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DISTRIBUTION AND CONSERVATION STATUS OF THE BALKAN LYNX (*Lynx lynx balcanicus* Bureš, 1941)

Dime Melovski[1], Gjorgje Ivanov[1], Aleksandar Stojanov[1], Vasko Avukatov[1], Aleksandër Trajçe[2], Bledi Hoxha[2], Manuela von Arx[3], Christine Breitenmoser-Würsten[3], Slavcho Hristovski[1,4], Spase Shumka[2,5] & Urs Breitenmoser[3,6]

(1) Macedonian Ecological Society, Blv. Kuzman Josifovski Pitu, 28-3/7, Skopje, Macedonia, ivanov@mes.org.mk, melovskid@mes.org.mk, stojanov@mes.org.mk, avukatov@mes.org.mk
(2) Protection and Preservation of Natural Environment in Albania, Rr. "Mujo Ulqinaku" 25 / 1 / 5, Tirana, Albania, b.hoxha@ppnea.org, a.trajce@ppnea.org, s.shumka@ppnea.org
(3) Carnivore ecology and wildlife management, Thunstrasse 31, 3074 Muri b. Bern, Switzerland, m.vonarx@kora.ch, ch.breitenmoser@kora.ch
(4) Faculty of Natural Sciences and Mathematics, University of Skopje, Arhimedova 5, 1000 Skopje, Macedonia, slavco_h@pmf.ukim.mk, melovski@pmf.ukim.mk
(5) Faculty of Biotechnology and Food, Agricultural University of Tirana, Koder Kamza, 1000 Tirana, Albania, s.shumka@ppnea.org
(6) Institute of Veterininary Virology, University of Berne, Länggassstrasse 122, 3012 Bern, urs.breitenmoser@vetsuisse.unibe.ch

Abstract

Melovski, D., Ivanov, Gj., Stojanov, A., Avukatov, V., Trajçe, A., Hoxha, B., von Arx, M., Breitenmoser-Würsten, Ch., Hristovski, S., Shumka, S., Breitenmoser, U. (2013). Distribution and conservation status of the Balkan lynx (*Lynx lynx balcanicus* Bureš, 1941). Proceedings of the 4th Congress of Ecologists of Macedonia with International Participation, Ohrid, 12-15 October 2012. Macedonian Ecological Society, Special issue 28, Skopje.

Population size and distribution of a target species are among the most important features in conservation biology. By knowing these parameters, an effective management for conservation can be applied in the range countries of its 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 to acknowledge the subspecies status of the Balkan lynx - *Lynx lynx balcanicus* Bureš (1941). However, this subspecies has never been recognized by a wider scientific public, even though morphometric and genetic analysis support the subspecies status. The topic of the critical status of the Balkan lynx has become even more alarming with a recent dramatic decline in population size and the probability of extinction in the near future.

The main objectives of this paper are to present the distribution range, population size and conservation status of the Balkan lynx. We have used three data sets in order to achieve the above mentioned goals: literature data, questionnaires from a baseline survey performed in the study area (western Macedonia and eastern Albania) and camera-trapping results. The conservation status of the Balkan lynx was assessed using the Species Information Service of the IUCN. The distribution range was calculated taking into account the IUCN standards, thus focusing on the Area of Occupancy (AOO) and Extent of Occurrence (EOO). The population size was calculated using the Area of Occupancy and the mean density of the Balkan lynx inside the Mavrovo NP extrapolated from the data acquired during the systematic camera-trapping session in 2010. The results show a decline in population size in comparison with the results of the baseline survey. The pessimistic scenario for the population size of the Balkan lynx is pointing to only 20 to 44 mature individuals, while the most optimistic one, to 220 individuals. These individuals are distributed mainly in the western part of Macedonia and eastern Albania. No firm evidence could be obtained for the presence of the Balkan lynx in the North of the study area (Kosovo and Montenegro). The Area of Occupancy for the Balkan lynx is probably between 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). We suggest taking urgent measures in order to save the Balkan lynx from extinction.

Key words: Balkan lynx, *Lynx lynx balcanicus*, distribution range, population size, status, historical review, IUCN Red List assessment.

