	2010	trapped	live	I	kept in a restaurant in Shkodra	Injured front leg
Mavrovo-Bistra	2010	trapped	live	I	/	radio-tagged and released
Mavrovo-Bistra	2006	tracks	live	II	/	mother with cub

Mavrovo-Bistra	2007	tracks	live	II	/	
Mavrovo-Bistra	2007	tracks	live	II	/	
Stogovo-Karaorman	2008	tracks	live	II	/	
Mavrovo-Bistra	2010	tracks	live	II	/	stone marten kill close to the track
Mavrovo-Bistra	2010	tracks	live	II	/	two individuals probably mating
Mavrovo-Bistra	2010	prey	live	II	/	roe deer kill
Mavrovo-Bistra	2010	scats	live	II	/	
Mavrovo-Bistra	2010	scats	live	II	/	
Mavrovo-Bistra	2011	tracks	live	II	/	two individuals probably mating

Periodically, there are no hard-facts which are dating from the period before 1990 and only two 'facts' are dating from the period from 1990 till 1999. For one killed lynx in Macedonia, we do not know the year. The rest of the C1 and C2 data (19) are newer than 2000. Most of the C1 data were found in Mavrovo-Bistra region – 7 records. Central-North region in Albania is the region with the second most findings having only 4 records. The list of most records per region is as follows: Stogovo-Karaorman, Shar Planina and North-Alps region (2 records each); Jablanica, Ilinska-Plakenska, Suva Gora-Cheloica, Central and East region in Albanian each have one record (Fig. 8). On the Figure 8 positions for which we were not sure on the locality are not presented (ex. captured lynx kept in the town of Skadar).

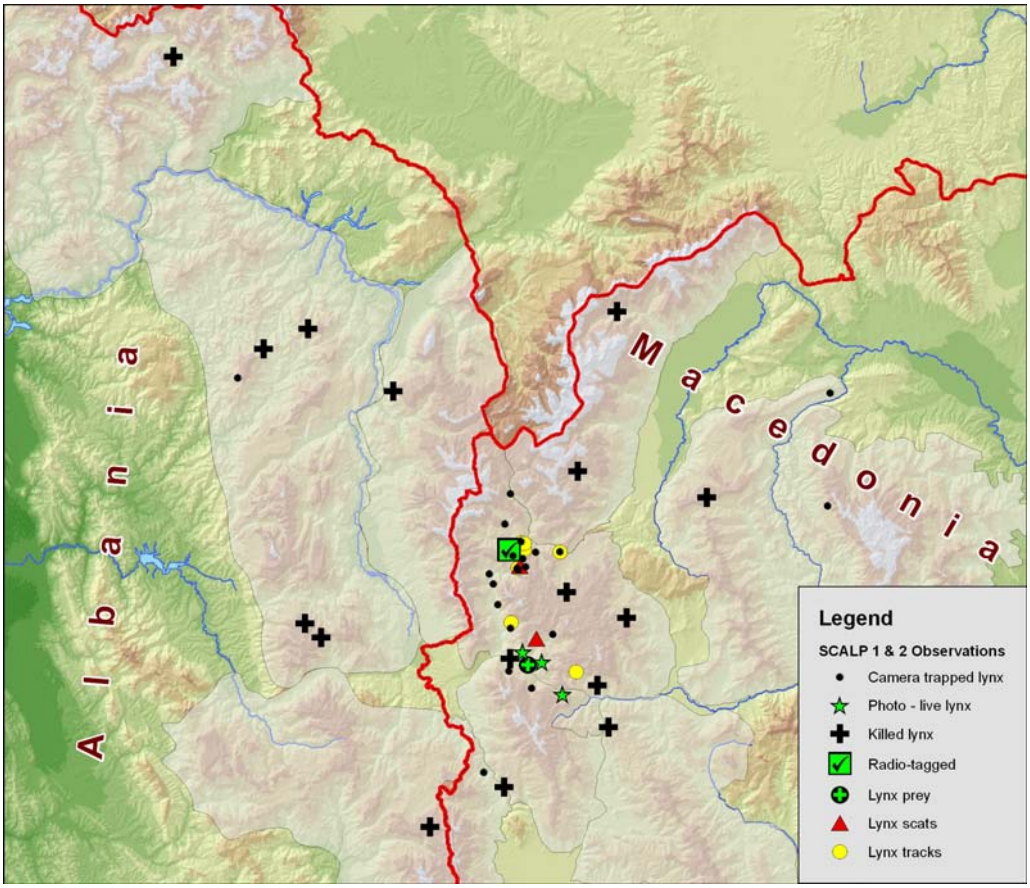


Fig. 8 All the 'hard facts' (Category 1) and Category 2 data in the study area. 23 sites where lynx has been photo-trapped (C1); 3 sites where lynx has been photographed (C1); 14 cases of confirmed killed lynx (C1); 1 found and verified lynx prey (C2); 2 verified lynx scats (C2) and 7 locations where lynx tracks were found (C2).

Six systematic camera-trapping sessions have been conducted in the studied area to date (Fig. 4 and Tab. 3), in order to confirm lynx presence areas as indicated by the Baseline Survey. Balkan lynx presence has been confirmed within four of them for the following regions: Mavrovo-Bistra (region 5 in Fig. 2), Jakupica (6), Jablanica (1) in Macedonia and Central-North region (II) in Albania (Tab. 3). A total of 76 photos were made with this method at 23 camera-trapping sites (Fig. 8). From the total of 76 lynx photos taken with this method in the study area, 56 are obtained with the systematic use of the cameras during the intensive sessions. Other 20 lynx photos were taken in Mavrovo-Bistra region with opportunistic use of the cameras beyond the systematic camera-trapping sessions. Region-wise, 62 lynx photos came from Mavrovo-Bistra, 7 from Stogovo-Karaorman and 4 from Jablanica region. Out of the total, 49 photos are from the Mavrovo National Park (Mavrovo-Bistra region plus the border of Stogovo Mt. – Stogovo-Karaorman region) taken during two systematic sessions carried out in 2008 and 2010. One photo was taken in each of the two regions: Jakupica and Suva Gora-Cheloica during the systematic session carried out in Jasen Protected Area. The only one proof of a living Balkan lynx specimen in the wild in Albania has recently emerged from Munella Mt. (Central North region, II in Fig. 2) during the systematic camera-trapping session in spring 2011 (Fig. 8 and Tab. 3). The two sessions where no lynx were photographed were organised in Galichica region (10) and Shebenik NP –Central region (IV) in 2008-09 and 2009 respectively.

In one occasion, during the lynx-capturing session in Mavrovo NP in 2010, a live specimen was caught in the box-trap for a radio-telemetry study. For the purpose of this work, the confirmation of this lynx as 'hard-fact' is only noted at the capturing site (Tab. 4).

Category 2 data are represented with 10 records in this work: 7 from verified tracks, 2 from scats and 1 record from a roe deer killed by lynx. All of these data come from Macedonia and are from live specimens (Tab. 4; Fig. 8). In seven occasions, the C1 and C2 observation includes more than one individual. Three times tracks from two different individuals were encountered (Mavrovo-Bistra region), while in one occasion (Stogovo-Karaorman region, in the border to Mavrovo-Bistra region) two lynx cubs were photographed. On three different camera-trapping photos, more than one lynx was pictured; twice a mother with cub and once most likely a lynx pair. Virtually every time more than one lynx are photographed, this occurs in the Mavrovo-Bistra region, except the near-by Stogovo-Karaorman cubs.

Data obtained from the 'chance observations' are presented in Figure 9.

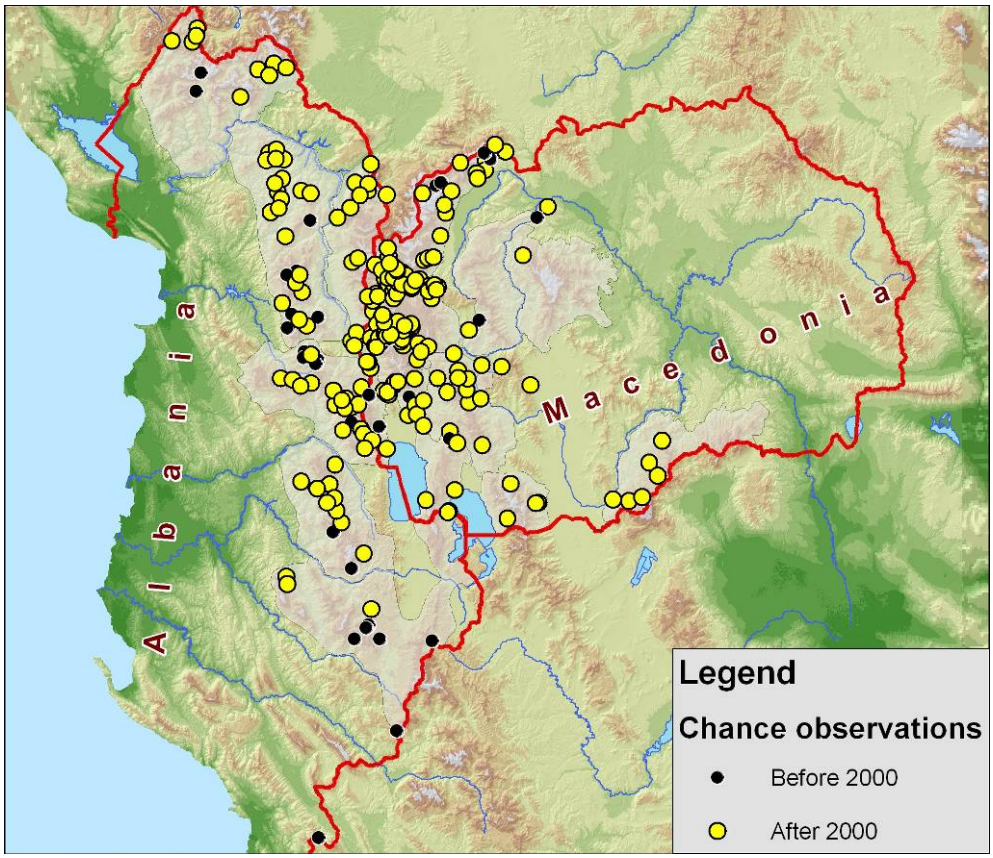


Fig. 9 'Chance observations' (Category 3) in the study area presented in the period before and after 2000.

In total, 252 records are presented on the map. Country-wise, 159 lynx signs come from Macedonia and 93 from Albania. The region where most of the signs are coming from is Mavrovo-Bistra (region 5 in Fig. 2) with 54 records, whereas from Jakupica region (6) there is only one lynx sign (Fig. 10).

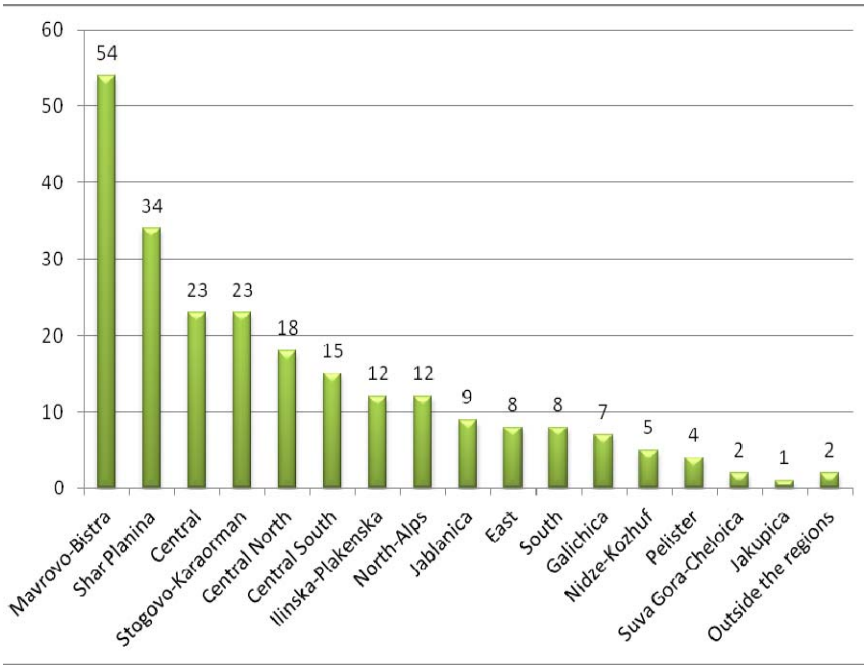


Fig. 10 Number of 'Chance observations' in each region of the study area.

Taking the type of the observation into account, most of the records fall under the 'observed lynx' category – 181 records. There are 45 records of people who personally killed or knew somebody who killed a lynx (Appendix IV – Fig. 30).

In 20 cases, people reported a sighting of 'more than one lynx, or mother with cubs' (Table 5). It is important to stress that 12 out of those 20 cases are reported to be outside the core area of the Balkan lynx (Mavrovo - Bistra region) and in 7 out of those 12 occasions people reported sightings of mother with cub(s). This information can lead to a consideration that there is a likely to be reproduction of lynx also outside the main area. Most of the records (17) are dating from the year 2000 onwards (Table 5). In total, 8 people (4 from each country) reported a domestic animal being attached by a lynx, while in two cases (both from Macedonia), a man got attacked by a lynx. There are 6 findings of dead lynx and only one report from lynx tracks.

Table 5. Chance observation of more than one lynx or mother with cubs. In the "mother and cubs" column, data where people specifically stress presence of a family group are recorded. Other cases are reported as "not sure" as it is not certain whether the "more than one lynx" observation was a lynx couple or a mother with sub-adult cub for instance. Positive answers for the "outside core area" column are given only for the Mavrovo-Bistra region.

Region	**Year**	**mother with cubs**	**outside core area**
Mavrovo-Bistra	/	not sure	no
Mavrovo-Bistra	/	yes	no
Stogovo-Karaorman	1992	yes	yes
Central	2004	not sure	yes
Central	2005	yes	yes
Central	2005	yes	yes
Nidze-Kozhuf	2005	yes	yes

Mavrovo-Bistra	2005	not sure	no
Nidze-Kozhuf	2006	yes	yes
Mavrovo-Bistra	2006	yes	no
Mavrovo-Bistra	2006	not sure	no
Mavrovo-Bistra	2006	not sure	no
Mavrovo-Bistra	2006	not sure	no
Ilinska-Plakenska	2006	yes	yes
Stogovo-Karaorman	2006	not sure	yes
Jablanica	2006	not sure	yes
Jablanica	2007	not sure	yes
Ilinska-Plakenska	2007	yes	yes
North-Alps	2007	not sure	yes
Mavrovo-Bistra	2010	yes	no

3.2.2 Calculation of distribution area

In total, the Minimum Grid Range (MGR_{min}) of the Balkan lynx inside the investigated area is 3700 km^2, or 37 grid cells (see chapter above). However, several (8) of the cells with good presence were isolated, hence did not have any neighbouring cell in the same category. Taking the Maximum Grid Range (MGR_{max}), we count 99 grid cells which are 9900 km^2. But also for the scarce presence, several cells were isolated, so their status was not confirmed by observations in neighbouring cells (Fig. 7).

Taking into account the Baseline Survey data, the Hard-facts findings and 'Chance observations' for Macedonia and Albania, as well as the most recent records on Balkan lynx presence in Kosovo and Montenegro (Grubač, 2000 and 2002; Paunović *et al.*, 2001), the calculated Minimum Area of Occupancy (AOO_{min}) where the Balkan lynx is **likely** to be present is 4007 km^2, while the Maximum Area of Occupancy (AOO_{max}) is 19886 km^2. These results represent the actual Area of Occupancy used during the Red List Assessment. The **possible** area of its distribution are calculated within the Minimum Extent of Occurrence (EOO_{min}) - 10124 km^2 and the Maximum Extent of Occurrence (EOO_{max}) - 58435 km^2 (Fig. 11).

