CAUCASIAN LYNX CONSERVATION AND RESEARCH IN ARMENIA

Manush Abrahamyan

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ABSTRACT:

There are no scientifically-based estimate of population size and actual data about distribution range for the lynx in Armenia. As result no conservation activities is developing in Armenia for this species. However urbanization, habitat destruction, hunting, narrow prey base and wildfire have a great impact on wildlife and especially on large mammals. Therefore, we have initiated the study of Caucasian Lynx (*Lynx lynx dinniki*) in Armenia with aim to develop the species conservation program. The baseline for this species was established, which incorporated the most data collected earlier. The camera trapping and questionnaires have filled some gaps of Lynx distribution. As result, the initial habitat suitability maps for Lynx have been created for southern Armenia. The preliminary estimation of density was made only for Khosrov Forest State Reserve, while for other sites data was not sufficient. The future research and awareness raising activities are essential for conservation of this charismatic large cats.

PARTICIPANTS:

Organizations:
Yerevan State University (YSU)
WWF-Armenia
Humboldt University, Berlin

Manush Abrahamyan – Project Leader, YSU (Figure 1, 2)
Ofelia Yelabekyan – Field researcher, Master student of YSU
Manan Asikyan - Field researcher, Master student of YSU
Astghik Markosyan – Field researcher, Bachelor student of YSU (Figure 1)
Marine Arakelyan – Advisor, Head of Zoology Department of YSU
Alexander Malkhasyan – Field researcher, WWF (Figure 1)
Lena Hertrich – Exchange student from HU to YSU in period April-July, 2018

From left to right: Bas Douma (volunteer); Astghik Markosyan (Field researcher), Alexander Malkhasyan (Field researcher) Manush Abrahamyan (Project leader) during the field work.

GOAL:

Evaluation of conservation status and sustainability of Lynx population in southern Armenia: We have particularly studied:

- Distribution
- Relative density
- Human-lynx conflict mitigation measures


Manush Abrahamyan (Project leader) during the field work.

WORKFLOW:

A. FIELDWORK

Creation of Lynx database: compile the previous all known data about Lynx observation and density in southern Armenia.

Lynx tracking, collecting available information from local people and PA's rangers (

Time: September- November, 2017

Pilot study with camera traps

Time: February –August, 2018

Number of camera traps = 14

Number of Sessions: 2

Deployment duration: 3 months

B. DATA ANALYSIS

Habitat sustainability of Lynx in southern Armenia:

Maps of habitat suitability

Response curves and important predictors

Gaps of study

Estimation of the population size of Lynx in Khosrov Forest State Reserve

C. AWARENESS RAISING MATERIALS DISTRIBUTION AND CONSERVATION EDUCATION

Opinion polls and interviews

Seminars for schoolchildren and distribution of materials among local people

FIELDWORK

Manush Abrahamyan

The whole field work have been divided on three main periods.

The first period has duration of three months September-November, 2017. During the first period following works will be held:

- Site selection:

For the site selection we used available data about Lynx observations and survey the area for presence the traces (footprints, excrement etc.) We selected camera trap locations based habitat, occurrence of prey and topographical aspects. For example, rocky areas was preferred by lynx for day resting sites and chances are high that lynx use trails along ridges. To determine the exact site we relied on expert advice and locations that have a high density of data. Practical considerations, however, will limit site selection. Sites above 1,500 m was excluded because of costly maintenance (high snow levels) during the snow season.

- Selecting territories for camera trapping:

The 160 km^2 study area was overlaid with a random generated 2.5 x 2.5 km sampling grid. We considered that only 60 km^2 is forest, the other parts of the area such as roads, settlements etc. must be excluded from the camera tracking. In every second grid cell, a site considered to have a high likelihood of Lynx detection was selected (forest road, hiking trail or occasionally a wildlife trail or bridge known to be used by Lynx). Within a given survey area, transect routes can either be positioned randomly or according to a strict pattern, e.g. a grid. In reality, especially in rough terrain, neither approach was practical. Because the goal is to detect as many Lynx as possible, transects was designed in order to assure a high probability to encounter Lynx tracks. In mountain ranges with a difficult topography and a very dynamic snow cover such as Armenian mountains, systematic track transects are not easy to use for detection of Lynx. Nevertheless tracks in the snow give important information on the presence of Lynx, and, if combined with other methods, can at least provide semi-quantitative information (Ryser *et al.* 2005). Therefore, we have found the track of Lynx in Gndasar, Artavan, Jermuk areas of Vayots Dzor. However because our surveys was not searched by means of systematic track transects, (relative) Lynx abundance cannot be estimated.

- **Camera trapping**

The second period was started at winter-spring season (February- March, 2018). Camera traps were installed in the Gndasar region of Vayots Dzor province, in vicinities of Hors village, which is part of migration corridor for large mammals and other wildlife. The data of the cameras were checked and collected at the end of second month (for 2 months).