Introduction

A small and long-term isolated population of the Eurasian lynx has survived in the south-western Balkans till present. The Balkan lynx was for the first time described as a separate subspecies in 1941 by the Bulgarian zoologist Ivan Bureš (*Lynx lynx balcanicus* Bureš, 1941). Almost 40 years later, the Serbian mammologist Gjoge Mirić did much more fundamental description of this subspecies but also gave a different scientific name (*Lynx lynx martinoi* Mirić, 1978). Even though this taxonomic status was never officially recognised by the wider scientific public, today's taxonomists and ecologists believe that Bureš's *balcanicus* should be considered as a legal name of the Balkan lynx (Krystufek, in press; Melovski 2012).

The issue of the Balkan lynx attracted many other scientists and conservationists in Europe because of its critical status in the 20th century. Being in the verge of extinction before and during the Second World War, the authorities in that time's Yugoslavia decided to grant this animal a legal status of protection. Very soon, the population started to recover and by 1974, the lynx population in the southwestern Balkan Peninsula counted around 280 individuals (Mirić 1981). However, these estimates were done taking into consideration very basic knowledge on lynx' ecological knowledge in general. Mirić estimated that these individuals in average shared 30 km^2 of a home range size, which in nowadays radio-telemetry studies is considerable underestimation (Sunde et al. 2000; Linnell et al. 2001; Breitenmoser-Würsten et al. 2007; Okrama et al. 2007).

The period in the 1990's and early 2000 was a nuisance for the wildlife of the Balkans. The split of Yugoslavia, the civil unrest in Albania and the ethnic conflicts in Serbia, Kosovo and Macedonia were part of the factors that brought back the Balkan lynx on its verge. Poor law enforcement and the appalling development politics of these countries in transition placed the nature conservation in the last priorities.

Having the above mentioned in mind, a group of external experts from Switzerland and Germany with local NGO's from Macedonia and Albania started the implementation of the ever first project for the conservation of the Balkan lynx. The Balkan Lynx Recovery Programme is an applied conservation project that began in 2006 and aiming in building capacities on a local level for a long-lasting monitoring and conservation of the Balkan lynx, assessing the conservation status of the Balkan lynx, rising the awareness in nature protection in the region while involving with rural communities and working towards the establishment of the new protected areas.

In this paper we are focusing on: 1. assessing the distribution and conservation status of the Balkan lynx population through surveying the present status of the population (distribution and population size) based on the local ecological knowledge and 2. listing the conservation status of the Balkan lynx according to the IUCN Red List criteria. The main data sets used in this paper are the questionnaire performed in Macedonia and Albania in order to determine the presence of the Balkan lynx, as well as the camera-trapping results to find out the potential population size. Finally, the gathered data were used so that we can evaluate the official status of the Balkan lynx according to the standards of the IUCN Red List of threatened species.

Methods

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). 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). 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). In order to include the whole potential range of the Balkan lynx, we have consulted the relatively recent papers on its distribution for Montenegro and Kosovo.

Present status and distribution of the Balkan lynx based on the LEK

LEK stands for Local Ecological Knowledge. 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). Across the entire potential distribution area in both countries we used a questionnaire (Baseline Survey) to compile local peoples' knowledge. The questionnaire included 13 wildlife species and 50 questions divided into six categories. 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