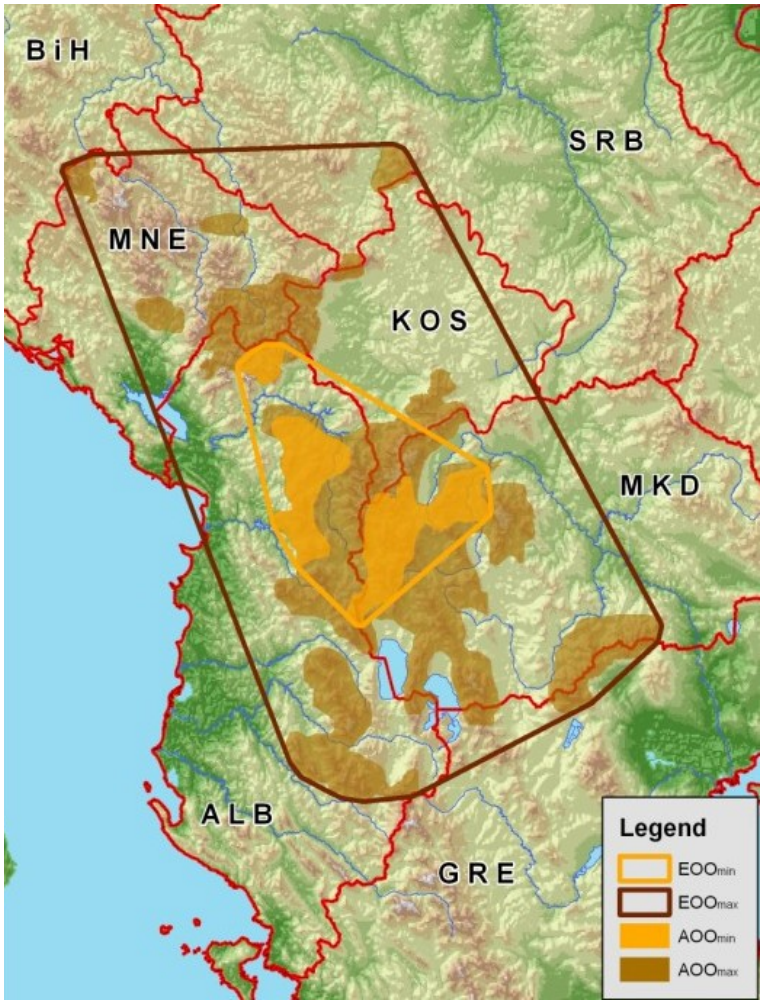


Fig. 11 Balkan lynx presence in its current distribution area. The AOO_{min} (orange polygons) taken from the C1 + C2 data from Macedonia and Albania and AOO_{max} taken from C 1, 2 and 3 data for Macedonia and Albania later than year 2000; C3 data for Montenegro and Kosovo taken from the recent literature and the MGR_{max} as an adjusted polygon. EOO_{min} is presented with orange polygon line, while EOO_{max} has brown polygon line.

3.2.3 Estimation of the population density and size

Estimation of the population size of the Balkan lynx was completed with the help from the results of the systematic camera-trapping session compiled in Mavrovo National Park in 2010. As the investigated area of the session was extended towards the south (Stogovo-Karaorman and Jablanica region), I only used the results for the Mavrovo NP territory, and compared them with the previous findings. Population density was calculated at **0.80 ± 0.31 individuals** per 100 km^2 (Stojanov *et al.*, 2010). Taking into account the standard deviation from the 2010 session (± 0.31 individuals per 100 km^2), the minimum population density is 0.49, while the maximum is 1.11 individuals per 100 km^2.

Pessimistic scenario: I have taken the **AOO_{min}** and:

The lowest value of the population size: $\frac{4007*0.49}{100}$ = 20 individuals.

The mean value of the population size: $\frac{4007*0.80}{100}$ = 32 individuals.

The highest value of the population size: $\frac{4007*1.11}{100}$ = 44 individuals.

Optimistic scenario: I have taken the **AOO_{max}** and:

The lowest value of the population size: $\frac{19886*0.49}{100}$ = 97 individuals.

The mean value of the population size: $\frac{19886*0.80}{100}$ = 159 individuals.

The highest value of the population size: $\frac{19886*1.11}{100}$ = 220 individuals.

3.3 Assessment of the conservation status

3.3.1 IUCN Red List Assessment

The results from the Baseline Survey, camera-trapping findings, threats, as well as the expert opinion on presence, distribution, population number and trend (von Arx *et al*., 2004) were used to perform a regional Red List assessment according to the IUCN guidelines. According to this analysis (Appendix V) the status of the Balkan lynx is **Critically Endangered** - **CR (C2a(i,ii)D)**. The acronyms in the brackets stand for more detailed explanation of the cause that the taxon is being listed in one of the threatened categories, i.e. the criteria used to determine its threatened category affiliation. In our case, the main cause that the Balkan lynx is considered critically endangered is the **C** – 'small population size and decline', or more specifically **C2** – 'a continuing decline' in **a(i)** – 'number of mature individuals in each subpopulation' is less than 50 and/or **a(ii)** – '90 to 100% of the individuals are in one subpopulation'. Finally, **D** represents a 'very small and restricted population' (Appendix V).

3.3.2 Population size and trend

The pessimistic scenario for the population size of the Balkan lynx ranges between 20 and 44 individuals if minimal extent of the AOO is considered. The optimistic one ranges between 97 and 220 individuals taken the maximal extent of the AOO.

According to the Baseline Survey, the population trend of the Balkan lynx is strongly decreasing. In Macedonia, no evidence from the Baseline Survey is pointing out an increase of the population trend in any regard (strong or weak). Only 2 grid cells are representing strong evidence for stable trend and 3 are with weak evidence for stable trend respectively. In 42 grid cells, people reported a general decline of the Balkan lynx. Strong evidence for a decline is reported in 32 grid cells while weak evidence in 10. In the rest of the 26 grid cells, the population trend could not be assessed (Fig. 7). 11 of those cells represent cells with a good lynx presence (where more than 50% of the people answered positively on lynx presence) which indicates inconsistency in peoples' opinion. In Albania the population trend could be assessed in only 9 grid cells, all of which indicating good lynx presence (see the distribution part above). In one cell there is a strong evidence for population decrease, six grid cells are with a stable assessment, among which two agree strongly and four weakly. In two grid cells there is a weak evidence for increase in the population trend. Both of these grid cells come from the North-Alps region (Fig. 7).

3.3.3 Threats

Threats to the Balkan lynx existence were assessed considering the Baseline Survey data, the recent literature and personal experience of the environment where the Balkan lynx were living during the 2006-2011 research.

Direct persecution poses a threat towards the survival of the Balkan lynx. All known losses to the Balkan lynx population according to the Baseline Survey questionnaire, the 'Chance observations' and the 'Hard fact' findings, are listed in the Appendix IV.

Figures 12, 13 and 14 illustrate the presence and trend of the lynx' prey as revealed from the Baseline Survey.

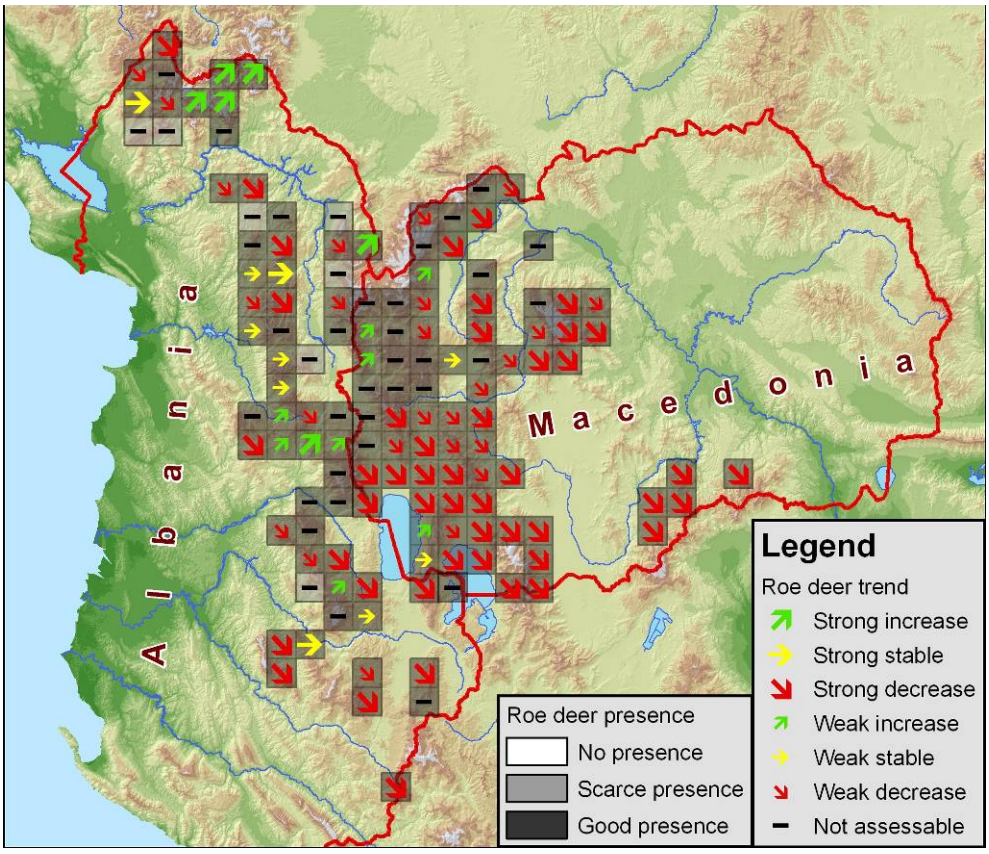


Fig. 12 Roe deer presence and trend in Albania and Macedonia.

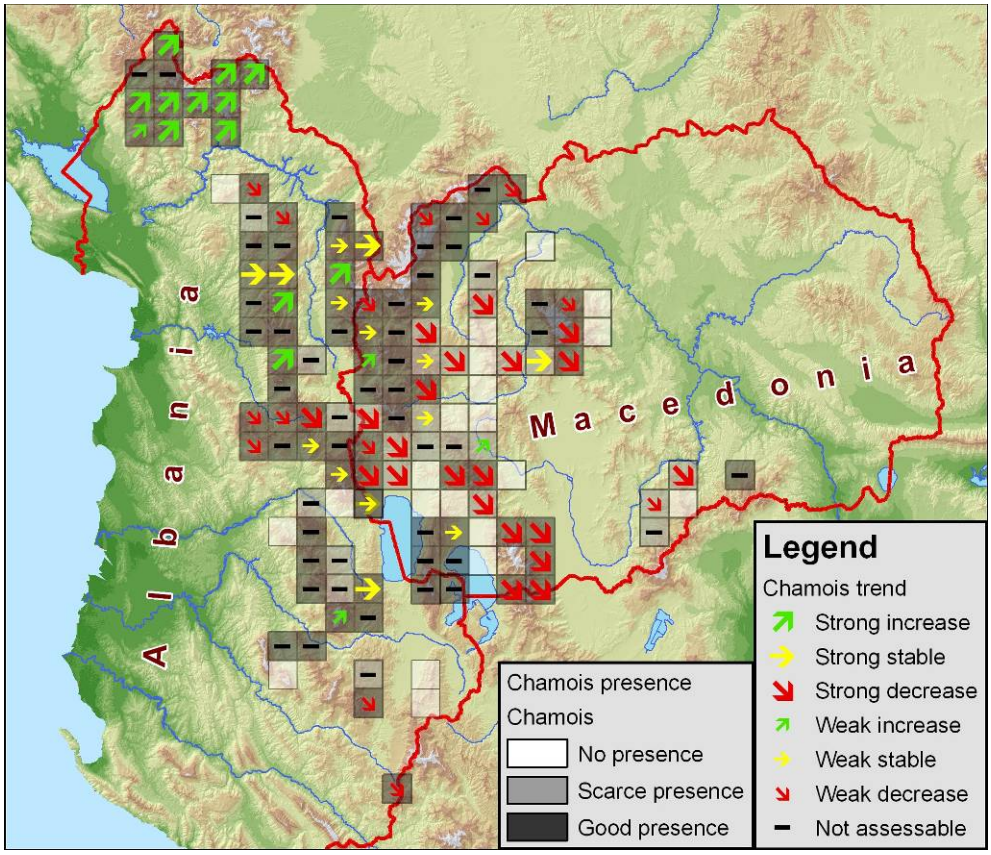


Fig. 13 Chamois presence and trend in Albania and Macedonia.

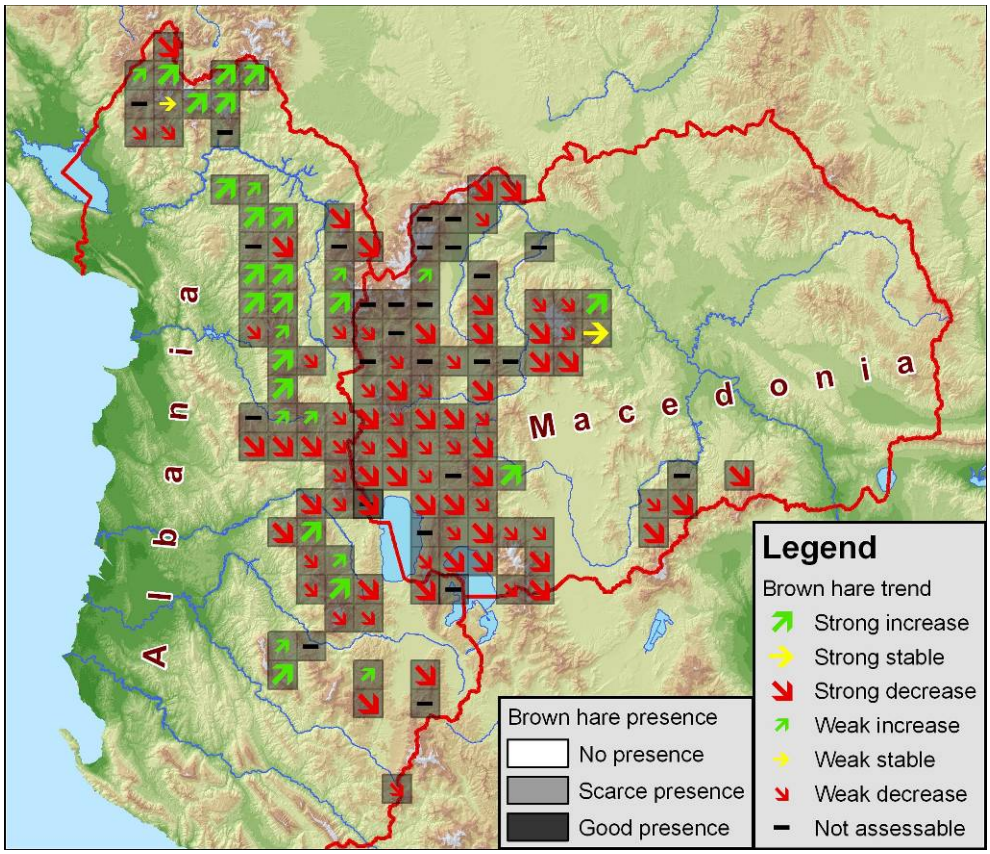
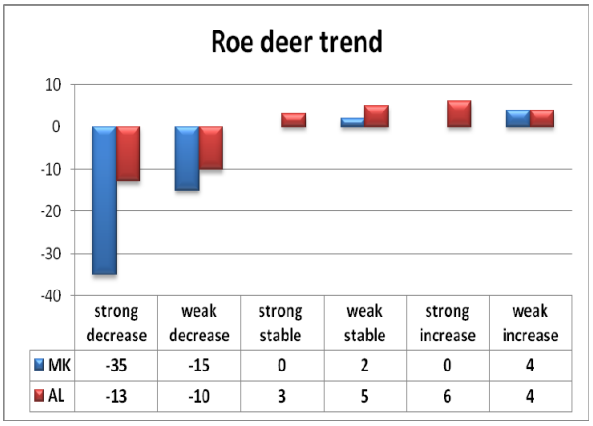
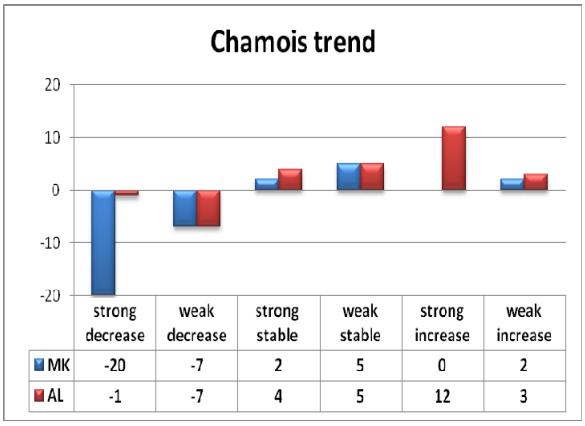


Fig. 14 Brown hare presence and trend in Albania and Macedonia.