Through installation of 14 camera traps we got photos of 23 mammal and 4 bird species. Bezoar Goats (*Capra aegagrus*) and Brown Bear (*Ursus arctos*) were among more frequently photographed animals. The Lynx was recorded in this area according to the footprints; however, no camera traps images were obtained. Probably, the density of Lynx population here is low. Among other large mammals the following species were detected: Beech-Marten (*Martes foina*), Badger (*Meles meles*), Otter (*Lutra lutra*), Fox (*Vulpes vulpes*) and Wolf (*Canis lupus*). Among middle size animals we recorded by direct observation there were the European Hare (*Lepus europaeus*), White-Breasted Hedgehog (*Erinaceus concolor*) and Least Weasel (*Mustela nivalis*).

Manush Abrahamyan (Project leader) during the field work.

The third period includes the camera traps installing during summer period (June-August, 2018) and analyzing of data collected since the first period of project till the end of the project. 14 camera traps were installed in Khosrov Forest State Reserve with aim to support the analysis of density of lynx in reserve. The new purchased traps were tested. The quality of new traps were not high and some of cameras have not worked properly and stopped to shooting after 1-2 weeks (Table 1) and one of cameras was destroyed by Brown Bear. Among 8 species of mammals Lynx was fixed only by one camera where two individuals (male and female) were recorded. At least 6 individuals of Brown Bears were recorded on 16 images of camera trapping.

Table 1. Testing of camera traps in Khosrov State Reserve.

N of camera	**Altitude**	**Installing date**	**Completion date**	**Captured animals***							
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	1923	08.05	14.06	0	2	4	0	0	1	1	0
2	1929	08.05	25.05	0	0	0	0	0	0	0	0
3	1983	08.05	18.05	0	0	0	0	0	0	0	0
4	1939	09.05	22.05	0	0	0	0	0	0	1	0
5	1914	09.05	16.05	0	0	0	0	0	0	1	0
6	1939	09.05	15.05	0	1	0	0	0	0	0	0
7	1594	10.05	20.06	2	3	0	1	0	2	3	2
8	1958	11.05	19.05	0	0	1	0	0	1	0	0
9	1958	11.05	30.08	0	8	0	0	8	2	0	1
10	1913	12.05	14.05	0	1	0	0	0	0	0	0
11	1898	12.05	17.05	0	1	0	0	0	0	0	0
12	1544	01.06	06.06	0	0	0	0	0	0	0	0

*1- Lynx, 2- Bear, 3-Marten, 4- Wolf, 5- Wild Boar, 6 –Weasel, 7 - Hare, 8- Badger.

The baseline information provided by the our fieldwork survey will inform future management interventions and conservation actions like establishment of conservation area, anti-poaching activities, introduction of sustainable pasture management scheme etc.

Habitat suitability of the Caucasian lynx (lynx lynx dinniki) in southern Armenia

Lena Hertrich
SUPERVISOR: MARINE ARAKELYAN Yerevan State University, Humboldt University Berlin

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Abstract

This study explores the habitat suitability for the Caucasian lynx (*lynx lynx dinniki*) in the provinces of Ararat, Vayots Dzor and Syunik in southern Armenia. Due to its isolation, both geographically and genetically, it can be considered a probably endangered subspecies, yet it is listed as least concern by IUCN due to data deficiency. To date, there is no monitoring or research program in Armenia for the Caucasian lynx. To explore its range, a MaxEnt model was fit using 72 presence points derived from camera traps and five predictors: distribution of bezoar goats, distance to roads, land cover, mean snow cover and terrain ruggedness, with distribution of bezoar goats being the most important one. The obtained habitat suitability map shows that there is quite some suitable habitat in southern Armenia. Yet, it is highly fragmented which probably poses a problem for the viability of the population. A preliminary estimate of population size in Khosrov forest state reserve was done, using the available suitable habitat in this area and typical home range sizes of Eurasian lynxes in Switzerland. According to this estimate, Khosrov forest state reserve could support a population of 2-7 lynxes, depending on the gender ratio and prey availability. Furthermore, gaps of study were identified. In all provinces there was suitable habitat which had not been sampled so far. Beyond, the data available are not sufficient for a robust estimation of population size in the study area, which is an urgent step for further conservation actions.

Introduction

The Caucasian lynx (*lynx lynx dinniki*) is a subspecies of the Eurasian lynx (*lynx lynx*). It is listed as least concern by IUCN due to data deficiency. Nevertheless, Breitenmoser et.al. (2008) report that the Caucasian lynx is endangered. In Georgia, it is already on the red list since 1983 (ibid.). One reason is the geographic and genetic isolation of the Caucasian lynx, which make them a valuable, unique species, with a small range though. The Caucasian subspecies is the most isolated one of all Eurasian lynxes. The range, formerly big, shrank significantly in the last years (Breitenmoser et.al. 2008). Habitat degradation, urbanization and poaching supposedly also put them in the Armenian part of the range under pressure. Anyhow, there is no monitoring or conservation program in Armenia so far, not even an estimation of population size. Information on the lynx by local people and researchers are contradictory. According to Vanuhi Hambardzumyan (NABU Armenia, personal communication), there were no human-wildlife conflicts with lynxes reported so far, which suggests that lynxes are rare or have at least enough suitable habitat and prey that they don't need to feed on livestock. On the other hand, some villagers report lynxes to occur widespread in Armenia. The lacking knowledge, isolated, shrinking range and pressure on unmodified areas pose an urgent need for research of the Caucasian lynx. This study of habitat suitability in southern Armenia should act as first contribution to a monitoring and management program of the endangered Caucasian lynx, giving information where the lynx potentially lives and therefore indicate areas where further research is advisable.