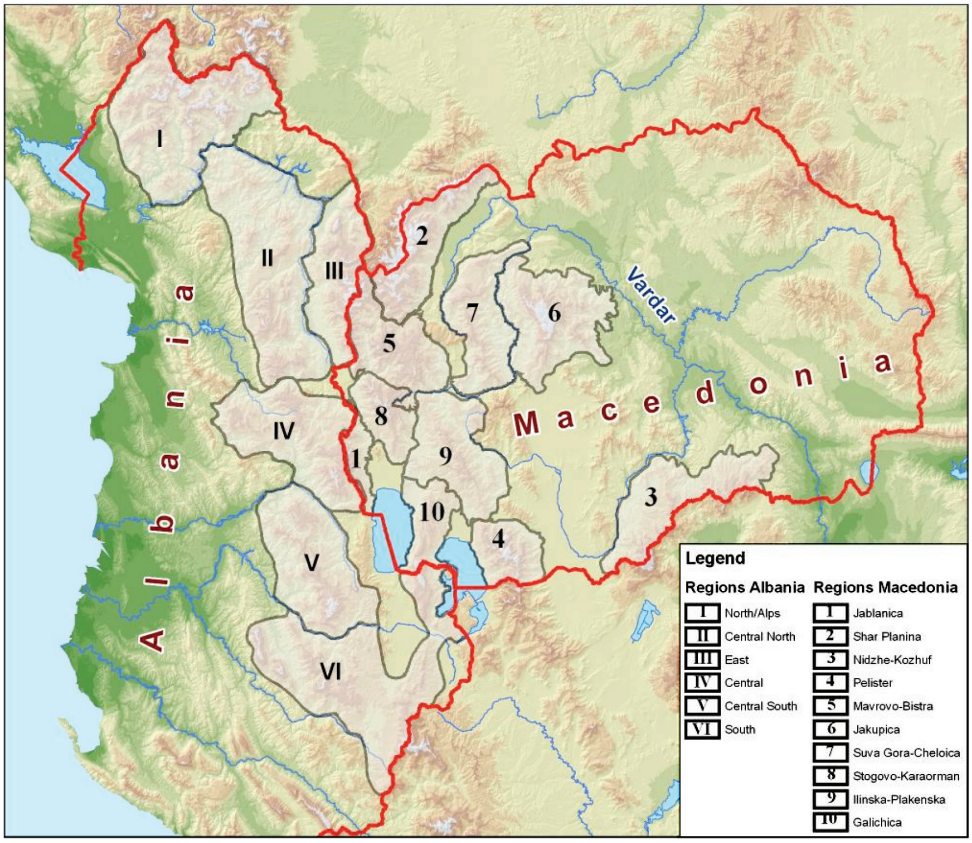

Fig. 1. The study area divided in regions.

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 paper, we've considered only the first group of questions. Particularly, distribution pattern and trends are outlined only for the lynx, as well as its main prey species (roe deer, chamois and brown hare). 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. The interviewing technique was face-to-face and the questionnaire was completed at the time of interviewing in order to avoid misinterpretation of data. During the survey, verified lynx findings such as: stuffed animals, lynx pelts, museum specimens, photographs of lynx were considered as a Category 1 data or "Hard facts". Records of livestock killed, wild prey remains, tracks and scats reported and confirmed by trained people, we considered as Category 2 data, whereas the positive interviews during the questionnaire for lynx sightings, as well as accidental and unverified lynx-observation reports fall into the Category 3 (Molinari-Jobin et al. 2003). Furthermore, camera-trapping photos of a lynx are considered Category 1 data.

We assessed the presence of predator and prey species 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. We 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.). We used the Corine Landcover (www.eea.europa.eu/publications/COR0-landcover) system and followed the forest areas or patches in-

side 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 Land-cover 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, 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. In this way, we 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 (IUCN, 2008). 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. We 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.

Estimation of the population density and size

We took two different data-sets in order to calculate the size and density of the Balkan lynx population: camera-trapping in a reference area and Baseline Survey data on Balkan lynx distribution. The population density was directly calculated taking the results from the two systematic camera-trapping sessions in one reference area (Mavrovo NP, Macedonia) in 2008 and 2010. Mean value of the two session is presented and then used with the intention of calculating the population size. This was done by extrapolating the population density (number of lynx individuals per 100km^2 in the reference area, over the whole distribution range of the Balkan lynx. We used the simple equation:

$$\frac{X * Y}{100},$$

where X is the **minimum** or **maximum** value 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. 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.

Assessment of the conservation status

The IUCN Red List assessment 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 to 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 (size and trend) and threats to the population.

We assessed the population trend of the Balkan lynx 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 a 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.

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 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 (Jobin et al. 2000; Molinari-Jobin et al. 2007) and a radio-telemetry study in Macedonia. Cases of poached lynx individuals were classified in three periods: before 1990, between 1990 and 2000 and after 2000 (see subchapter "Present status and distribution of the Balkan lynx based on the LEK" in this chapter).