According to the questionnaire, brown hare and roe deer are widespread in Macedonia and Albania. From the total of 136 grid cells in both countries, only 7 grid cells indicate scarce presence. There are apparently more chamois in Albania than Macedonia. In Albania, in 50 out of 63 grid cells locals indicated good presence of chamois, whereas in Macedonia 39 out of 73 grid cells show good presence. All together, there are only 21 grid cells where no presence of chamois is found. This indicates that the distribution and presence of the assumed important prey species are still good, but the population trend is pointing towards a long term decline. Figure 15 reveals great decline in the roe deer population in the whole territory of Macedonia and Albania, except for the North-Alps region. Chamois population trend was difficult to assess for the local people, hence in most of the grid cells in both countries the trend was not assessable. In Macedonia however, the grid cells in which the trend could be assessed show decreasing trend in the last 5 years when the questionnaire was completed. The only region in which the chamois population still seems to thrive is the North-Alps region in Albania (Fig. 13). Brown hare population trend in Macedonia is similar to the one for the roe deer – strongly decreasing. In Albania, the opinion is regionally divided. While in the North-Alps and Central-North regions people think that the brown hare population is increasing, in the Central and Central-South regions the situation was judged opposite. A stable trend is very rarely reported (especially in Macedonia) by the informants, thus the number of the grid cells showing stable population trend are negligible (Fig 15).





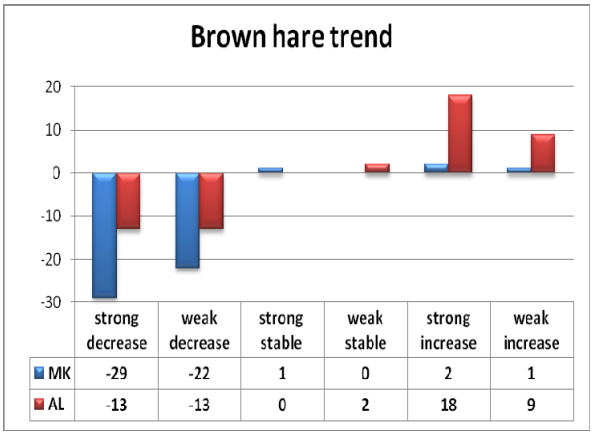


Fig. 15 Trend charts for Balkan lynx prey animals. Blue columns represent data from Macedonia, while the Albanian data are given in the red columns. Numbers in the table are showing the number of grid cells within a certain country. Negative numbers present the number of cells with negative/decreasing trend. There are total of 39 grid cells where the roe deer trend could not be assessed in both countries; 68 grid cells where chamois could not be assessed and 26 for brown hare.

Threats towards the Balkan lynx taken from the literature are presented in Table 6 (von Arx *et al*. 2004).

Table 6. Threats to the Balkan lynx population. ← arrow indicates threats relevant for the past; ↔ stands for a present threats; → shows threats that might inflict the Balkan population in the future. The combination of arrows represents combination of periods for a certain threat: future, past or present. Bold arrows are the most important threat factors for the survival of the Balkan population in a given country. The question marks states a lack of knowledge for a given threat in a given country. Whether the competition from other carnivores living in the area – wolf and fox for instance are a real threat to the Balkan lynx, is yet to be discovered. Without any ground knowledge, we can only assume that the particular threat affects the Balkan lynx population. Derived from von Arx *et al*. (2004).

	Threats	Macedonia	Albania	South Serbia & Kosovo	Montenegro
1.	Poaching	**← ↔**	**← ↔**	**← ↔**	← ↔
2.	Prey/food base reduction	**↔**	**↔**	**↔**	**↔**
3.	Habitat degradation	↔	**↔ →**	**↔**	↔
4.	Fragmentation	↔ →	↔ →	↔ →	↔ →
5.	Trapping/snaring	←		←	↔
6.	Restricted range	↔ →	↔ →	**↔ →**	**↔ →**
7.	Limited dispersal		**↔ →**	**↔ →**	**↔ →**
8.	Low densities		**↔**	**↔**	**↔**
9.	Population fluctuation			← ↔ →	← ↔ →
10.	Agriculture		↔		
11.	Tourism/recreation	↔ →	↔ →	↔ →	↔ →
12.	Vehicle and train collision	↔ →	↔ →	↔ →	↔ →
13.	Competition	?	?	?	?
14.	War/civil unrest	←	←	←	

The order of these threats follows the importance of certain threats according to the literature. The first four threats in the Table 6 (poaching, prey reduction, habitat degradation and fragmentation) are mentioned in every article in the target country reports in von Arx *et al*. (2004). Poaching of the Balkan lynx as a direct and unsustainable hunting of its prey as an indirect threat is certainly posing a great risk for the population (Fig. 16). In addition, trapping and poisoning are factors for the direct persecution of the lynx (Grubač, 2000; 2002). Habitat degradation is an obvious problem in Albania. The large areas of forest that were destroyed in the 1990s have not yet had time to regenerate. Most of the beech and fir forests consist of young trees, while the treeless hills and ravines are affected by heavy erosion (Fig. 17). The population of the Balkan lynx is also strongly fragmented, which, according to von Arx *et al*., (2004), is distributed over an area of ca. 5000 km^2 and split into eight patches. The River Drim forms a border between the Dinarides (North-Alps region and the mountains in Montenegro) and Scardo-Pindic mountain range (the rest of the investigated

regions), separating the lynx subpopulations. Considering the findings of this research, it will be challenging to connect the possible individuals from the north (Montenegro, north Albania) with the core population in Mavrovo area (Fig. 11). Nidze-Kozhuf region is also considered a fragmented part of the main core area, divided by populated plains with farmland (Fig. 7 and Fig. 11). Intrinsic factors such as restricted range, limited dispersal and low density are an obvious threat to the survival of the Balkan lynx given the small distribution range and the reduced population size.

Fig. 16. Poaching still poses the biggest threat to Balkan lynx. Although strictly protected in both countries, pelts from the Balkan lynx (killed on Stogovo-Karaorman region – Tab. 4) can be found in public restaurants in Skopje (left), while hides (killed on Suva-Gora Cheloica region – Tab. 4) are sometimes exposed to illegal exports in the neighbouring countries (right).

Fig. 17. Degraded habitat inflicted with erosion in Shebenik Mt., Central region (region III in Fig. 2), Albania. Such landscapes can very often be seen in the countryside.

4. Discussion

4.1 Literature reviews and historic decline of the Balkan lynx population

Reviews and written data on the Balkan lynx presence have existed for more than a century. Whether as a notes on sightings, hunting reports, monographs on Balkan lynx population size and distribution, or reviews on its status, these published data represent a substantial portion of the historical facts on the Balkan lynx survival and extinction (Appendix II). However, all of this written information is based on expert opinion or published chance observations. None of the experts in the area has ever done any systematic field inquiries following certain methodology, and no scientifically robust methods to estimate densities were completed. Generally lynx (and other wide-ranging carnivore) densities were overestimated. The assumed densities up to the publications of Mirić (1981) were considerably overestimated. Only when the first home-range size and density estimations based on radio telemetry became available in the late 1980s, experts started to calibrate their opinions based on reliable information. True research on Balkan lynx' biology and ecology has been applied for the first time with the beginning of the projects 'Balkan Lynx Recovery Programme' and 'Status, ecology and land-tenure system of the critically endangered Balkan lynx in Macedonia and Albania', when reliable methods such as radio telemetry and camera trapping were used. I assume that the reduction of the range is more or less correctly presented in the literature and that the temporal recovery after the Second World War as a consequence of legal protection (Mirić 1981) is also fact, that however the population size was overestimated and most likely more prominently in the early literature than in publications after 1990.

4.2 Present status of the Balkan lynx based on the LEK

For the first time a systematic field-based collection of information on the Balkan lynx and its potential prey species has been carried out, covering an area from central, northern and eastern Albania to western and central Macedonia (Ivanov *et al.*, 2008). The Baseline Survey has revealed many important data on the distribution, trend and abundance of the Balkan lynx, with considerable data coming directly from the local people living in its distribution range. The abundance, trend and presence of its main prey, and the conflicts between the people and the large carnivores, helped us to see what the main obstacles, strengths and opportunities to the survival of the Balkan lynx population are. So far, the Baseline Survey study has been completed in Macedonia and Albania. Further studies are now needed in Montenegro and Kosovo to fill the gaps in baseline data and to utilise the existing knowledge. Expert opinion and sporadic interviews accomplished so far in these countries are neither up-to-date nor sufficient to confirm the presence of the Balkan lynx today and there is a need to start more scientific-based methods like the camera-trapping and radio-telemetry. Furthermore, the basic information on the lynx and its prey are a considerable contribution for the development of the Regional Conservation Strategy (Ivanov *et al.*, 2008).

The results from the Baseline Survey on the presence of the Balkan lynx in Macedonia confirmed conclusions/assumptions from earlier expert assessments. Indeed, the situation of the Balkan lynx is even worse than the last expert estimate of 80 to 105 individuals distributed on

approximately 6700 km^2 (von Arx *et al*., 2004). The results in this thesis are suggesting a realistic estimate of 20 to 44 individuals taking the minimal extent of the Area of Occupancy and a population density of 0.8 adult individuals per 100 km^2. As much as one may think of the pessimistic scenario being too pessimistic, the population density taken directly from the Mavrovo NP as core area for the Balkan lynx distribution puts forward even more pessimism in the calculations. The reason for choosing the results of the 2010 camera-trapping session over the one conducted in 2008 for the calculation of the population size is the fact that the 2010 data are newer and the confidence interval in the 2010 session (± 0.31 individuals per 100 km^2) is higher. Thus, the lower numbers required taking the negative value for the population size would be more reliable for the regions where the living environment and other quality conditions are not as good as in Mavrovo NP. Mavrovo NP within the Mavrovo-Bistra region (region 5 in Fig. 2) can be considered as core area of the Balkan lynx population with highest reported presence. Favourable conditions that this protected area is offering in terms of relatively large areas of suitable habitats, abundant prey base and ground protection allowed the lynx to survive during the past three centuries of harsh persecution. The other two national parks in Macedonia (Pelister and Galichica) did not indicate a constant presence of the Balkan lynx. Even if there might be a certain number of individuals there, a good connection must be established to the Mavrovo area in order to ensure exchange of individuals and spread of the population. The Ilinska-Plakenska Mts. (region 9 in Fig. 2) are serving as a very important bio-corridor connecting the three existing national parks in Macedonia (Schwaderer *et al*., 2008) (Fig. 3). Shar Planina region (2) is another possible direction of north – north-east dispersal of the Balkan lynx towards Kosovo. Eastwards, the mountains connected to the Suva Gora-Cheloica (7) and Jakupica (6) regions are also possible area for the Balkan lynx existence in Macedonia. In Albania on the other hand, the results revealed a very fragmented distribution of lynx. More research is needed (e.g. camera-trapping studies) to find out whether there are still reproducing individuals present, rather than simply dispersing individuals (Fig. 18).

Fig. 18 New hope. The first camera-trapping photo of a wild lynx in Munella Mt., Central-North region in Albania (region II in Fig. 2). Whether it is a dispersing or a resident individual, we are still not sure. More data (coming this winter) are needed from this area to confirm its origin.

Comparing the population density gained with the camera-trapping studies in Mavrovo NP with the reintroduced lynx population in the Swiss Jura Mountains, we conclude that the results are very similar: 0.7-0.8 adult resident lynx per 100 km^2 (Breitenmoser-Würsten *et al*., 2007). Similar density can also be found in the Dinaric population with an average of 0.8 individuals per 100 km^2 (von Arx *et al.*, 2004). In Sweden the density is even lower with 0.48 adult resident lynx per 100 km^2 (Liberg & Andrén, 2004).

An alarming negative trend of the Balkan lynx population was encountered with the Baseline Survey in Macedonia. In most of the grid cells in Albania the trend could not be assessed. In some cells, people's opinion differed greatly, and in others, they did not have any opinion, that may indicate the extinction of the species in these parts. These results may reflect the real situation considering the rapid increase of lynx poaching reported in the past 15 years (Ivanov *et al.*, 2008). Illegal hunting of the ungulates in both countries is another factor limiting the lynx dispersal outside the core area. Nevertheless, prey presence according to the Baseline Survey is still very optimistic, what was not confirmed by the field signs of prey species compiled during the subsequent field work in the frame of the BLRP. Therefore, further field investigation is needed to confirm the real situation of potential lynx prey.

The collected hard facts are a proof that the Balkan lynx still exists in the survey area and that it is successfully reproducing. However, there was widespread evidence of illegal killing of lynx in both countries; though while conducting the interviews few people (53 out of 873 (6%)) reported direct or indirect knowledge of killed lynx. This can be interpreted either as a true statement, or as fear of prosecution because of the legal protection given to the Balkan lynx is. Additionally, some of the statements for killed lynx could refer to a single/the same case more than one time. Taking the three periods for known cases of poached lynx into account in Macedonia? (before 1990, between 1990 and 2000 and after 2000), there are 32 cases of poached lynx after 2000, 5 cases between 1990 and 2000, 6 cases are older than 1990. In Albania for 9 cases the poaching took place more than 5 years ago but one cannot be certain whether it was before 1990 or between 1990 and 2000. The fact that most of the poached lynx took place after 2000 can be related to some or all of the following: the difficulty for people to recall older cases; interviewing a relatively young generation where most of their activities (legal and illegal) took place in the more recent period (e.g. after 2000); and the law enforcement in the past was more efficient and the people respected the laws. Poaching together with habitat degradation, depletion of prey base and fragmentation of the habitat are the most prominent threats to the survival of the Balkan lynx. Mitigating the main threats is a must in the coming years. Poaching is perhaps still a valid reason for the disappearance of the lynx from the other territories in the Balkans (Mirić, 1981). A lot has to be done in education and law-enforcement in order to deal with this threat.

The Baseline Survey was a milestone activity from where other monitoring methods like the camera-trapping and radio-telemetry, took off. It indicated that Mavrovo NP may host the only source population with evidence of breeding. All other confirmed lynx presence sites were within dispersal distance of sub-adult lynx. The camera-trapping results provided direct evidence to support estimates of the population size and density in Mavrovo NP, and the radio-telemetry study will reveal the land-tenure system, the social organization, prey spectrum and other important aspects for a

long-term conservation project. Without this knowledge, no conservation programme can safeguard the survival of any endangered taxon.

4.3 Taxonomic importance

It is believed that the Balkan lynx re-colonised the Balkan Peninsula after the last glacial period some 12000 years ago and settled in the forested area south of the Danube river (Fig. 6), whereas the Carpathian Mts. were already a forest refuge in that time, thus hosting the Carpathian lynx population throughout the ice age to present (Gugolz *et al.*, 2008; U. Breitenmoser pers. comm.). In recent history, the Balkan lynx population started to attract various zoologists because of its small size, limited range of distribution and its taxonomic status. First publications on the Balkan lynx, emphasizing its taxonomic uniqueness came as early as in 1940s, when it was for the first time acknowledged with subspecific status (Bureš, 1941). Mirić was a key figure in developing Bureš' ideas and defining the Balkan subspecies; supporting Bureš' 'guestimate' that the Balkan lynx should be granted its own subspecies status, but he changed the actual subspecies name (Mirić, 1978) (see Appendix III for a more detailed explanation). Many authors supported the idea that the Balkan lynx should be considered a distinct subspecies (Kratochvil, 1968b, Festetics, 1980), some of them however, did not (Hemmer, 1993) (Apendix III). Hemmer considered the Balkan lynx to be a cline (a group of specimens showing a gradual change of characters or features across its distribution range), suggesting a colonisation route from south to north and placing the Balkan, Carpathian and Scandinavian populations in one group. According to Hemmer (1993), the somewhat reduced body size of the Balkan lynx does not justify the sub-specific splitting of the Balkan lynx (*balcanicus* Bureš, 1941) from the Carpathian lynx. On the other hand, new molecular evidence has proved that the Balkan lynx is different from the neighbouring Carpathian population regarding its genetic profile, and is in fact more similar to the Northern-European population (Breitenmoser-Würsten & Obexer-Ruff, 2003; Gugolz *et al.*, 2008). However, the genetic differences so far described are not sufficient to justify the distinction of subspecies across Europe, and analyses using more markers will be needed (conclusions from the International Exploratory Workshop "Genetic status and conservation management of reintroduced and small autochthonous Eurasian lynx *Lynx lynx* populations in Europe", Saanen, Switzerland, 24–27 October 2011).

In terms of conservation, the question whether the Balkan lynx is a separate subspecies is finally not decisive. Evolutionary Significant Unit (ESU) is perhaps one way to describe this population - a population that is considered distinct for purposes of conservation (http://en.wikipedia.org). In order for a taxon to be operationally useful unit for evolutionary and ecological studies, it needs to be recognizable and identifiable as distinct entity (Riddle & Hafner 1999). Riddle & Hafner also argue that ecologists should use the term of ESU as a basic unit for analysis when evidence cannot support the geographical and evolutionary information by formally recognized species.