Study area

The study area comprises the provinces of Ararat, Vaots Dzor and Syunik. The environmental conditions are represented in figure 1 on page three. These are the predictors used in the model. As we can see, bezoar goats (*capra aegagrus*) are not everywhere, but also not particularly rare. Furthermore, the terrain is quite mountainous and rugged, represented by the fraction of pixels with a slope higher than 40%. The whole study region is covered with snow in winter, with a minimum of 5 cm and a maximum of 68 cm. Finally, the area is remarkably influenced by humans, as the two predictors land cover and distance to roads show. The land is mainly covered with potential range land and crop land. Natural land cover such as different kinds of forest, sparse vegetation, water and snow only make up a small part of the territory.

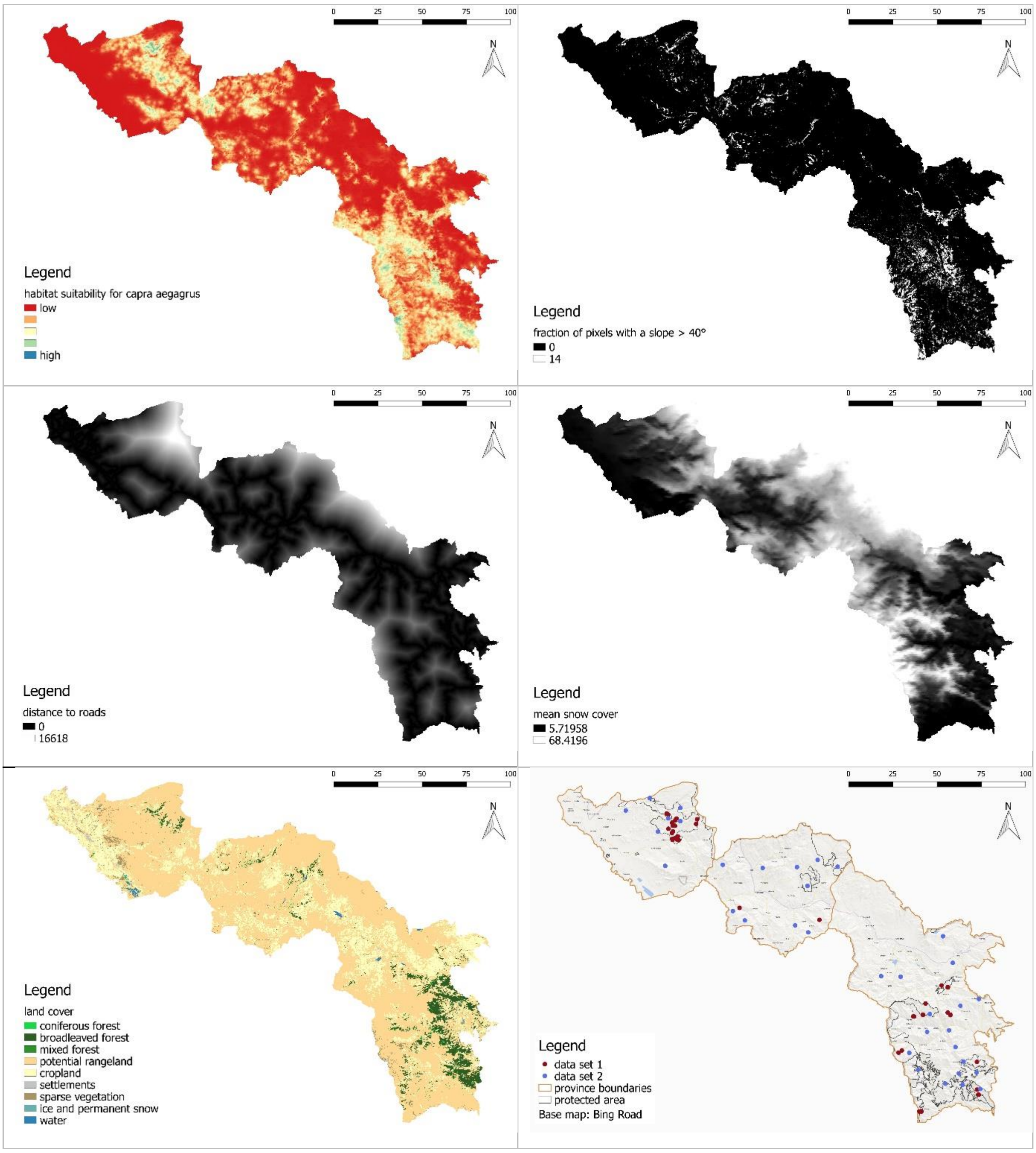


Figure 1: environmental conditions of the study region; represented by the main predictors for the model + spatial distribution of lynx presence points