Results

Present status and distribution of the Balkan lynx based on the LEK

Tab. 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**

During the intensive questionnaire survey throughout western Macedonia and eastern Albania we visited 258 villages where we interviewed a total of 873 people (Tab. 1)**.**

In Macedonia only, 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. Balkan lynx presence (Fig. 2) was reported for the following regions: Shar Planina (region 2 in Fig. 1), 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. 2). In Albania, random informants (138) were mostly present at the interviews and are followed by farmers (53) and hunters (48), while veterinarians (9) were the category with the fewest people in the sample size. The areas with the most reported lynx presence were 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. 1), Central-North (II) and North-Alps (I) regions (Fig. 2). 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. 2).

Moreover, the distribution of the Balkan lynx was calibrated using the Category 1 and 2 findings and the Chance observation (Category 3). 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 of this kind and 19 findings which are considered Category 2 data (lynx tracks, scats or prey animals). Camera-trapping photos are also category 1 data. During our studies, we manage to photograph 88 photos of lynx at 26 camera-trapping sites. These sites represent 26 locations where a 'hard-fact' is encountered and are part of the AOO_{min} calculation. Beside the C 1 and 2 data, and the systematic questionnaire performed in the countries, 252 spontaneous lynx sightings (C3 data) reported by people were gathered and are used to shape the AOO_{max} polygons.

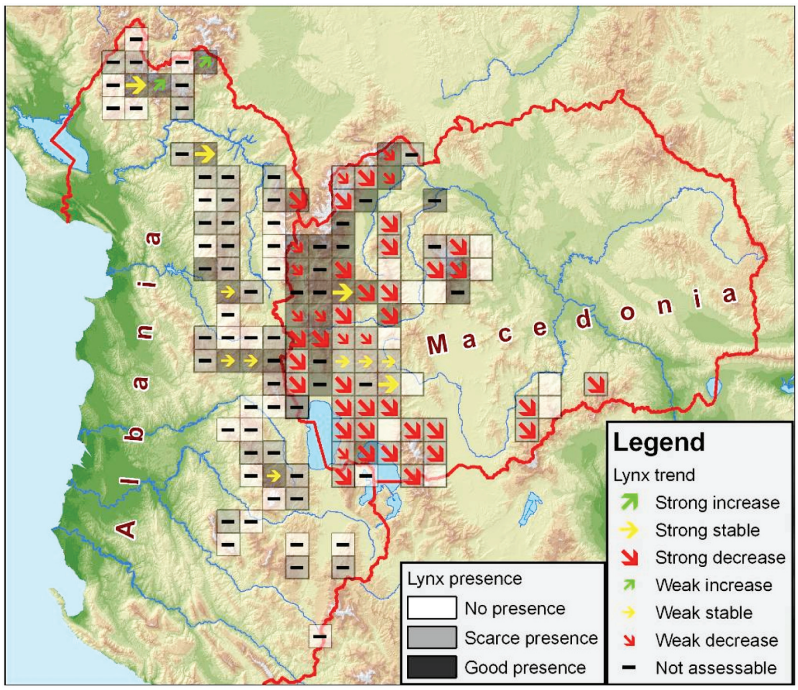

Fig. 2. Balkan lynx presence and trend in Albania and Macedonia.