This thesis demonstrates that the Balkan lynx is an autochthonous metapopulation that must be considered as Critically Endangered according to the IUCN Red List Criteria, and it therefore deserves conservation attention with high priority. Urgent measures for its protection will become even more important as no large carnivore population in Europe was so far extinct under the operation of the Bern Convention (Breitenmoser-Würsten & Breitenmoser, 2001).

4.4 Implementation of conservation actions: challenges and opportunities

Actions to conserve the Balkan lynx are already underway. In 2006, one of the most detailed and systematic projects for conservation of the Balkan lynx begun in the region of south-western Balkans. Two countries (Macedonia and Albania) are involved so far, and the intentions are that two more (Kosovo and Montenegro) will join the efforts to conserve one of the most endangered large carnivore populations in Europe.

In June 2008 a regional workshop to develop a Conservation Strategy took place in Peshtani, Macedonia. Experts in the field, governmental organizations and interested groups from both Macedonia and Albania had a chance to contribute to the Strategy in order to meet the goal: to secure a viable population of the Balkan lynx living in a matrix of protected, sustainably managed habitats and multiple use landscapes in coexistence with the rural population. The Strategy needs to respect the biological and ecological knowledge gained by the experts in the field and also the socio-economical, political and administrative aspects. It sets out the general long term and range-wide goals (Breitenmoser *et al*. 2008). The Strategy was developed under the auspices of the Bern Convention and facilitated by the IUCN/SSC Cat Specialist Group, and it will hopefully act as an institutional prerequisite in taking any actions connected to the conservation of the Balkan lynx in the region. One of the Conservation Strategy's aims was to serve as a frame for more detailed National Actions Plans in the range countries which will serve as tools for the implementation of the Strategy.

Furthermore, a human dimension study took place as a part of the BLRP looking into the human attitude towards the large carnivores and knowledge about their ecology and biology. The study revealed that the attitudes of the rural public towards bear and lynx are much more positive than towards wolf in Albania, and that these attitudes should be taken into consideration when preparing conservation and management plans for large carnivores (Trajçe, 2010). In this regard however, Lescureux *et al*. (2011) showed that the general belief that the lynx was a charismatic and popular species was not entirely true for the people living in the rural areas of Mavrovo-Bistra and Shar Planina regions in north-west Macedonia. This ethno-ecological study confirmed that more educational activities should be tackled in the future, in order to acquaint the public not only with the critical status of the Balkan lynx, but also with its importance in the normal functioning of the natural ecosystems. The challenge for Balkan lynx conservation goes beyond its critical status for it is a species unknown to the public (Lescureux *et al*., 2011).

After assessing the conservation status of the Balkan lynx (this thesis) and considering human dimension findings from the previously mentioned studies, a successful conservation rationale for the last autochthonous lynx population in the Balkans can now be derived.

4.5 Comparison of trend with earlier findings

The disappearance of the lynx from most of the territories in the Balkans has started already in the 17th century during the Ottoman supremacy. By the end of the 19th and beginning of 20th century the lynx was still present in most of the countries in the Balkans but with reduced distribution and population size. In the beginning of the 20th century, it started to disappear from most of the northern and eastern countries, reducing its range to the border zone between Macedonia-Albania-Kosovo and Montenegro (Appendix II). According to Mirić (1981), the population after the Second World War started to increase and reach ~280 individuals in Macedonia, Albania,

Kosovo, Montenegro and Greece. Other authors too estimated the population size and density of the Balkan lynx giving various thoughts on the distribution trend. Grubač (2000) estimated a population of 12 to 18 individuals in Serbia (including Kosovo) with a negative tendency and 30-35 individuals in Macedonia with a stable to slightly decreasing trend. According to the same author, the trend in Montenegro cannot be assessed due to lack of knowledge. In Albania, the lynx has suffered a strong decline since 1950, with a loss of more than 60% of its population (Bego, 2002). The last research based on an expert studies (von Arx *et al.*, 2004) revealed a guestimate of 80 to 105 individuals in the entire range and a decreasing trend. Compared with this study, the population size may even be halted with again a decreasing trend (Fig. 7). It appears that the Balkan lynx has reached a second bottleneck after the one reached during the 1935-1940 when the population was estimated to be 15-20 individuals. With today's estimation of 20 to 44 individuals in the cautious scenario (see results) for the entire range, the Balkan lynx seems to approach the verge of extinction for the second time.

4.6 Assessment of the conservation status

The data obtained in this thesis helped to assess the status of the Balkan lynx. Giving the results obtained from the assessment, the situation of the small, autochthonous population of the Balkan lynx is alarming. Facing high extinction risk, the Balkan lynx is not far in joining the fate of the large carnivores throughout Central and Western Europe in the 18th and 19th century (Breitenmoser, 1998). We face a huge challenge for its recovery. Considering the IUCN Red List criteria, the next step will be to look into downlisting the Balkan lynx to a lesser category. According to IUCN (2008), a taxon may be moved from a higher to a lower threat-category if none of the criteria of the higher category has been met for five years or more. It is thus clear that in the near future efforts for negating the main threats (see the threats in the Results chapter) should be the foremost focus. Economic change in the countries of the Western Balkan has brought advantages and disadvantages in the field of the nature protection. Throughout the recent history, the countries of the Western Balkans have endeavoured enormous social and political changes. Civil unrest in Albania in 1997, NATO military intervention in 1999 (Grubač, 2000) and the ethnic conflicts in South Serbia, Kosovo and Western Macedonia, led to the acquisition and abuse of military equipment by the local people, thus depleting the population numbers of the carnivores and herbivores in the countries. This way they have brought the already weak Balkan lynx population to the verge of extinction. We can be almost certain of the fact that such a small and isolated population is facing inbreeding, and inbreeding depression is an additional threat. On the other hand, immigration of Carpathian lynx might threaten the genetic uniqueness of the Balkan lynx in the future. Grubač (2000) predicts possibility of connection from specimens coming from Bosnia and Herzegovina (Dinaric population) with the Balkan population in the territories of west and south (Kosovo) and south-east parts of Serbia (Carpathian population) (Fig. 5). This connection with the re-introduced Dinaric population can be expected in the territories of Montenegro as well. The new camera-trapping results of the lynx presence in the Bulgarian part of Osogovo Mt. (Zlatanova *et al*., 2009) and east Serbia (Paunović pers. comm.) could likely be the south spread of the Carpathian population which is now known to be distributed in east Serbia (Mirić and Paunović, 1992; Paunović, 1995; Grubač, 2000). These individuals can easily spread westwards along the mountains in north Macedonia and all the way to Shar Planina (Fig. 5). Invasion of Carpathian lynx could lead to hybridisation between the two assumed subspecies. This is however nothing to act against; if the Balkan lynx population is strong and healthy, it will withstand such invasion (as it has done for thousands of years), if not, introgression of Carpathian lynx genes might boost the population. Genetic research on the Balkan

lynx needs to be advanced, but so far, there is no indication that the population could not recover if the “classical” threats such as poaching, prey depletion and habitat destruction are mitigated.

Poaching is still number one threat to the survival of the lynx. From the total of 60 (57 of which we know the year) reported and verified killed lynx, 38 occurrences (67%) took place after 2000, while only 19 cases happened before this year. Although recent cases might have been detected (or remembered) better, we cannot conclude that the risk of poaching has diminished with the improved political and economic stability over the past 10 years. These findings indicate that awareness is low and law enforcement is still weak.

On one hand, economic development has neglected nature conservation activities, but on the other hand accession approaches to the European Union imply that all Balkan lynx countries should adhere to sustainable and nature-friendly development. Humans still present the major threat to the Balkan lynx.

5. Conclusions

The data gathered within the Balkan Lynx Recovery Programme helped us realize how serious the situation is regarding the survival of the Balkan lynx. The rather realistic scenario is indicating that there is a population of 20 to 44 individuals in the whole known range of the Balkan lynx. According to the IUCN Red List standards, this population should be granted a status of Critically Endangered. What adds to this pessimism is that the calculation was carried out using the average density from the Mavrovo National Park (0.8 individuals per 100km^2), where habitat quality, prey abundance and ground protection are on a satisfactory level. The Baseline Survey pinpointed where the next activities for protection should be focused on and what are the main threats to the survival of the Balkan lynx.

5.1 "Political" importance

The lynx is a strictly protected species by the Albanian Law for the protection of wild fauna (2008), Law on Hunting (2010) and by the Macedonian Law on Hunting (2009). In the Biodiversity Strategy and Action Plan of Albania (NEA, 1999) the lynx (*Lynx lynx*) is one of the priority mammal species for which a Species Action Plan is required within the next two years and implemented immediately after (Bego, 2002). According to the European legislation, the lynx is included in both the EU Habitats Directive (Annex II – animal and plant species of community interest whose conservation requires the designation of special areas for conservation), and the Bern Convention (Appendix III – protected fauna species). Its taxonomic and conservation status should be officially acknowledged as soon as possible in order to attract the political attention and to more easily raise funds for its recovery.

The Balkan lynx is of significant importance for the Macedonian people. It has been generally known as the "Macedonian lynx", referring to its "uniqueness" and naming it as a symbol of the wilderness. It is prominently pictured on the Macedonian 5-Denar coin and until 1994 was placed on the Macedonian post-stamp (Fig.19). Being as charismatic as it is, the Balkan lynx represents an umbrella species, since its conservation automatically puts other ecologically related species and habitats under the same "umbrella" of protection. However, the conservation of a large carnivore requires involvement of many different disciplines such as: wildlife ecology and management, landscape conservation and management, anthropology and sociology, law and politics and thus many different partners to cooperate with. Only with the cooperation of the (1) scientific community which will provide the knowledge needed for a long term conservation, (2) the governmental agencies providing legal and administrative frameworks and law enforcement, and (3) the NGOs, other interested stakeholders and above all the local people, we may be hoping to guarantee safe haven for the Balkan lynx.

Fig. 19 Macedonian five-Denar coin, valid from 1993 till present (left); Macedonian post-stamp valid until 1994 (right).

5.2 Recommendations for further conservation work

The principle of the Balkan Lynx Recovery Programme is to combine a species conservation project with a landscape conservation approach; hence to use the lynx both as an umbrella and flag-ship species to promote the conservation of natural and sustainably used landscapes, and in turn to secure the survival of the lynx through the establishment of protected areas and habitat corridors. There is a perfect overlap to the Green Belt Initiative covering mostly areas where the Balkan lynx still exists. Transboundary protection is inevitable taking into consideration the low density of the large carnivores and their home range on one hand and the generally small territories of the European countries on the other. Shar Planina-Gjalica Lumës; Jablanica-Shebenik and Prokletije Mt. (Albanian Alps), represent very significant part of the Balkan lynx range (Fig. 3) and are a true example of a pristine nature. Hence, the conservation of viable populations requires an international approach with common visions and goals. Furthermore, the human dimension component in the BLRP expanded the view of the lynx conservation onto a different perspective. The continuation of the BLRP project includes thorough public awareness campaigns and education, which is so far lacking in the Balkan lynx range countries.

Estimating the population size of the Balkan lynx is one of the more important parameters for its further conservation work. By knowing the size, the density, social aspects, land-tenure system, demography and the prey factor, detailed and solid actions concentrated on the specific problems can be outlined. The relatively new applied research project called “Status, ecology and land-tenure system of the critically endangered Balkan lynx in Macedonia and Albania” has already resulted with the first radio-tagged Balkan lynx individual. More individuals are needed for assessing other important ecological features.

An immediate need emerges to standardize the method applied in Macedonia and Albania with Kosovo and Montenegro in order to calibrate the data obtained with this research and conclude/officialise the conservation status of the Balkan lynx under the auspices of the Bern Convention.

Wildlife conservation is perhaps one of the most delicate and difficult jobs. Yet, working on it gives great pleasure of hopefulness and humanity!

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8. Appendices

APPENDIX I. Baseline Survey questionnaire

The following appendix presents the exact question form which was used during the filed inquiry within the Baseline Survey.

Village questionnaire – face to face.

Key informants (hunter, forest-worker / wood-cutter, game warden, shepherd, shop or café owner - plus at least 2 normal people).

Underline that this data is for scientific purposes and is not for government use.

Introduce yourself. Offer a card and if available information material. Explain the project. Explain the intention of the questionnaire.

Have a page with drawings of all animals on the list.

1. Distribution of species

We are interested in collecting information on the distribution of a range of species in Macedonia / Albania

			Roe deer	Red deer	Chamois	Wild boar	Hare	Capercaillie / grouse	Red fox	Jackal	Wolf	Stray dogs	Wild cat	Lynx	Bear	No data
1.1	Is it present in your area?	yes/no														
1.2	How common is it?	1-3														
1.3	Are there more now compared to 5 years ago?	+/=/-														
1.4	Have any been found dead?	personal/other person p/o														
1.5	When was the last one found dead?	time period														
1.6	Have any been killed?	personal/other person p/o														
1.7	When was the last one killed?	time period														
1.8	Have any been observed?	personal/other person p/o														
1.9	When was the last one observed?	time period														

1.10	Have any tracks been seen?	personal/other person p/o														
1.11	When were the last tracks seen?	time period														
1.12	Have you found any wild prey animals killed by this carnivore species? Which predator species do you think it was?	personal/other person p/o							xxxx xxxx x	xxxx xxxx x	xxxx xxxx x	xxxxxx xxxxxx xxx	xxxxxx xxxxxx xxx	xxxx xxxx x	xxxxxx xxxxxx xxx	
		predator														
1.13	When was the last wild prey kill of this carnivore found?	time period							xxxx xx	xxxx xx	xxxx xx	xxxxxx xxxx	xxxxxx xxxx	xxxx xx	xxxxxx xxxx	
1.14	Have you found a den?	personal/other person p/o	xxxx x	xxxx x	xxxx x	xxxxx	xxxx x	xxxxx								
1.15	When was the last den found?	time period	xxxx x	xxxx x	xxxx x	xxxxx	xxxx x	xxxxx								

> If person claims to have seen a lynx or any sign of a lynx (lynx alive, lynx killed, prey killed by lynx, tracks, sounds), use additional questions from handbook – or if somebody knows somebody else who has seen any sign of a lynx find that person.

p/o – p = personal, o = other person
1-3 - 1 = rare / 2 = common / 3 = abundant
+/=/- + increase / = stable / - decrease
check if they know difference between “wild cats” and “cats that are wild”.

Time period :

- < 6 months
- 6 - 12 months
- 1 - 5 years
- 5 - 15 years
- > 15 years

2. Conflicts

These questions reflect the general situation in the area of the village

Wild animals can sometimes cause problems for people. We are interested in collecting information on any conflicts that occur between the following species and people

	?		Lynx	Bear	Wolf	Jackal	Red fox	Wild cat	Stray dogs	Unknown species	Doesn't know
2.1	Do you know if any of the following domestic animals been killed in your area in the last 12 months?										
	2.1.1 - sheep	yes/no									
	2.1.2 - goats	yes/no									
	2.1.3 - pigs	yes/no									
	2.1.4 - cattle	yes/no									
	2.1.5 - dogs	yes/no									
	2.1.6 - chickens / ducks / geese	yes/no									
	2.1.7 - donkeys	yes/no									
	2.1.8 - horses	yes/no									
	2.1.9 - beehives	yes/no									
2.2	If YES in which seasons has the depredation	winter /spring /summer									

	occurred during the last 12 months	/autumn									
2.3 a	Have you heard of any people being attacked or killed during the last 5 years?	napadnato / ubieno									
2.3 b	If YES did the animal have rabies? (How do you know?)	yes/no									
2.4	Do you believe that these animals are potentially dangerous for your own safety?	yes/no									
2.5	Have you heard of anybody having damage during the last 12 months?	yes/no; What animal caused the damages?									
	2.5.1 - crops										
	2.5.2 - fruit trees										
	2.5.3 - vegetable gardens										
2.6	Are there more or less of the following livestock in your village now as compared to 5 years ago?	+/=/-									
	2.6.1 - sheep										
	2.6.2 - goats										
	2.6.3 - cattle										

3. Animal husbandry details

Do you have any domestic animals or beehives?