Target species

Spatial behavior

The Caucasian lynx (*lynx lynx dinniki*) is a subspecies of the Eurasian lynx (*lynx lynx*). Its current distribution comprises the Caucasus mountains south to Turkey, Iraq and Iran (Breitenmoser et.al. 2015). According to Breitenmoser et.al. (2008) Eurasian lynxes in Switzerland live solitary and territorial, while territorial refers to individuals of the same sex. Home ranges of one male and one female, as well as females with their kittens, can overlap. Kittens usually stay one year with their mother, until the next mating season in spring. After this year, kittens disperse and try to occupy their own territory. During this dispersal, young lynxes that are not able to occupy their own territory often don't survive (Breitenmoser et.al. 2008). According to Heptner et.al. (1992), lynxes follow their prey in winter, changing their home range. This could not be proved by telemetric data (Breitenmoser et.al. 2008). When prey is very scarce, lynxes give up their home range and disperse to another area (Heptner et.al. 1972). For hunting, lynxes split their home range in several parts where they only return once in 1-2 weeks (ibid.). This might be due to their hunting habit, tracking their prey and then surprisingly attacking it. In most cases, lynxes don't chase for longer than 20m. If the chase lasts longer, it is more likely to be unsuccessful. As lynxes are not very successful in chasing over long distances, their prey should not get used to them, which is the reason for the different hunting sections and solitary living (Breitenmoser et.al. 2008). On the contrary, Heptner et.al. (1972) reported that lynxes sometimes hunt in couples, which nevertheless could not be confirmed by the telemetric studies of Breitenmoser et.al. (2008). Moreover, places for hunting differ from those for staying during the day. During the day, lynxes in Switzerland are in terrain with an average slope of 41°, while killed prey was found in areas with an average slope of 34° (ibid.). The size of the home range is smaller in rugged terrain than in flat land (Heptner et.al. 1972). Home ranges of males are bigger than those of females (ibid.). In addition to the home range, lynxes have a roaming area, where they don't behave territorial and only show up occasionally. The distinction was made by Breitenmoser et.al. (2008), derived from telemetric data.

Habitat

Over the entire range of the Eurasian lynx, the habitat involves a broad variety of conditions and landscapes. In the Caucasus region, the lynx inhabits rocky, rugged terrain covered with different kinds of forest. These comprise fir, oak or deciduous forests. Preferred is dense undergrowth, where it is easier to hunt. Rocky sections, wind-fallen trees and other features in the landscape serve as outlook and den (Heptner et.al. 1972). Over the entire range, the lynx inhabits areas with snow cover in winter. With the fur at its paws, that grows in winter, and its high legs, it is especially adapted to walking in snow. The snow should not be deeper than 40-50 cm though or having a solid crust that supports the weight of the animal (ibid.). In winter it is sometimes seen close to villages.

Prey

According to Breitenmoser et.al. (2008), the Caucasian lynx mainly feeds on ungulates, followed by birds and small mammals. Heptner (1972) mentioned, in more detail, tur (*capra sp.*), chamois *(rupicapra rupicapra)*, red deer *(cervus elaphus)*, roe deer *(capreolus capreolus)*, wild boar *(sus scrofa)*, and mouselike rodents. The highest percentage, as in the table shown below, is occupied by tur, chamois and mouselike rodents (ibid.). Different sources agree on an average daily amount of 1-1,5kg (Breitenmoser et.al. 2008, Heptner 1972). Like most carnivores, lynxes don't eat every day, but sometimes eat much at once and then starve for a few days until killing their next prey. Depending on the size of the killed prey, lynxes use it for several days (Breitenmoser 2008). Prey availability is supposed to have a big influence on lynx distribution and was also in other spatial models for the Eurasian lynx the main predictor (Filla et.al 2017).

Food item	Winter-spring	Summer	Autumn	Entire year
Tur [*Capra* sp.]	26.0	19.2	14.3	19.1
Chamois [*Rupicapra rupicapra*]	26.0	16.6	14.3	17.6
[Red] Deer [*Cervus elaphus*]	8.7	10.2	5.7	8.8
Roe deer [*Capreolus capreolus*]	4.3	1.2	8.5	3.6
Wild boar [*Sus scrofa*]	13.0	2.5	—	4.4
Hare [*Lepus europaeus*]	—	1.2	—	0.7
Squirrel [*Sciurus* sp.]*	—	—	5.7	1.5
Mouselike rodents	21.7	43.0	28.5	36.0
Mammals of moderate size (not identified)	—	2.5	5.6	2.7
Black grouse	4.3	5.0	11.4	6.6
Small birds	—	2.5	—	1.5
Insects	—	1.4	11.4	6.6