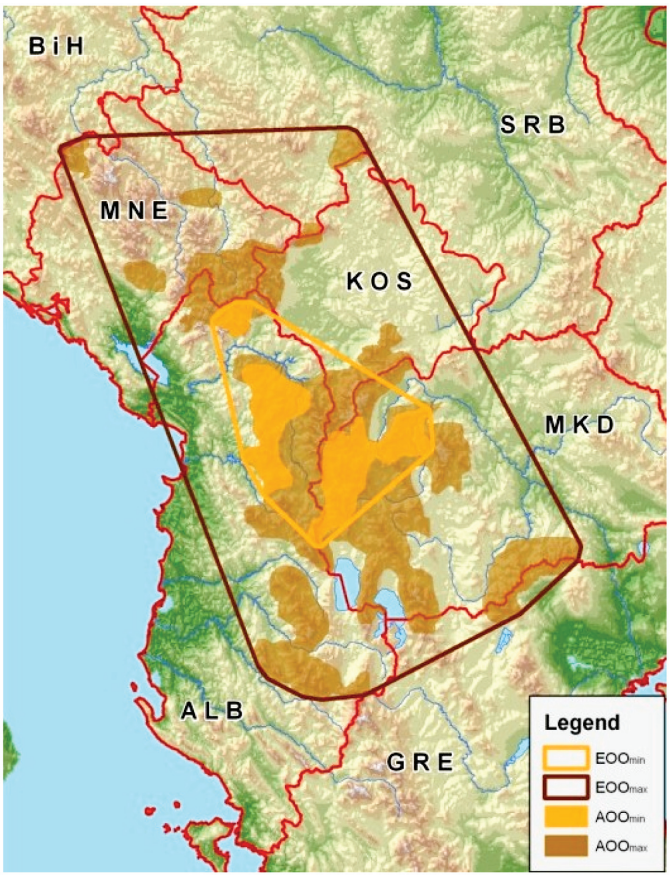

Fig. 3. Balkan lynx presence in its current distribution area. The AOO_{min} (orange polygons) taken from the C1 + C2 data from Macedonia and Albania and AOO_{max} taken from C 1, 2 and 3 data for Macedonia and Albania later than year 2000; C3 data for Montenegro and Kosovo taken from the recent literature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

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 counted 99 grid cells which equal 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. 2).

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 is calculated within the Minimum Extent of Occurrence (EOO_{min}) - 10124 km^2 and the Maximum Extent of Occurrence (EOO_{max}) - 58435 km^2 (Fig. 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 $\mathbf{AOO_{min}}$ and:

The lowest value of the population size:

$$\frac{4007 * 0.49}{100} = 20 \text{ individuals.}$$

The mean value of the population size:

$$\frac{4007 * 0.80}{100} = 32 \text{ individuals.}$$

The highest value of the population size:

$$\frac{4007 * 1.11}{100} = 44 \text{ individuals.}$$

Optimistic scenario: I have taken the $\mathbf{AOO_{max}}$ and:

The lowest value of the population size:

$$\frac{19886 * 0.49}{100} = 97 \text{ individuals.}$$

The mean value of the population size:

$$\frac{19886 * 0.80}{100} = 159 \text{ individuals.}$$

The highest value of the population size:

$$\frac{19886 * 1.11}{100} = 220 \text{ individuals.}$$

Assessment of the conservation status

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 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. 2). 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 indicate 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. 2).

Threats relevant for the survival of the Balkan lynx are shown in table 2.

The order of these threats follows the importance of certain threats according to the literature. The first four threats in the table 2 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. 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.

Tab. 2. Threats to the Balkan lynx population.

	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	←	←	←	

← 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).

Most of the beech and fir forests consist of young trees, while the treeless hills and ravines are affected by heavy erosion. 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. Nidze-Kozhuf region is also considered a fragmented part of the main core area, divided by populated plains with farmland. 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.

According to the analysis mentioned above, 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'.

Discussion and conclusions

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 are 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 (Breitenmoser 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 paper 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. Mavrovo NP within the Mavrovo-Bistra region (region 5 in Fig. 1) 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 national parks in Macedonia and Albania (Pelister, Galichica, Albanian Alps) 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. 1) are serving as a very important bio-corridor connecting the three existing national parks in Macedonia (Schwaderer et al. 2008). 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.

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, which 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, which 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. Additionally, some of the statements for killed lynx could refer to a single/the same case more than one time. 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 is revealing the land-tenure system, the social organization, prey spectrum and other important aspects for a long-term conservation project. Estimating the population size of the Balkan lynx is one of the more important parameters for its further conservation work. By knowing these parameters, detailed and solid actions concentrated on the specific problems can be outlined. The research project called "Status, ecology and land-tenure system of the critically endangered Balkan lynx in Macedonia and Albania" has already resulted in the first three radio-tagged Balkan lynx individuals. More individuals are needed for assessing other important ecological features. Without this ecological knowledge, no conservation programme can safeguard the survival of any endangered taxon.

In terms of taxonomy, 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 (1999) 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 paper 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. Considering the IUCN Red List criteria, the next step will be to look into down-listing 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. 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).

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