If YES

3.1	How many of the following animals do you have at present?	Number

	3.1.1 - sheep	
	3.1.2 - goats	
	3.1.3 - pigs	
	3.1.4 - cattle	
	3.1.5 - chickens	
	3.1.6 - donkeys / mules	
	3.1.7 - horses	
3.2	How many of the following domestic animals have you personally lost to depredation during the last 12 months?	number /predator /notes
	3.1.1 - sheep	
	3.1.2 - goats	
	3.1.3 - pigs	
	3.1.4 - cattle	
	3.1.5 - dogs	
	3.1.6 - chickens / ducks / geese	
	3.1.7 - donkeys / mules	
	3.1.8 - horses	
	3.1.9 - beehives	
3.3	Where did the depredation occur?	y/n / number / predator / notes
	3.2.1 - in the barn	

	3.2.2 - in a pen		
	3.2.3 - in the forest		
	3.2.4 - on a field		
	3.2.5 – on a mountain pasture		
3.4 a	Did you report the incidence?	yes/no	
3.4 b	If YES: to whom?		
3.4 c	If NO, why not?	Notes	
3.5 a	Was there a formal attestation?	yes/no	
3.5 b	If YES: by whom?		
3.6	Did you receive any compensation for the losses?	yes/no	
3.7	Do you pen the animals at night?		
	3.10.1 - in a pen	yes/no	
	3.10.2 - in a barn	yes/no	
	3.10.3 - leave them grazing freely at night	yes/no	
3.8	In daytime do the animals graze		
	3.11.1 - on a field	yes/no	
	3.11.2 - on a mountain pasture	yes/no	
	3.11.3 - in the forest	yes/no	
3.9	Does a shepherd stay with the animals by day?	yes/no	
3.10	How many livestock guarding dogs do you have?	Number	

3.11	How do you respond / prevent to carnivores that cause damage?		
	3.15.1 - move the livestock to a different area	yes/no	
	3.15.2 - intensify shepherding	yes/no	
	3.15.3 - poison	yes/no	
	3.15.4 - shoot them	yes/no	
	3.15.5 - organise a hunt	yes/no	
	3.15.6 - chase them away	yes/no	
	3.15.7 - other	yes/no	
3.12	If you are a transhumance shepherd – where do the flocks live during winter/summer?		
3.13	How many beehives do you keep?	Number	
3.14	How do you protect beehives?	yes/no	
	3.7.1 - fences		
	3.7.2 - log cabins		
	3.7.3 - stone cabins		
	3.7.4 - hanging from tree		
	3.7.5 - none		
3.15	How far from your house do you keep your beehives during summer?	Distance (m)	

4. Socio-economic environment

	Present	15 years ago
4.1 Is there a school in the village? (yes/no)		
4.2 Is it possible to buy gasoline in/near the village? (yes/no)		
4.3 How far away is the closest doctor? (km)		
4.4 What is the population of your village? (number)		
4.5 How many houses are occupied? (% of total number)		
4.6 Is there a bus service? (yes/no)		
4.7 a Is there a shop in the village?		
4.7 b Is there a cathering fscility in the village?		

5. Informant

5.1 Are you a permanent / seasonal resident?	
5.2 How long have you lived in this village?	
5.3 Your name?	
5.4 Occupation?	
5.5 Sex?	
5.6 Age?	
5.7 General impressions of informant (Notes)	

6. Village

6.1 Village name	
6.2 GPS location	
6.3 General impression of village *	

* e.g. % abandoned houses

Access – road for cars (4x4 only or not), road quality (asphalt or dirt), bus service etc.

Date:_____

APPENDIX II. Historical maps on Balkan lynx distribution

Historical maps on the Eurasian lynx distribution in Europe and particularly in the Balkans are presented in this Appendix. The maps are in chronological order as published. Some of the maps are visually corrected: re-drowned and highlighted in order to better interpret the data.

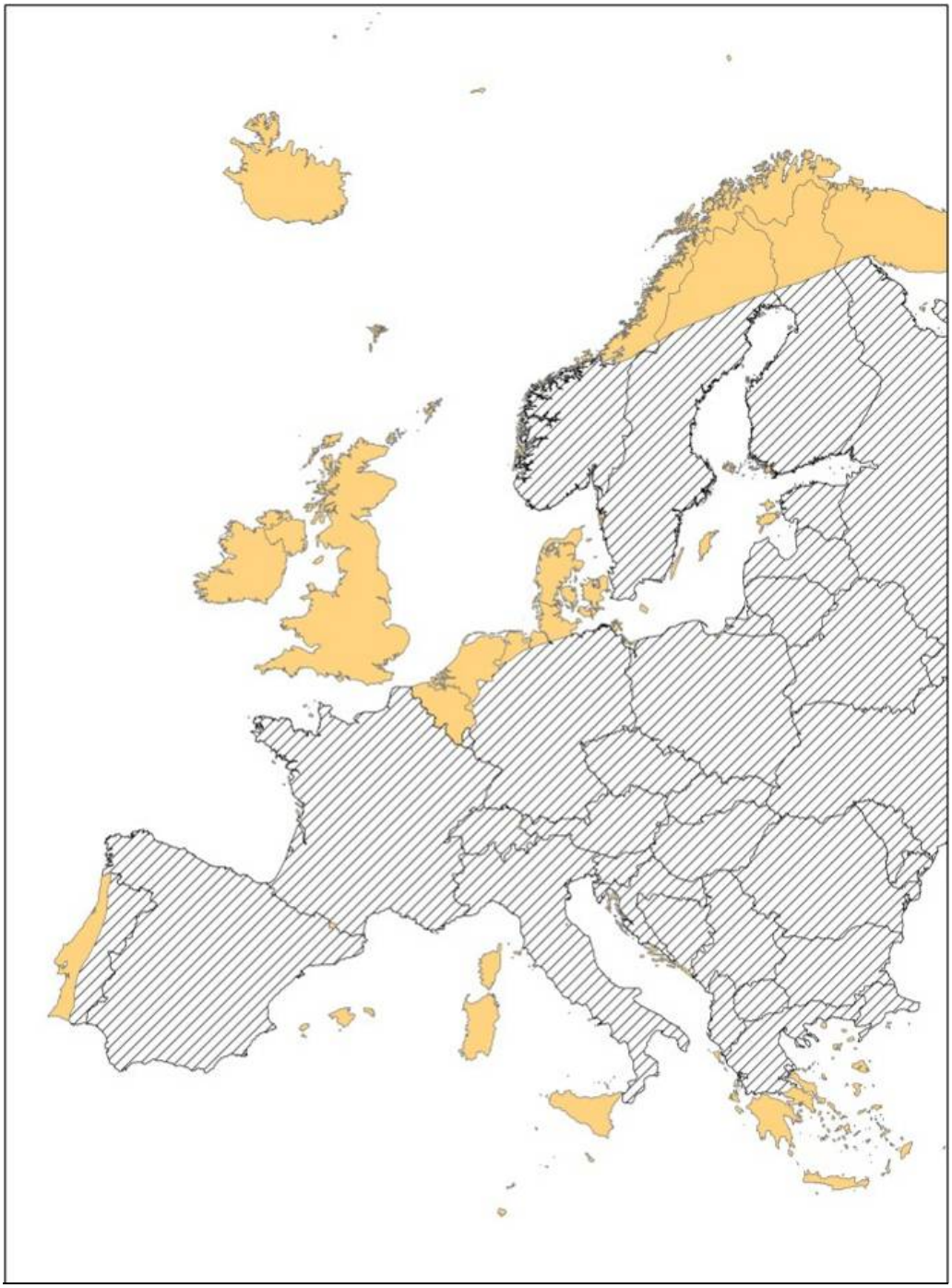


Fig. 20 Presumed prehistoric distribution (oblique stripped lines) of the lynx in Europe according to Kratochvil et al. (1968a).

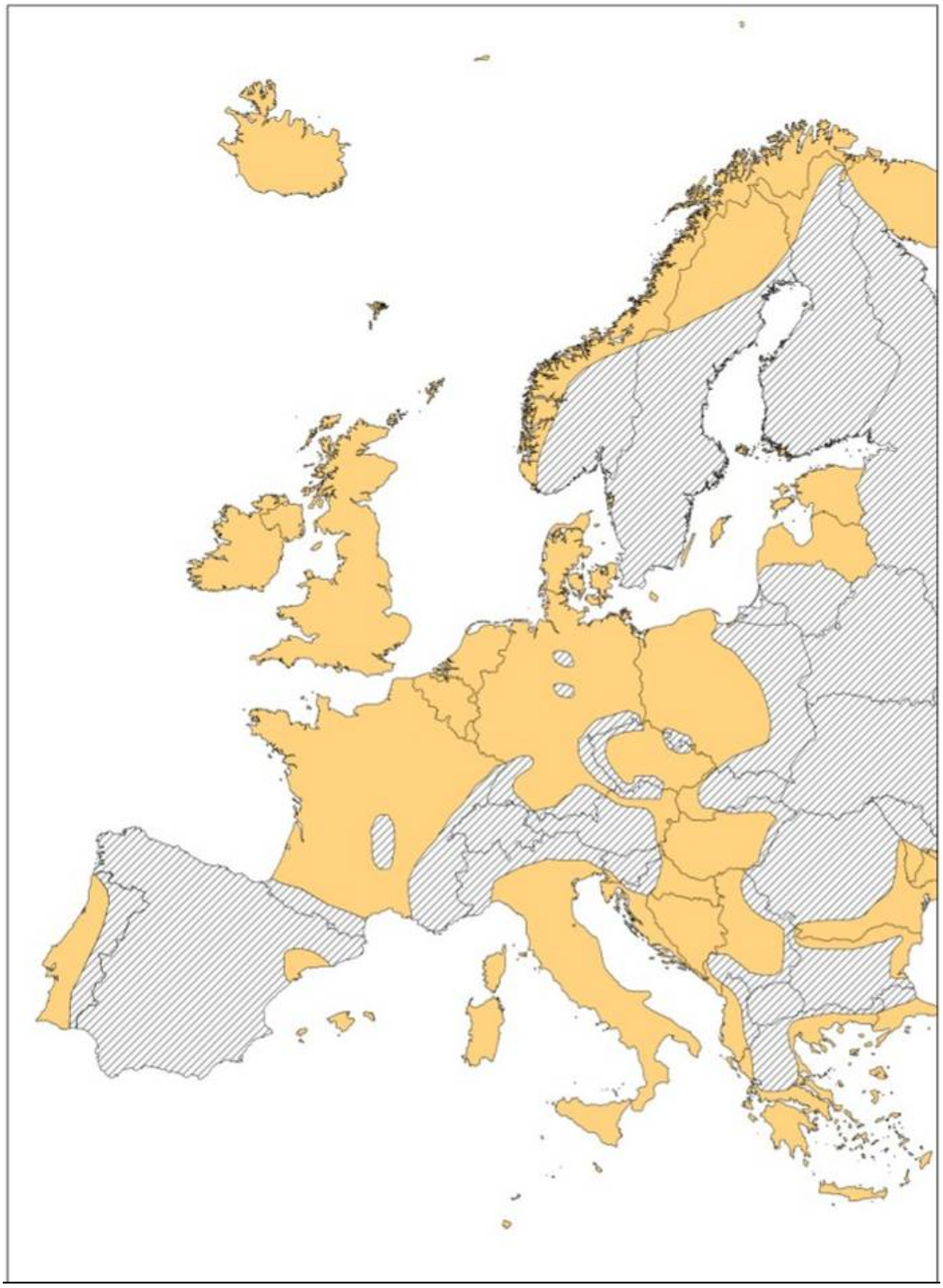


Fig. 21 Distribution of the lynx towards 1800 (oblique stripped lines) according to Kratochvil et al. (1968a).

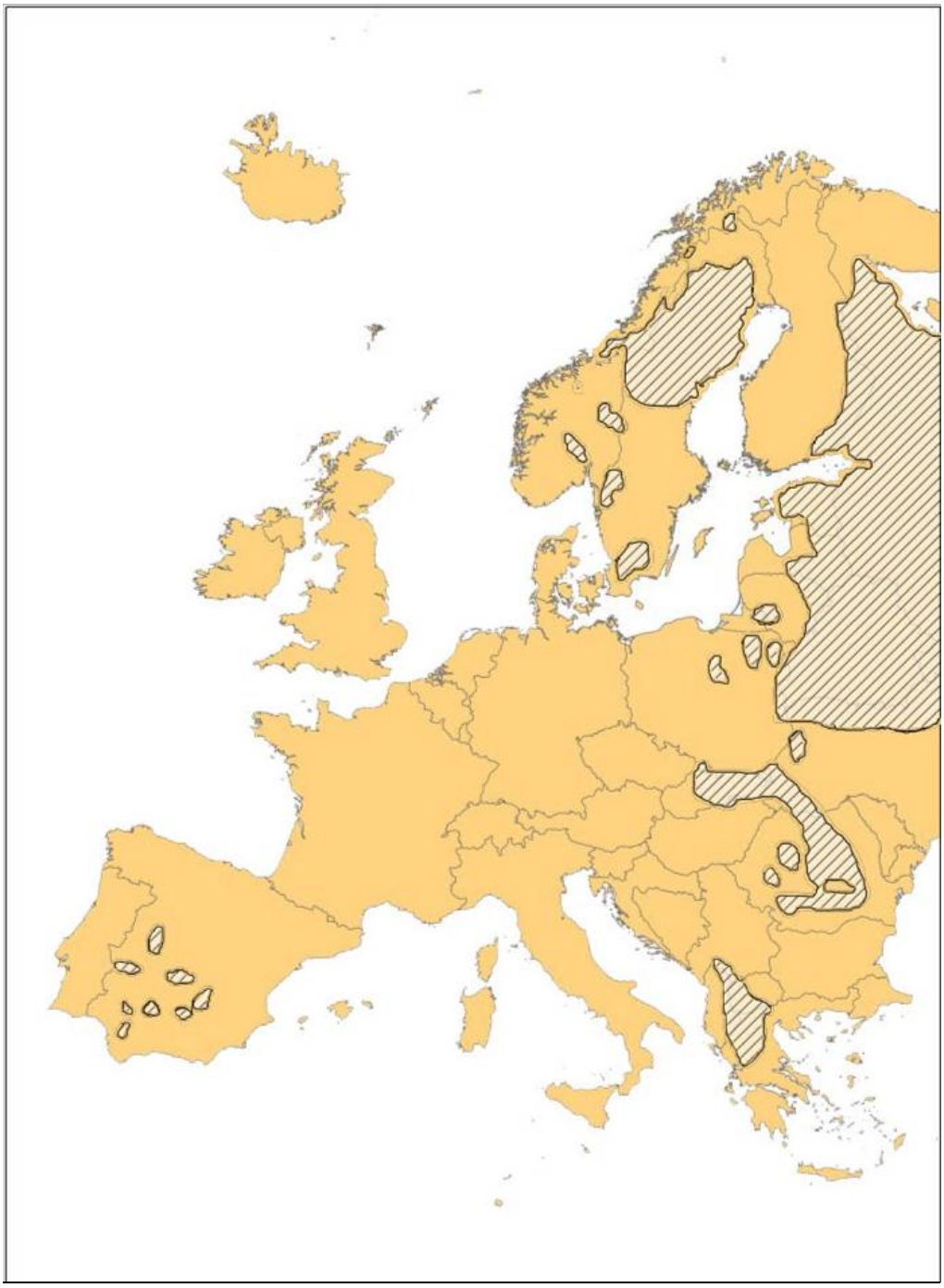


Fig. 22 Distribution of the lynx towards 1960 (oblique stripped lines) according to Kratochvil *et al*. (1968a).