Table 1: Prey species of the Caucasian lynx. (Heptner 1972, p. 601)

Methods

SDM – Maxent general

The software MaxEnt used in this study is a software used (among others) for species distribution modelling (SDM). SDMs estimate the habitat suitability of a given area based on the conditions at presence points (Phillips et.al. 2006). As the model is based on presence points, which represents the conditions at places where the species actually lives, the realized niche is modelled rather than the fundamental (ibid.). The first SDMs were based on presence-absence data, which are difficult to obtain; often only presence-only data are available. MaxEnt is a software dealing effectively with presence-only data (Merow et.al. 2013). Still, presence-only data include some drawbacks. Absence data give information about which areas were surveyed, allowing for an estimation of the spatial bias, and the detectability of the species (Hijmans et.al. 2011). In MaxEnt, conditions at presence locations are contrasted against the density estimation of conditions in the entire study region. According to the maximum entropy principle, the distribution should be as close to the prior that every point has a probability of 0.5 (default setting) of occurrence. This prior assumption is then constrained by the environmental input layers. The predicted distribution chosen by MaxEnt (among many possible) is therefore the most random one while still considering the environmental constraints provided (Merow et.al. 2013).

Presence data

All presence data used were kindly provided by WWF Armenia. They were divided into two sets. The first set contained 71 presence points in the provinces of Syunik, Ararat and Vayots Dzor. They were all sampled in protected areas in the time span between 2011-2017. The sampling method and time span of the second data set were unknown, but records are distributed randomly all over Armenia. For this study, only those from southern Armenia, in the same districts as for the first data set, were chosen which resulted in a number of 35 presence records. The total number of presence points were therefore 85 presence points.

Predictors

The tested predictors for this model can be separated in three clusters: anthropogenic, environmental conditions and prey availability. As anthropogenic variables the Euclidean distance to roads and the Euclidean distance to settlements were available, as environmental predictors elevation, land cover, slope, fractional slope, mean snow cover of the years 2001-2012 and the standard deviation of slope and snow cover. Fractional slope was the percentage of pixels with a slope higher than 30, 35 or 40%, representing terrain ruggedness. All three of them were tested as individual layer. For prey availability a summer and a winter model of Armenian mouflon (*ovis orientalis gmelini*) habitat suitability and a habitat suitability model of bezoar goat (*capra aegagrus*) were available. All of them were kindly provided by Hendrik Bluhm and Benjamin Bleyhl (Humboldt University Berlin). The predictors were at a spatial resolution of 300m.

Procedure

According to Merow et.al. (2013), there are two approaches for modelling. The first one assumes that individuals have been sampled randomly and the number of presence records represents population density, the second one assumes that grid cells have been sampled randomly. When the total population size is known, the first model predicts the expected number of individuals for each grid cell. The second model predicts the habitat suitability for each grid cell. As the population size is unknown in our case and a model that predicts habitat suitability was desired, the second approach was chosen. Therefore, only spatially unique records were used for model building, duplicates in a grid cell were removed. This reduced the presence records in the first set from 71 to 50 observations, the 35 observations of the second data set all fell in individual grid cells and were therefore all used for model fitting. This resulted in a total number of 85 presence points used for model fitting.

In a next step, collinearity between predictors was tested. Collinearity can be a problem, because it might inflate variance of regression curves and therefore lead to a wrong selection of relevant variables (Dormann et.al. 2012). The function removeCollinearity of the package virtualspecies returns all predictors with a pearson correlation higher than 0.7 as a cluster. Distance to roads and distance to settlements were correlated. Distance to settlements is implicitly included in distance to roads and was therefore chosen as predictor for human disturbance. Moreover, elevation, snow cover and the standard deviation of snow cover were correlated. Elevation often serves as a proxy for other variables, in this case obviously snow cover, so it was excluded. As snow cover showed a higher contribution to the model, it was chosen over the standard deviation of the latter. Naturally, the fractional slopes were correlated. The one with the highest contribution, fractional slope 40 was chosen. Finally, the mouflon models were correlated. Both didn't contribute much to the model, so both were excluded.

In a next step, variables were chosen. Therefore, a jackknife test was run with different variables, and 10-fold cross validation with different variables was performed. The pseudo-absences for cross validation were randomly chosen over the study area with a total number of 50.

As two different data sets were available, one with a strong spatial bias and the other of unknown sampling method, these were individually tested, as well as together. It was also tried to account for spatial bias by randomly removing some presence points from the first data set, so both the spatially biased and the apparently random data set had the same size. This resulted in a total of 72 presence points used for training.

Results

Habitat suitability Maps

The habitat suitability map for lynxes looks very similar to that for bezoar goats, which means that the lynx predictions rely mostly on the abundance of prey, which is also supported by the maxent outputs (see below).