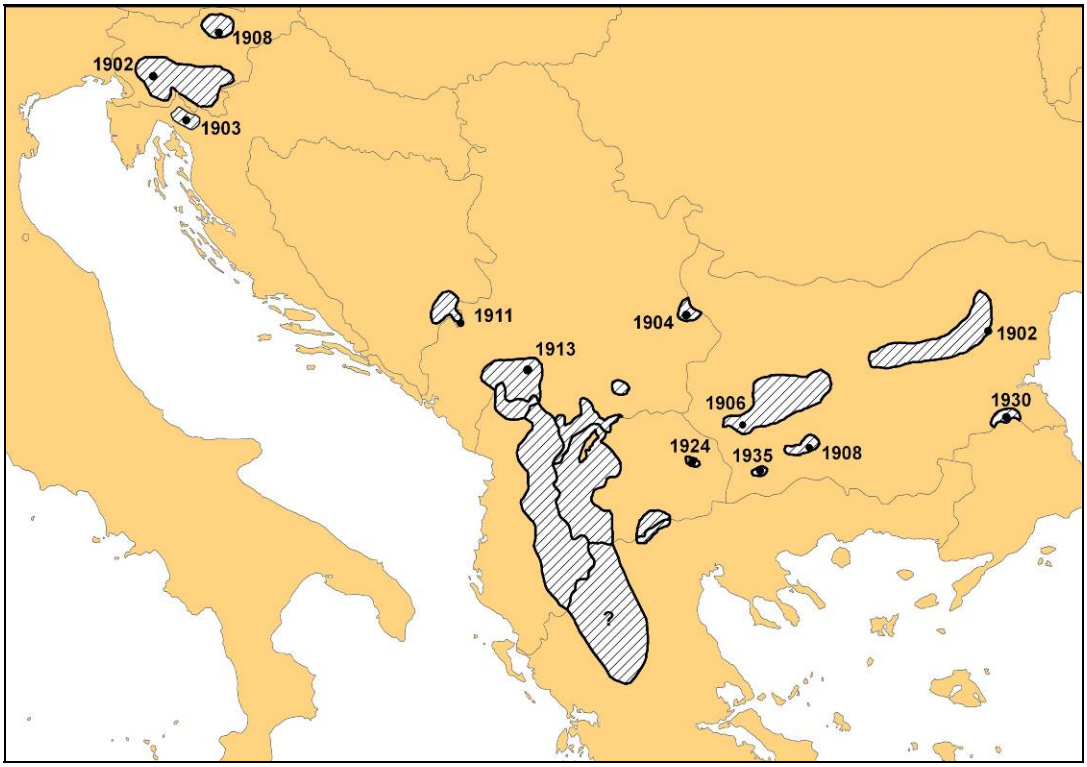


Fig. 23 Known distribution of the Balkan lynx at the end of the 19th and the first half of the 20th century (oblique stripped lines). Numbers indicate the extinction years for certain polygons. Question mark stands for uncertainties in the distribution pattern. The data for the map derived from Mirić (1981).

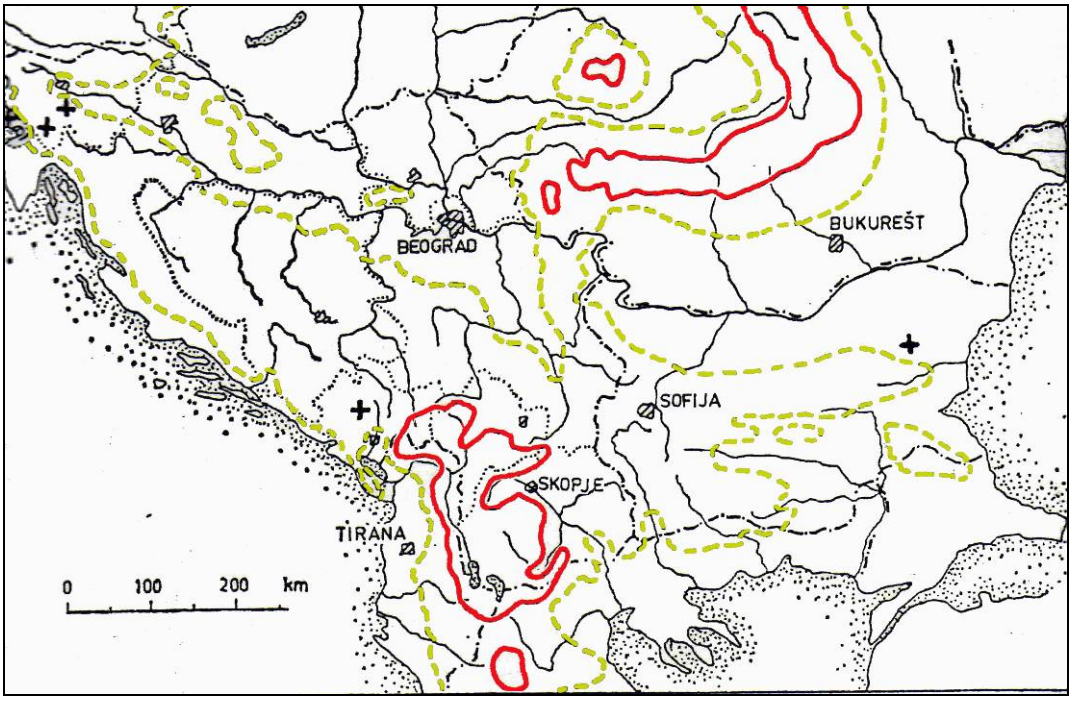


Fig. 24 Borders of the distribution range of the lynx (*L. lynx* L.) in the Balkan Peninsula and neighbouring regions at the end of the 18th century (dashed green-yellow line) and around 1974 (solid red line). Sub-fossil remains are represented with black crosses (Mirić, 1981).

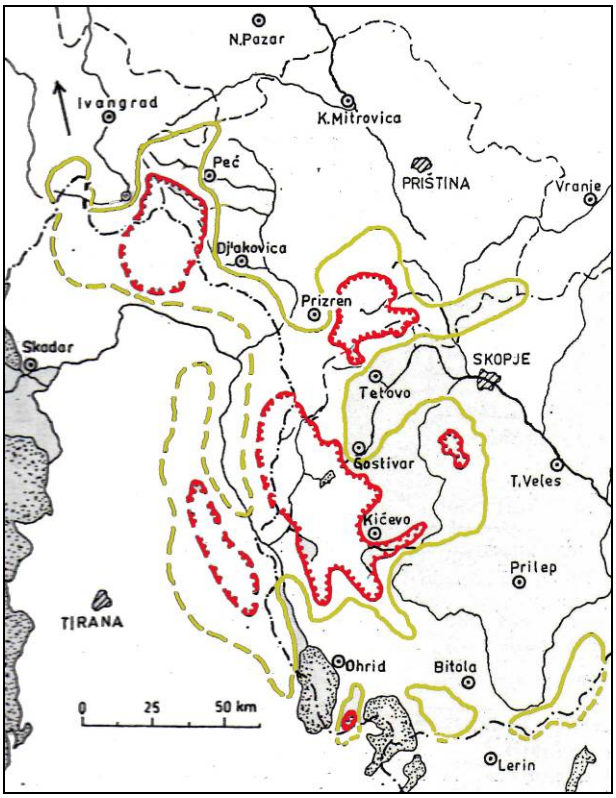


Fig. 25 Borders of the distribution range of the lynx (*L. lynx* L.) in the Balkan Peninsula around 1974 (Mirić, 1981). According to the author, red polygons are representing the density of 1 lynx in 6 to 20 km^2; inside the green-yellow solid lines 1 lynx can be found in 20 to 60 km^2; outside this borders, lynx was sporadically distributed. Dashed green-yellow line stands for assumed distribution range in Albania and Greece.

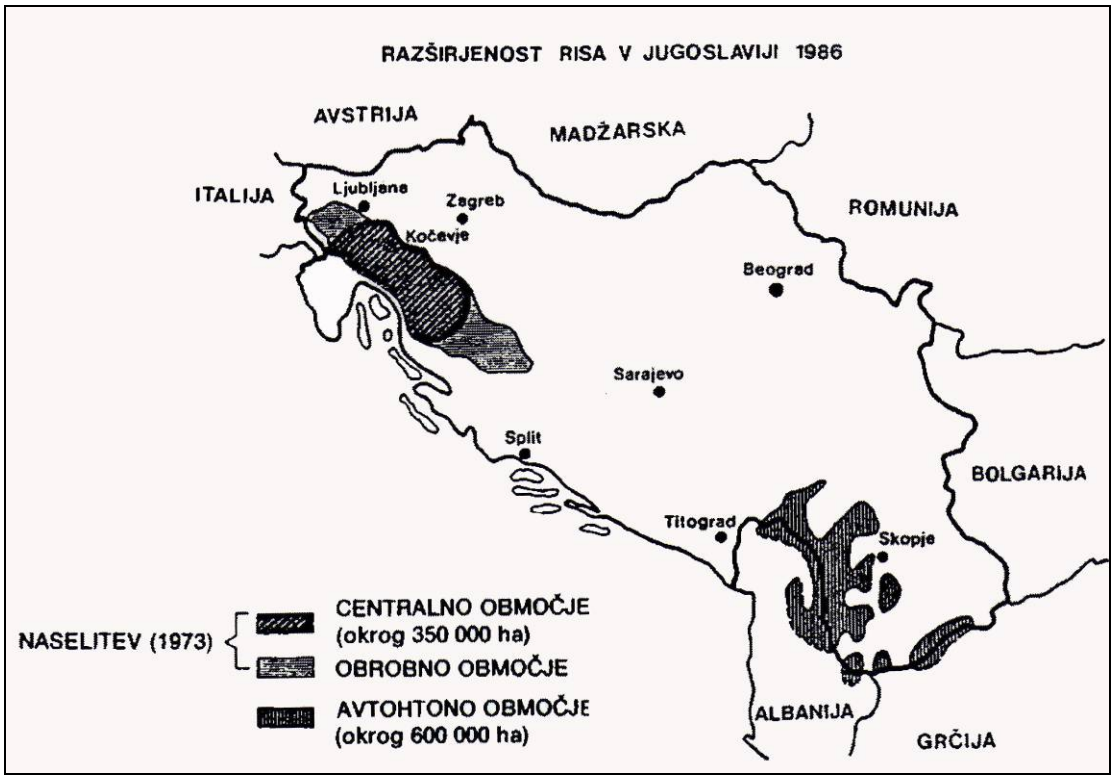


Fig. 26 Distribution of the lynx in former Yugoslavia in 1986 according to Čop (1988). The reintroduced population (Carpathian lynx) in the north is represented with two polygons: dark striped line indicating the central area (around 3500 km^2) and gray solid polygon indication the marginal zone. The autochthonous Balkan lynx population in the south is represented with gray vertical stripes. It is distributed on around 6000 km^2, including the area in Albania and Greece.

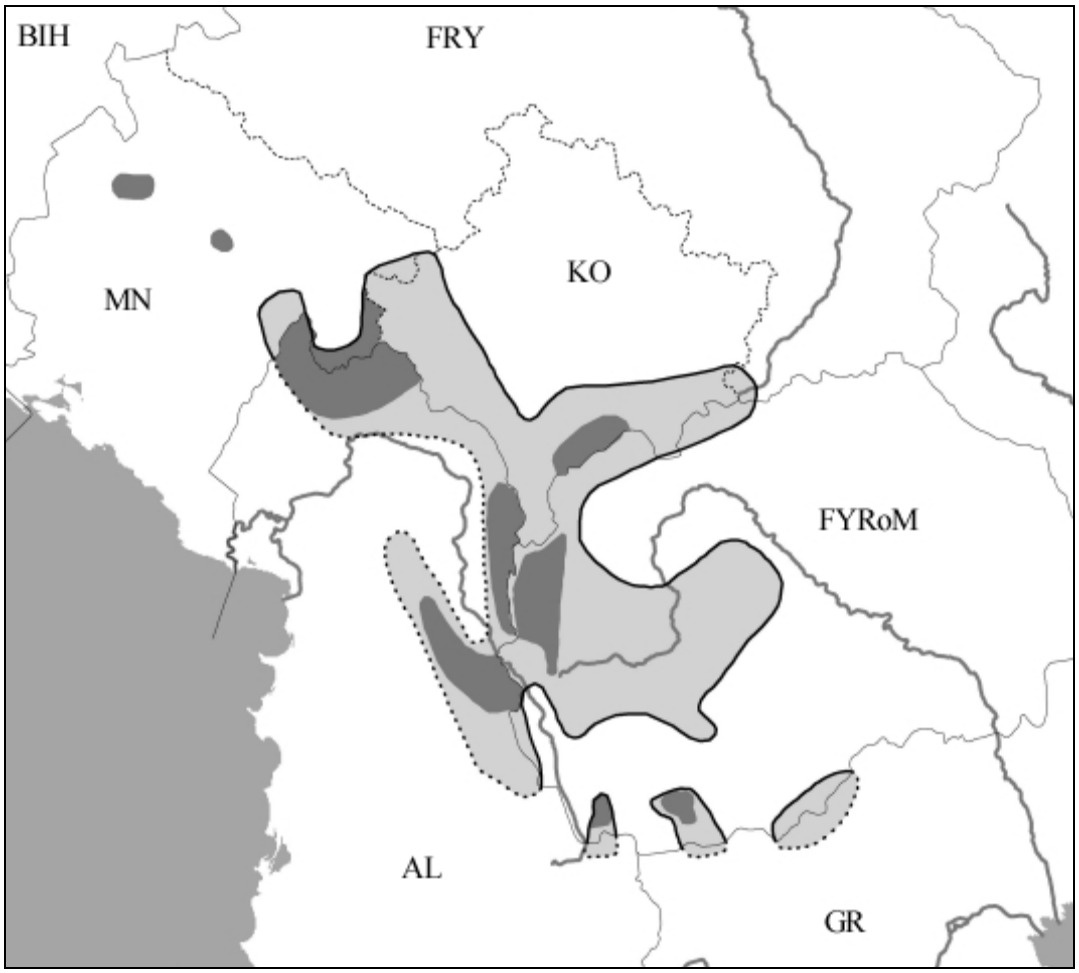


Fig. 27 Distribution of the Balkan lynx population in the 1970s (light grey shaded; after Mirić 1981) and today (dark grey shaded surface; compilation of the information from this report). Thin solid lines: international boundaries, thin dashed lines: national boundaries, thick solid lines: major rivers (Breitenmoser-Würsten & Breitenmoser, 2001).

APPENDIX III. Review of the taxonomy of the Balkan lynx

Taxonomy is nowadays a debated issue. Modern science is questioning the taxonomic outcomes and descriptions of species that begun in the 18th century with the binomial nomenclature proposed by Carl Linnaeus (1707-1778). Many species names have changed from those given by their original authors after new findings in their morphological or molecular characteristics or certain ecological features. Nevertheless, taxonomy goes beyond the species level into more detailed description of species' attributes. Many ranks like subspecies, tribe, section, series, variety and form are used to describe the vast diversity of plants. However, according to the International Code of Zoological Nomenclature-ICZN (www.iczn.org/code), subspecies is the only accepted rank below the level of species.

The Eurasian lynx (*Lynx lynx,* Linnaeus 1758) is one of the four lynx species in the world. From the Atlantic in the west to the Pacific Ocean in the east, the Eurasian lynx has one of the largest distribution ranges in the cat family. Modern taxonomy now recognizes nine subspecies of the Eurasian lynx (von Arx et al., 2004). Three of them are distributed in Europe.

The Balkan lynx was first named as a subspecies by the Bulgarian zoologist Ivan Bureš (1886-1980) in 1940's as *Lynx lynx balcanicus* (Bureš, 1941). In that time there was a general lack of knowledge on the taxonomy of the cat family and as explained by Bureš, many Bulgarian scientists considered the lynx living in the Balkans as an enclave of the Iberian lynx (*Lynx pardina*), (Hristovich 1893; Velev 1901; Ned'alkov 1901; Kovachev 1925; Petkov 1929). In fact Bureš paper stressed that the lynx from the Balkans belonged to the Eurasian lynx and not to the Iberian. As a second priority, Bureš suggests that the Balkan lynx should be considered a subspecies, based on the coloration of the skin and skull morphological measurements taken by Popov (1933). Even though it was not described in a proper taxonomic way, Bureš was the first one to emphasis the subspecies determination of the lynx on the Balkans. According to Kratochvil *et al*. (1968a), biometric and craniometrical data are missing in the work of Bureš, but even so, he accepted Bureš's proposal and confirmed the status of the Balkan lynx as a subspecies.

One decade later, the Serbian mammalogist Gjorge Mirić (1919-1994) gave a much more detailed description of the Balkan lynx and confirmed its taxonomic status, (Mirić, 1978; 1981). In his papers, Mirić compares different skull measurements and coloration of the skin between the Balkan, Carpathian, Scandinavian and lynx from the Caucasus. Skull measurements clearly showed that the Balkan lynx has smaller body size, especially compared to its neighbouring population – the Carpathian lynx, as well as smaller average body mass. Mirić's sample size consisted of 29 lynx specimens from Kosovo, western Macedonia, Montenegro, Bosnia and northwest Greece. Mirić changed the subspecies name of the Balkan lynx to *Lynx lynx martinoi* considering previously given name by Bureš as *nomen nudum* (Simeonovski & Zlatanova, 2001). According to his paper (Mirić, 1973), the description of the new subspecies that Bureš gave based only on the coat coloration is not justified. Taking into account the ICZN this was unconventional because the published commercial or scientific work which was publicly available is one of the first conditions which Bureš met in his article (Article 8 of the Code). Also, to be available, a new name published after 1930 must be accompanied by a description or definition that states in words characters that is purported to differentiate the taxon (Article 13 of the Code) (Andrew Kitchener pers comm). Even though it wasn't done in a proper taxonomic manner, Bureš met the two most important criteria of the ICZN thus retaining the rights to keep the original subspecies name given, while Mirić's *martinoi* will automatically become a junior synonym. In the presented work, I have used *balcanicus* to scientifically refer to the Balkan lynx.

Because of its status as a separate subspecies, the importance of conservation actions for the Balkan lynx is even more urgent. New and preliminary results from genetic research, indicating that the Balkan lynx is indeed different from the Carpathian lynx and should be accepted as a distinct subspecies (Breitenmoser-

Würsten & Obexer-Ruff 2003; Breitenmoser et al. 2008; Gugolz *et al.*, 2008). Historically speaking, this can be explained by the colonisation processes which took place after the last glaciations, some 12.000 years ago (Urs Breitenmoser, pers. comm.). Namely, the Balkan lynx has re-colonised the forested area of the southern Balkans and spread its range towards north-west direction, along the Dinarides and up to the Alps. The northern border of this population was most probably the Danube River (Fig. 6) (Simeonovski & Zlatanova, 2001), where anthropogenic influence (wood cutting, hunting, farming etc) started relatively early in the human history. Carpathian Mts. on the other hand remained a forest refuge during the last glaciations (Gugolz *et al.*, 2008). It can be expected that these forests represented a refugium for the forest-living species such as the lynx. Hemmer (1993) however, disagrees with Balkan lynx taxonomic status and argues that the post-glacial re-colonisation started from the Balkans towards Scandinavia hence uniting the Balkan, Carpathian and Scandinavian population phylogenetically. Hemmer's arguments could be denied by the above mentioned fact that the Carpathian Mts. were a forest refuge during the last glacial and also, lynx living in the plains north of the Carpathians (Poland and the Baltic states) is genetically different from the Carpathian one hence indicating a non-continuous spread from the south, or the re-colonisation might simply went around the Carpathians.

APPENDIX IV. Known losses

Regarding the legal status, the Eurasian lynx (*Lynx lynx*) is protected by several international directives and conventions. It is included on the Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); protected under the the Conservation of European Wildlife and Natural Habitats (Bern Convention - Appendix III) and strictly protected under the EU Habitats & Species Directive (Annexes II and IV). The species is fully protected by law in all of the Balkan range countries. In Albania the species has been protected since 1969, while in Macedonia, as part of Yugoslavia, the species is under protection since 1949. Newer laws has also been implemented where lynx is considered a strictly protected species by the Albanian Law for the protection of wild fauna (2008) and Law on Hunting (2010) and by the Macedonian Law on Hunting (Official Gazette of RM 26/09) and the List of strictly protected species (Official Gazette of RM 139/11) according to the Law on Nature Protection (Official Gazette of RM 67/04)

Known loses to the Balkan lynx are gathered from two data sets: literature-statistics and baseline survey data.

1. Literature-statistics data

Known cases of killed lynx are orderly kept since before 1935. As part of the Balkan-Net project led by the Greek NGO Arcturos, Melovski & Hristovski (2002) summarized all the written literature data for the three large carnivores for population number and cull in Macedonia. Figure 28 presents the shot lynx individuals in the XX century. The number of 97 hunted lynx in the years before 1935 is explaining one of the factors for the bottleneck which the Balkan lynx population experienced in the period between 1935-1940 (Breitenmoser-Würsten & Breitenmoser, 2001). After placing the lynx under the strictly protected game species in 1949, its hunting rapidly decreased. Within the same project, Bego *et al.* (2002) did not state any data on killed lynx on the Albanian side. The only published data on known lynx loses from Albania are from Ferdinand Bego and Haki Zoto in the ELOIS report (von Arx *et al*., 2004), where they state that there are 19 illegally killed lynx in the years from 1996 till 2001, or 2 individuals in 1996, 2 in 1997, 7 in 1999 and 8 in 2000.

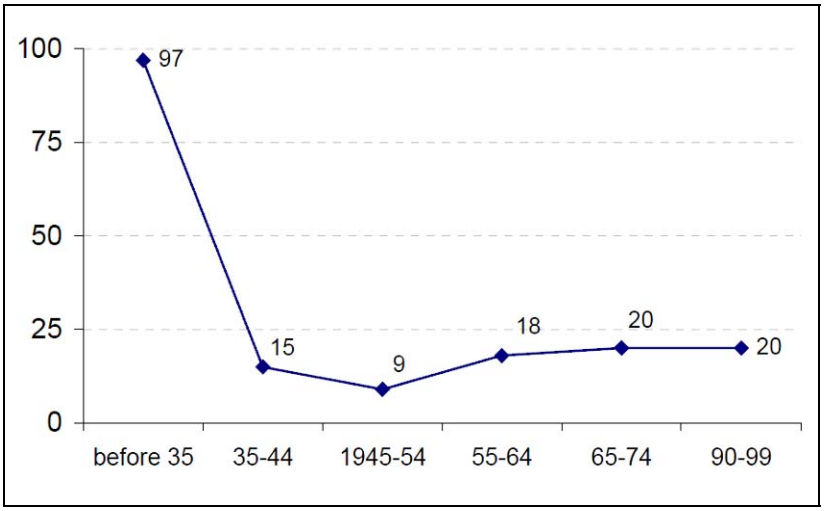


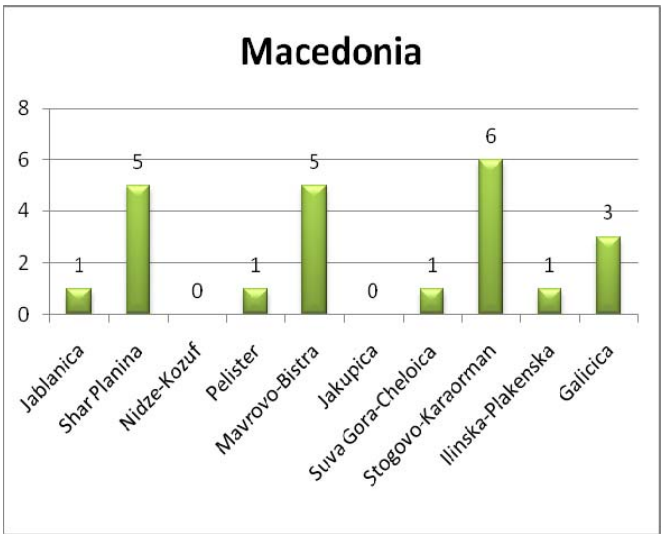
Fig. 28 Number of killed lynx specimen in Macedonia in the 20th century (Melovski & Hristovski, 2002).

Moreover, the State Statistical Office in Macedonia (www.stat.gov.mk) is publishing reports for the game harvest in the country from the year 2000 onwards. In the 2008 report there are 21 lynx shot in the Skopje region. These data seem to be exaggerated and not reliable mainly because, according to the same report, the population size of the Balkan lynx is estimated to be 142, among which 110 are claimed to be from Skopje region. In the other reports from 2000-2007 (one report), 2009 and 2010, there are no data on lynx being shot in the country. In the 2009 report the population size is estimated at 31 lynx in the whole country. This shows that the 2008 report is a clear mistake and should not be considered in any statistical analysis.

2. Baseline survey data

a. Baseline survey questionnaire

According to the Baseline Survey questionnaire carried out in both countries, a total number of 53 people (6%) admitted of having killed or heard of somebody else killed a lynx in the vicinity of their dwellings (Fig. 29). Country-wise, in Macedonia 23 people reported lynx being killed. Out of the total, 5 kills took place before 1990; 4 cases are dating from the period between 1990 and 1999; 10 kills took place from 2000 onwards and for the rest of the 4 cases, we don't know the year. In Albania the number of people confirming about killed lynx is 30. Most of the kills took place in the period from the year 2000 onwards (21 cases). Five cases took place in the period between 1990 and 2000 and the rest of the cases (4) are older than 1990Most of the cases took place in the Central Albanian region (8), followed by Stogovo-Karaorman and East region (6 each) and Shar Planina, Mavrovo-Bistra, North-Alps and Central-North region with 5 cases each. Nobody declared on having killed lynx in Jakupica and Nidze-Kozhuf region (Fig. 29).



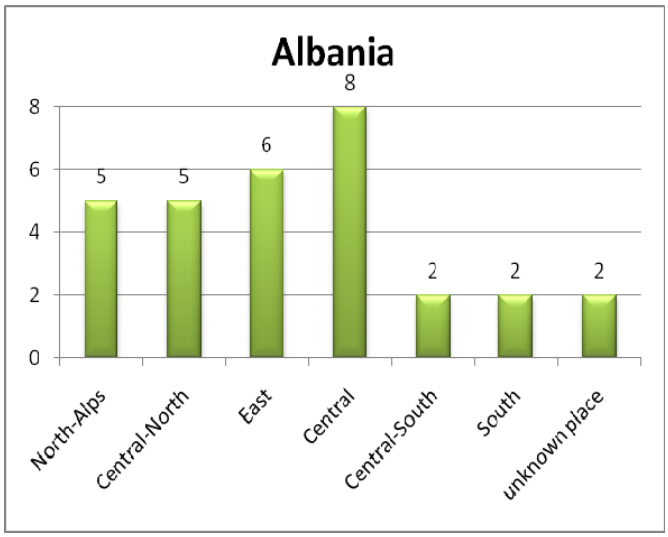


Fig. 29 Number of reported killed Balkan lynx individuals according to the Baseline Survey questionnaire. The results are separated by the surveyed regions.

a. 'Chance observations' and 'Hard facts' findings

The 'Chance observations' within the Baseline survey, revealed 45 illegally reported actions towards the Balkan lynx (Fig. 30). In the Central region of Albania 11 people admitted of having killed lynx or heard other people of doing so. Of course, there is a chance of reporting the same case more than once in which all these information are subject to a certain bias. The Northern-Alps, Central North and east region in Albania each have 6 reported shot lynx. Mavrovo-Bistra region is the only region in Macedonia having more than 2 reported lynx kills. In Nidze-Kozhuf, Pelister, Jakupica and Suva Gora-Cheloica there is no report of a lynx being killed.

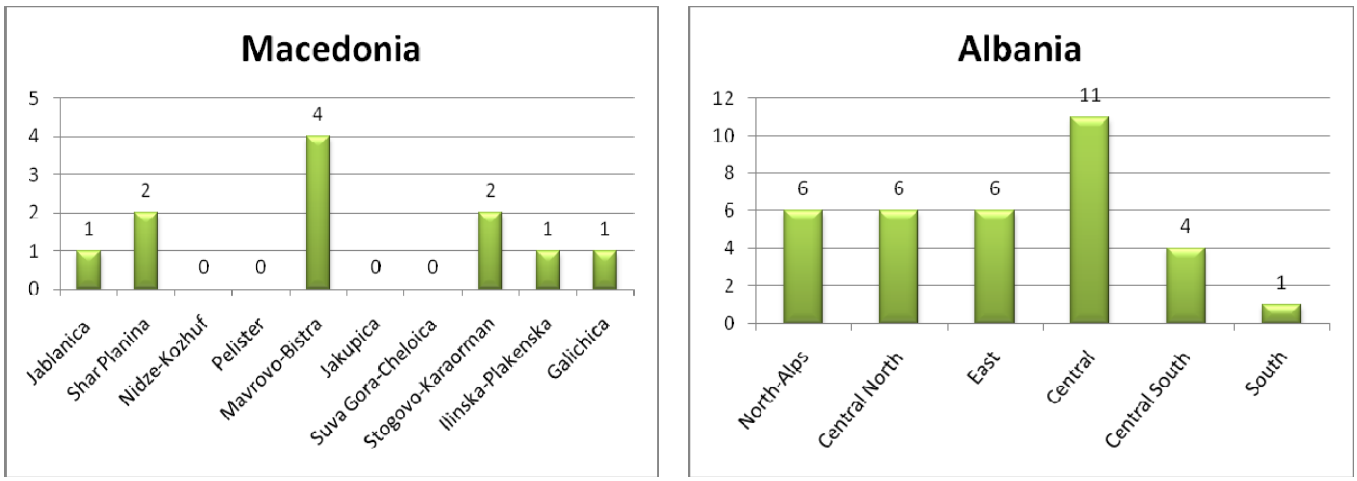


Fig. 30 Number of reported killed Balkan lynx individuals according to the 'Chance observations'. The results are separated by the surveyed regions.

Apart from the Baseline survey and 'Chance observation' data which are C3 data, there are 17 known cases of killed lynx in a form C1 data or 'Hard facts' (Tab. 4). Supplementing the reported killed lynx individuals from the 'Chance observations' and the 'Hard facts' of dead lynx individuals, the BLRP team count 62 cases of illegally killed lynx (C1 = 17 and C3 = 45) (Fig. 31).

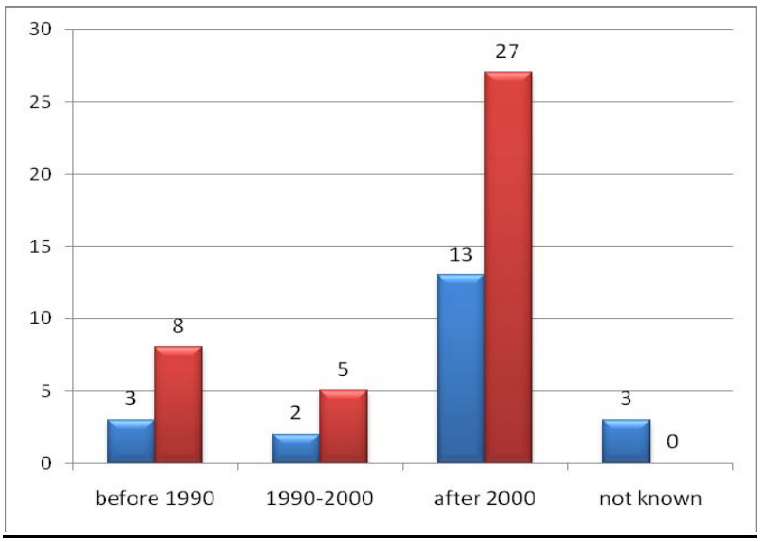


Fig. 31 Number of killed lynx individuals derived from the 'Hard facts' (C1) and 'Chance observations' (C3) for both countries. The data are sorted into the three periods: before 1990, between 1990 and 2000 and after 2000. The blue column represents the Macedonian, while the red column stands for Albanian data.

Periodically, most of the cases (41) of poached lynx took place after 2000. In the period between 1990 and 1999 only 7 cases of illegally killed lynx are known, and before 1990 there are 11 cases. For 3 cases, the year is not known (Fig. 31). Again, this information are subject to a certain bias as this can be interpreted as the difficulty for some of the interviewees to recall older data, as well as the relatively young age of some of the people being interviewed. Country-wise, 40 reported kills derive from Albania and 22 data are from Macedonia. The fact that almost 2/3 of the reported kills come from the Albanian side is certainly a threat and can be a consequence of the low law enforcement and illegal possession of weapons in the Albanian countryside.

NOTE: The reality on how much these cases are overlapping cannot be evaluated. There is a high probability that different people and not only from the same region are refereeing to the same case of killed lynx more than once.

APPENDIX V. IUCN Red List assessment

The International Union for Conservation of Nature (IUCN) is the largest conservation network, founded in 1948 as the world's first global environmental organization. Today, IUCN's network is consisted of more than thousand government and NGO member organizations and is running many field projects connected to nature conservation and sustainable development (www.iucn.org). The IUCN Red List of Threatened Species (hereafter The Red List) is set up, maintained and managed by the IUCN Species Programme and is the world's most comprehensive inventory of the global conservation status of plant and animal species. The Red List was developed for classifying species at high risk of global extinction, i.e. for assessment at the global level. The general aim of this system is to provide an explicit and objective framework for the classification of the broadest range of species according to their extinction risk. The system for classifying species is consisted of certain categories and criteria (IUCN, 2001). There are nine clearly defined categories into which every taxon (animal, plant species or their lower taxonomic levels) in the world can be classified (Fig. 32). The categories Critically Endangered, Endangered and Vulnerable belong to the "threatened" subcategory and are assigned to taxa on the basis of quantitative criteria that are designed to reflect varying degrees of threat of extinction (IUCN, 2008). These criteria are relevant to all species and all regions of the world. The aim is to convey the urgency of conservation issues to the public and policy makers, as well as help the international community to try to reduce species extinction.