According to the map, suitable habitat is quite widespread in southern Armenia. Nevertheless, there are only islands of suitable habitat, surrounded by highly unsuitable habitat. This probably poses a problem, since lynxes usually don't cross vast areas of unsuitable habitat during the regular dispersal when leaving their mother (Zimmermann et.al. 2006). Only when resources are very scarce, lynxes migrate to other areas (Heptner 1972). This was also the case for the lynx population in the bohemian forest, where suitable habitat was available, but was not occupied because lynxes could not hurdle the barrier of unsuitable habitat (Magg et.al. 2015).

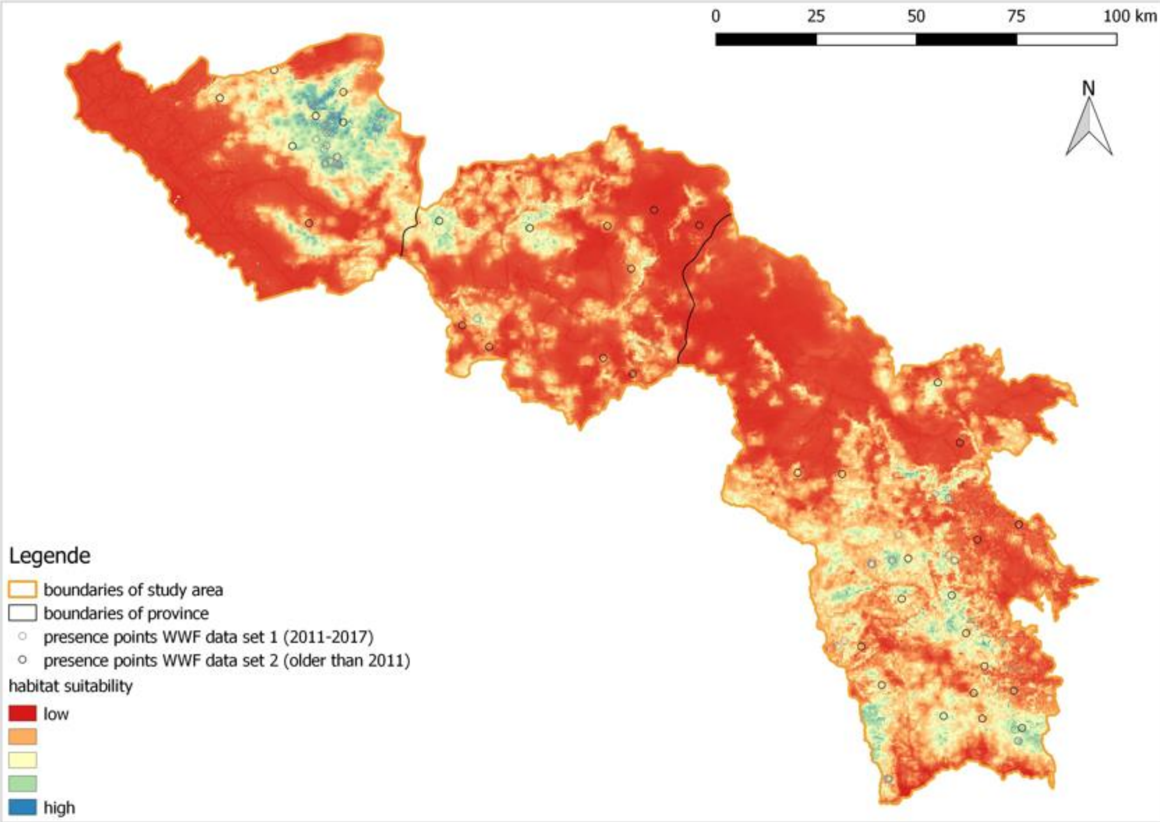


Figure 2: Habitat suitability of lynx lynx dinnikii in the provinces of Ararat, Syunik and Vayots Dzor. This map shows the logistic output, representing the percental habitat suitability of each raster cell. Values range from 0-100%

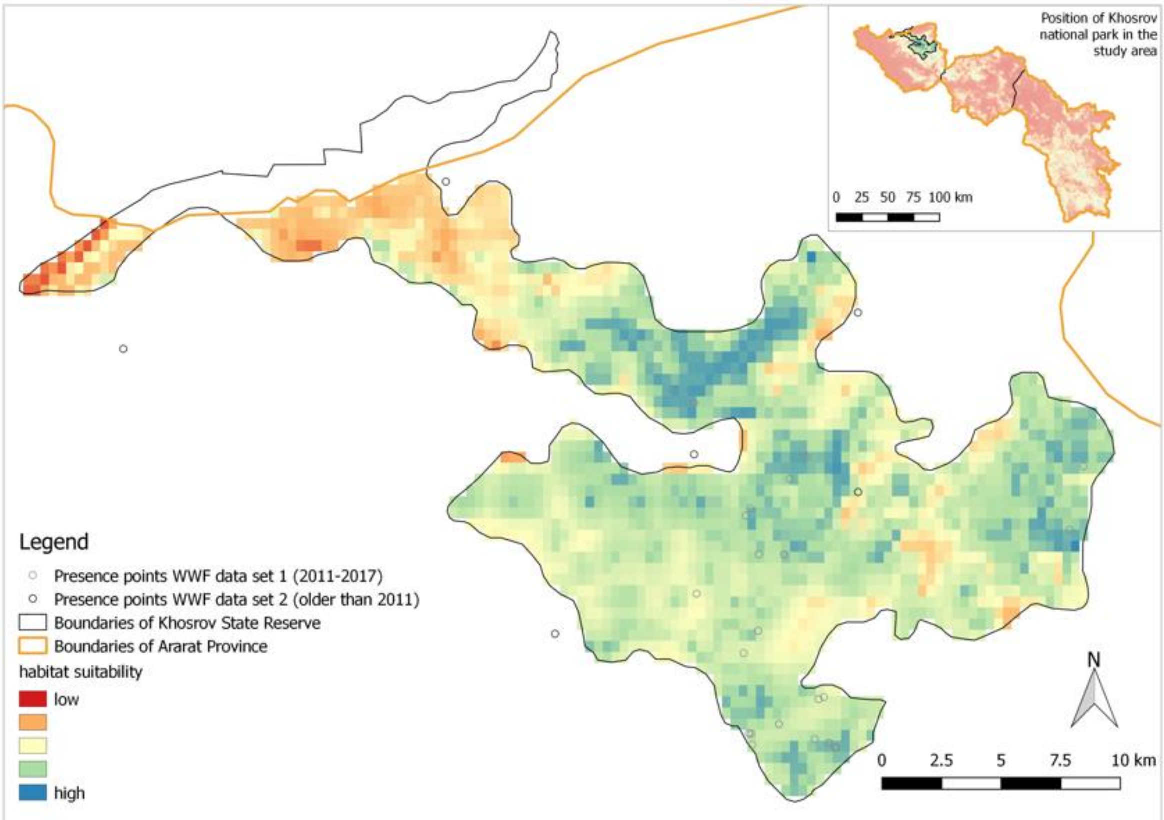
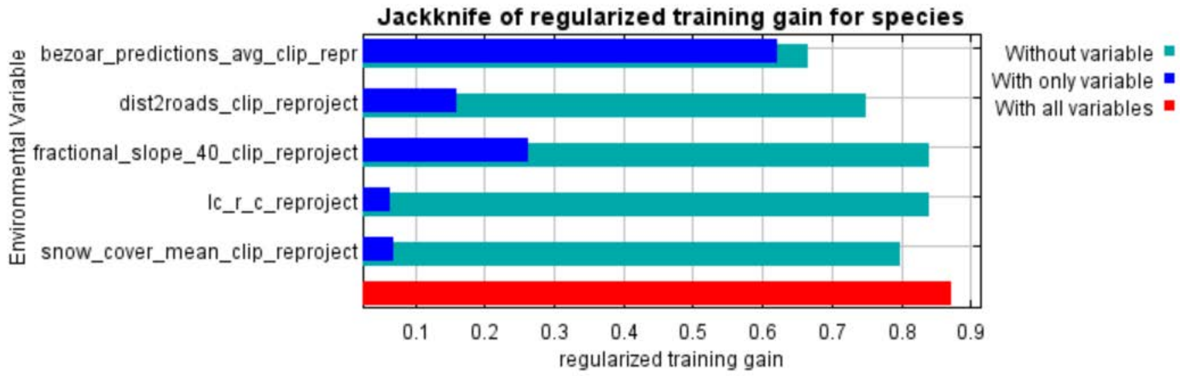


Figure 3: Habitat suitability of lynx lynx dinnikii in Khosrov state reserve. The empty part falls into Kotayk province and therefore outside the study area. This map shows the logistic output, representing the percental habitat suitability of each raster cell. Values range from 0-100%

Variable	Percent contribution	Permutation importance
bezoar_predictions_avg_clip_repr	63.7	72.4
dist2roads_clip_reproject	12.3	16.8
fractional_slope_40_clip_reproject	10.4	0.4
snow_cover_mean_clip_reproject	8.7	7
lc_r_c_reproject	5	3.4