Species Information Service (SIS) is an informatics tool developed by the IUCN Species Programme to help the assessors conduct an IUCN Red List Assessment (https//sis.iucnsis.org). SIS can also allow authorized users to update and make changes in the information contained in the IUCN species database in which all the published species assessments originate. In order to compute the Species Information Service and come up with an as accurate as possible assessment, ground knowledge (or close estimates) are needed on the following: 1. Distribution of the targeted taxon in terms of Area of Occupancy and Extent of Occurrence (see the Methods chapter); 2. Population information in terms of size of the population, population fluctuations and reduction; 3. Habitat and ecology of the targeted taxon – what is the habitat type the taxon is occupying, is the habitat declining, what are the life history, breeding strategy and movement patterns of the investigated taxon?; 4. The potential use and trade of the taxon; 5. Major threats which are hampering the taxon's survival; 6. Conservation measures undertaken; 7. Ecosystem services provided by the taxon.

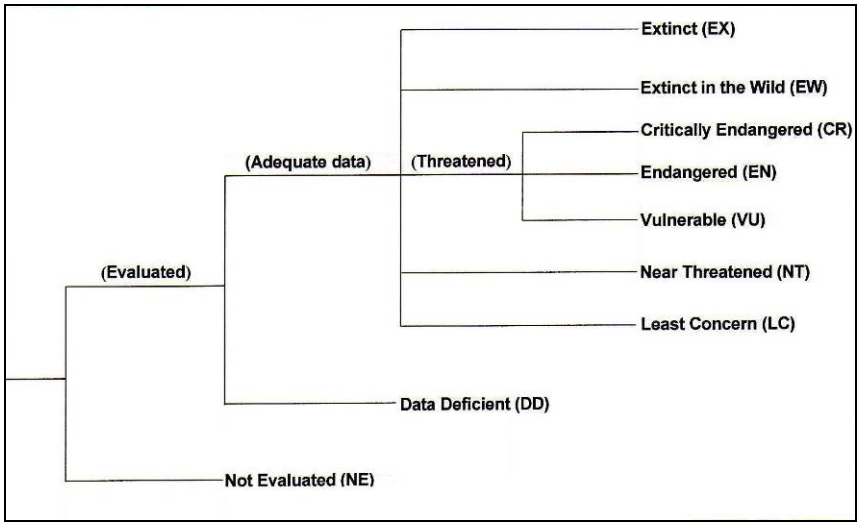


Fig. 32 Structure of the IUCN Red List categories (IUCN, 2008).

Lynx lynx - (Linnaeus, 1758)

ANIMALIA - CHORDATA - MAMMALIA - CARNIVORA - FELIDAE - Lynx - lynx

Common Names: Lynx (French), Shiluus Mii (Mongolian), LINCE BOREAL (), Evroasiin Shiluus (), Lince Boreal (Spanish), Eurasian Lynx (English), Lince (Spanish; Castilian), Lynx Bor?al (French)
Synonyms: No Synonyms

Taxonomic Note:
Balkan lynx was for the first time described an own subspecies in 1941 by the Bulgarian zoologist Ivan Buresh (Buresh, 1941). The name that Buresh gave to the Balkan lynx was *Lyx lyx balcanicus.* Later on Serbian mammologist Gjorge Miric did much more thoroughly morphometric measurements on skulls of 29 lynx speciements from the Balkans and concluded differences in the size with the specimens from the neighboring Carpathian population, as well as with specimens from Scandinavia and Caucasus (Miric, 1978). Miric changed the subspecies name of the Balkan lynx into *Lynx lynx martinoi* with no further references to the previously given name by Buresh.The importance of conservation actions was underline by new and preliminary results from genetic research, indicating that the Balkan lynx is indeed different from the Carpathian lynx and should be accepted as a distinct subspecies (Gugolz *et al*., 2008; Breitenmoser *et al*. 2008).

Red List Assessment

Red List Status

Red List category not determined

Assessment Information

Evaluated?	Date of Evaluation:	Status:	Reasons for Rejection:	Improvements Needed:
False	-	-	-	-

Assessor(s): Dime Melovski, Macedonian Ecological Society

Evaluator(s): (Not specified)

Contributor(s): (Not specified)

Assessment Rationale

Europe
The Eurasian lynx was driven extinct in much of western and central Europe over the last few centuries. However, over the past few decades, as a result of conservation action, the status of the species has improved. Reintroductions have restored it to some areas of its former range, although many of these reintroduced populations remain fragmented and extremely small. However, the lynx population within the EU remains small (below the population size threshold for Vulnerable under Criterion C, although it does not currently meet the subcriteria). If ongoing conservation action ceased, it is expected that the species would quickly start to decline again, and could meet Criterion C1 in the near future. Consequently it is assessed as Near Threatened. Continued

protection is required to ensure the continuing recovery of this species.

Balkan
According to the IUCN Red List criteria, the Balkan lynx population is Critically Endangered CR(C2a(i, ii) D). The total size of the population is estimated to be about 20-44 individuals at best, distributed over different patches, indicating a strong population fragmentation. Local experts indicated a decrease for both population size and trend in 1990-1995 as well as 1996-2001.The latest assessment done in the frame of the Balkan Lynx Recovery Programme in Macedonia and Albania and taking into account the local ecological knowledge, revealed that in Albania due to the lack of knowledge the population trend cannot be assess, while in Macedonia the figures show decline. So far, there is only one known core area, where reproduction is confirmed.
Taxonomic status of the Balkan lynx is still not officially recognized. However, its morphometric distinctness was previously acknowledged by two authors who described it as a different subspecies (Bures, 1941; Miric, 1978). Also, genetic analysis taken from the museum specimens confirmed the differences of the Balkan lynx from the neighbouring Carpathian subspecies.

Reasons for Change

(Not Specified):

Distribution

Geographic Range

The Balkan lynx is distributed in the south-west Balkans. Albania, Macedonia, Kosovo, Montenegro and potentially Greece are countries that are sharing this scattered and fragmented population.
Albania: Lynx occurs in the Albanian Alps (north) and central-central east Albania,
Macedonia: western part, mainly in the areas in and between the national parks Mavrovo, Galicica and Pelister, but most probably also in the Shar Planina Mts. bordering with Kosovo. In December 2010, camera-trapping session revealed individual in central-north part of Macedonia (Jasen PA).
Kosovo: not confirmed observation from the southern border with Macedonia (Shar Planina Mts.) and Prokletije Mt. (Albanian Alps) western part, bordering with Albania and Montenegro.
Montenegro: not confirmed observation from the southern border with Albania and Kosovo - Prokletije Mt. (Albanian Alps).
Greece: From time to time single, unconfirmed observations are reported from the border regions of Greece with Macedonia and Albania. Uncertain origin is considered to be the lynx occurrence at the Nestos River delta, east Greece close to the Turkish border. (Panayatopoulu & Godes, 2004).

Elevation / Depth / Depth Zones

Elevation Lower Limit (in metres above sea level): 600

Elevation Upper Limit (in metres above sea level): 2000

Depth Lower Limit (in metres below sea level): (Not specified)

Depth Upper Limit (in metres below sea level): (Not specified)

Depth Zone: (Not Specified)

Map Status

Map Status: Done

Biogeographic Realms

Biogeographic Realm: Palearctic

Occurrence

Countries of Occurrence

Country	Presence	Origin	Formerly Bred	Seasonality
Albania	Extant	Native	-	Resident
Greece	Presence Uncertain	Vagrant	-	-
Macedonia	Extant	Native	-	Resident
Montenegro	Extant	Native	-	Resident
Serbia	Extant	Native	-	Resident

Large Marine Ecosystems (LME) Occurrence

LargeMarineEcosystems: (Not specified)

FAO Area Occurrence

FAOOccurrence: (Not specified)

Population

Lynx in Europe were widely extirpated within the past several hundred years, reaching a nadir in the 1950s. Populations were reintroduced from the late 1970s onward, and the total number of lynx in Europe (excluding European Russia) is c.8,000. Populations in central and southern Europe remain very small and fragmented, although there are larger populations in Fennoscandia, the Baltic states, and European Russia (Breitenmoser *et al*. 2000). The lynx's stronghold is a broad strip of southern Siberian woodland stretching through eastern Russia from the Ural mountains to the Pacific. There is little information on population status and trends from the lynx's wide Asian range (Nowell and Jackson 1996, Cat Specialist Group 2002). For the European populations, detailed status and trend information can be found on The Balkan population is the smallest and most threatened autochthonous lynx population in Eurasia. It experienced a severe bottleneck in 1935-1940 with an estimated number of only 15-20 individuals left. After World War II the population started to recover, especially in Kosovo and Macedonia (Miric 1981). In the 1960-70s, it also reappeared in Montenegro. The population estimation was some 280 lynx in 1974 (Miric 1981). Latest inquiry (ELOIS 2004) showed that the population estimate is between 80 and 105 mature individuals. Two intensive camera-trapping session in Mavrovo NP (study area 436 km^2) revealed minimum number of mature individuals is 7, with standard error 1,82, confidence interval 6 to 14 individuals and population density 0.84 ± 0.24 individuals per 100 km^2 (Melovski et al. 2008). The second session in 2010 showed an estimation of minimal number of individuals was 6 with standard error 2.35. Population density was calculated at 0.80 ± 0.31 individuals per 100 km2. The population density can be obtain taking into account the minimal and maximal range of the Area of Occupancy (4000-20.000) and then multiply it with the standard deviation of the population density and divide the number by 100 (population density is for mature individuals per 100 km^2). The results are 20 to 44 individuals taking only the minimal value of the AOO. The

higher value is most likely an overestimate due to the fact that no results Category 1 and 2 data were found outside the core area of the Balkan lynx distribution.

Population Information

Continuing decline in mature individuals?	Qualification:	Justification:
Yes	Projected	-

Habitats and Ecology

Throughout Europe and Siberia, lynx are associated primarily with forested areas which have good ungulate populations (Nowell and Jackson 1996). In Central Asia they occur in more open, thinly wooded areas. Small ungulates are the lynx's primary prey (Nowell and Jackson 1996, Cat Specialist Group 2002). In Europe, the lynx's preferred diet includes roe deer and chamois. Lynx will also take larger ungulates such as red deer, moose, or wild boar occasionally. Where ungulates are not available, birds, hares and rodents form important prey. In Norway, Sweden and Finland, lynx also kill significant numbers of semi-domesticated reindeer. Depredation on sheep is also a problem in some countries.

Balkan lynx occupies mountainous terrains spreading mainly in the most southern parts of the Dinaric range and throughout most of the Scardo-Pindic range. Main habitats are: deciduous (beech, oak, horn beam, hop-horn beam), evergreen (fir and pine) and mixed forests (fir-beech). Uses the rocky and sunny sites for daily bed. Rarely in the summer period visits high-mountain pastures. It is using shrub lands and cultivated area (mountain meadows) primarily for hunting.
Balkan lynx's diet is so far confirmed with the preliminary results obtained from the radio-telemetry study conducted in Macedonia within the SCOPES project - Status, ecology and land-tenure system of the critically endangered Balkan lynx (*Lynx lynx martinoi*) in Macedonia and Albania (http://www.snf.ch/E/international/europe/scopes/Pages/default.aspx). Roe deer is consisted in 64% of its diet, chamois 24% and the rest belongs to the European brown hare (Melovski *et al.* 2010).

IUCN Habitats Classification Scheme

Habitat	Suitability	Major Importance?
Forest -> Forest - Boreal	Suitable	-
Forest -> Forest - Temperate	Suitable	-

Life History

Generation Length	Justification:
4-5	-

Age at Maturity: Female

2 Years

Age at Maturity: Male

3 Years

Size at Maturity (in cms): Female

70-111

Size at Maturity (in cms): Male

72-130

Longevity

17 Years

Average Reproductive Age

7-8 Years

Maximum Size (in cms)

130

Size at Birth (in cms)

20

Gestation Time

67-74 Days

Reproductive Periodicity

yes

Average Annual Fecundity or Litter Size

2

Natural Mortality

-

Breeding Strategy

Does the species lay eggs?

False / No

Does the species give birth to live young

True / Yes

Does the species exhibit parthenogenesis

False / No

Does the species have a free-living larval stage?

False / No

Does the species require water for breeding?

False / No

Movement Patterns

Movement Patterns: Congregatory/dispersive

Systems

System: Terrestrial

Use and Trade

General Use and Trade Information

UseTradeDocumentation:
(Not specified)

Threats

Lynx are vulnerable to destruction of their ungulate prey base. Hunting pressure may also play a role in lynx population declines. Habitat destruction through clear-cutting can have a negative effect on lynx abundance. There is no information beyond harvest reports on which to base an assessment of the biological impact of commercial trapping for furs, and thus its significance as a threat is difficult to judge (Nowell and Jackson 1996, Cat Specialist Group 2002). The lynx's disappearance in lowland Europe was due to human persecution, deforestation, loss of prey species, expansion of agriculture and an increase in human populations. Although the lynx is not endangered, these threats still affect it today throughout Europe. Habitat loss, loss of prey due to logging and hunting, and human population pressures have serious negative impacts. Humans still present a major threat to the lynx, particularly to small or reintroduced populations.

General and most serious threats to the Balkan lynx population are the following: small population number; limited prey base; habitat degradation (especially in Albania and Kosovo) and poaching.
The fact that the population size is estimated to be 30-50 mature individuals is posing a great threat of extinction to the Balkan lynx. The metapopulation is most probably divided in several subpopulations in a fragmented landscape. Corridors are not yet known.
Poaching is posing threat in two ways: directly, through loss of individuals and indirectly, through loss of lynx's prey (roe deer, chamois, brown hare) (Ivanov *et al.* 2008).
Deterioration of habitat is generally an issue in Albania. Overly exploited forest throughout the 19th and 20th century have a hard time to recover. Moreover, the civil unrest in Albania in 1997 heisted the arm depositories which led to a massive over-hunting in the countryside. Similar situation followed in Macedonia and Kosovo during the conflict in 2001.
Tourist resorts and recreational activities have insignificant effect for the population. Still, sport-hunting and ski resorts can be considered disturbances for the area of the national parks, where most of the Balkan lynx

population is existing.
Last but not least, the spreading Carpathian (through Eastern Serbia) and Dinaric (though Croatia, Bosnia and Herzegovina) populations which is a reintroduced population from the Carapthian Mountains (Carpathian subspecies), may pose a threat to the genetic uniqueness of the Balkan population.

Conservation

Included on CITES Appendix II, protected under the Bern Convention (Appendix III) and strictly protected under the EU Habitats & Species Directive (Annexes II and IV). Conservation measures in place and recommended for the European populations are as follows:
Balkan
The species is fully protected by law in all range countries. A recovery strategy and two (Macedonia and Albania) national action plans for the Balkan lynx f do exist, however they are not ratified by the relevant ministries.
A three year project named "Balkan Lynx Recovery Programme" started in Macedonia and Albania in 2006. Based on two principles, this project's aim was to combine the lynx protection in the sustainably managed protected area system in both countries. Balkan lynx was chosen as a flagship and umbrella species. The project's main goals were: survey and monitoring of the Balkan lynx; collecting baseline information on Balkan lynx's distribution, population trend, abundance, prey availability etc.; developing range wide Conservation Strategy and National Action Plans; define areas along the European Green Belt in the Balkan lynx distribution and lobby for their proclamation; and build professional partnership consisted of relevant stakeholders in the field of nature protection (Breitenmoser et al. 2008). The project was sponsored by the Swiss-based MAVA foundation.
In parallel with this activities a Human Dimension project commenced in both countries and was funded by the Research Council of Norway. Basic principle of the project was to build the capacities to meet the challenges of cross border cooperation in large carnivore conservation.

Second phase of the Balkan Lynx Recovery Programme begun in 2010 which basically is the continuation of the previously defined goals and activities. Novelty in the second phase of the project is the enlargement of the activities towards Montenegro and Kosovo and conducting baseline survey in the two countries.

The need for ground-truth data on Balkan lynx's biology and ecology led to the first scientific project called: Status, ecology and land-tenure system of the critically endangered Balkan lynx (*Lynx lynx martinoi*) in Macedonia and Albania. The project was supported by the Swiss National Scientific Foundation and was under the SCOPES programme (Scientific Cooperation between Eastern Europe and Switzerland). The project started in 2010 and will last until the end of 2012. So far, one individual was captured and fitted with a radio-collar. First data on lynx's home range size, diet and land-tenure system were gathered. More individuals are needed in order to find out the Balkan lynx's social organization.

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