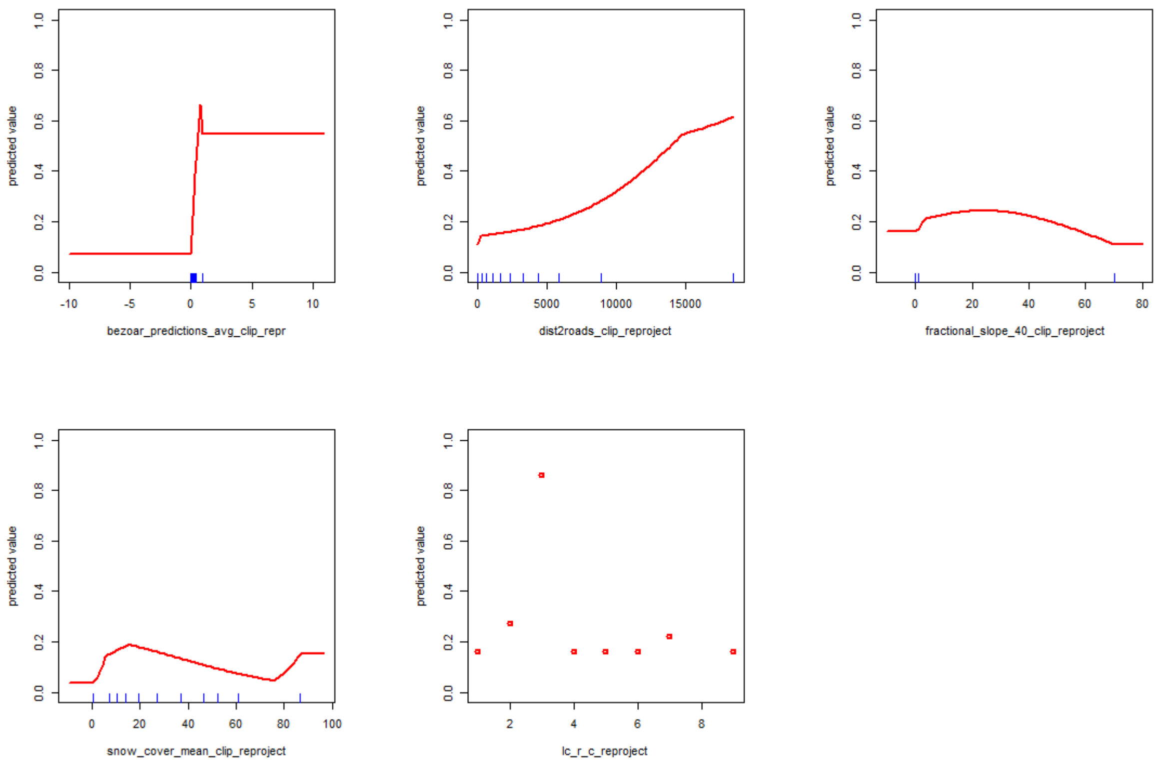


Figure 4: MaxEnt outputs – variable contribution, jackknife results and response curves. Values for land cover are: 1 – coniferous forest, 2 – broadleaved forest, 3 – mixed forest, 4 – potential range land, 5 – cropland, 6 – settlements, 7 – sparse vegetation, 8 – ice and permanent snow, 9 - water

Response curves and important predictors

The model yielding the highest AUC after the cross validation comprised the variables ‘distance to roads’, ‘habitat suitability of bezoar goat (*capra aegagrus*)’, ‘terrain ruggedness’ (represented by the fraction of pixels with a slope higher than 40%), ‘mean snow cover’ and ‘land cover’. The mean AUC after 10-fold cross validation was 0.83. Leaving the predictor ‘land use out’ yielded the same AUC. Fitting the model without the predictor ‘bezoar habitat suitability’ yielded a lower AUC (0.79) with different predictor contribution and permutation. Figure 3 shows the percent contribution and permutation importance, jackknife results and response curves from MaxEnt output. Percent contribution refers to the importance of the predictor in model fitting but does not reflect the importance for prediction. Permutation importance shows the drop in AUC when this variable is randomly permuted and is therefore the relevant measure for determining variable importance. Jackknife determines the model performance when leaving a certain variable out and training only with this variable. Response curves show the predicted probability for each value of the predictor.

The most important variable is obviously the predicted habitat suitability for bezoar goats. The response curve for this predictor doesn’t make sense from an ecological point of view but can be explained by the highest available value of that model, which is 0.59. The drop of the curve occurs after this extreme value, where it is not based on true data anymore. The high permutation importance and the lower AUC of a model without that predictor prey availability is the most important factor determining lynx distribution. Human disturbance, represented by distance to roads is the second most important predictor, which is ecologically explained through the shy behavior of the lynx and the need for undisturbed terrain for hunting. Snow cover is an important variable, as mentioned above, as from a certain depth of snow lynxes can’t move well anymore, which also affects hunting and other activities. According to this model, lynxes are already negatively affected by a snow cover of 20 cm, not like Heptner et.al. stated, 40-50 cm. The importance of land cover is surprisingly low, with the highest response to mixed forest, followed by sparse vegetation. Fractional slope has a low predictive value but is important for model fitting. The initial rise might be related to bezoar habitat suitability, but also to the preference of lynxes for rugged terrain. With a higher fractional slope, the terrain might not be traversable for lynxes anymore, which explains the drop.

The tests with different data sets yielded the highest AUC for the first data set than for the second, which was only sampled in national parks. This isn’t a surprise, as conditions in different national parks are quite similar and models therefore easier to fit. When testing both data sets individually, response curves differed significantly. For set 1 they showed less response to all variables, which can be explained by the more uniform conditions in national parks, where set 1 was sampled.

Gaps of study

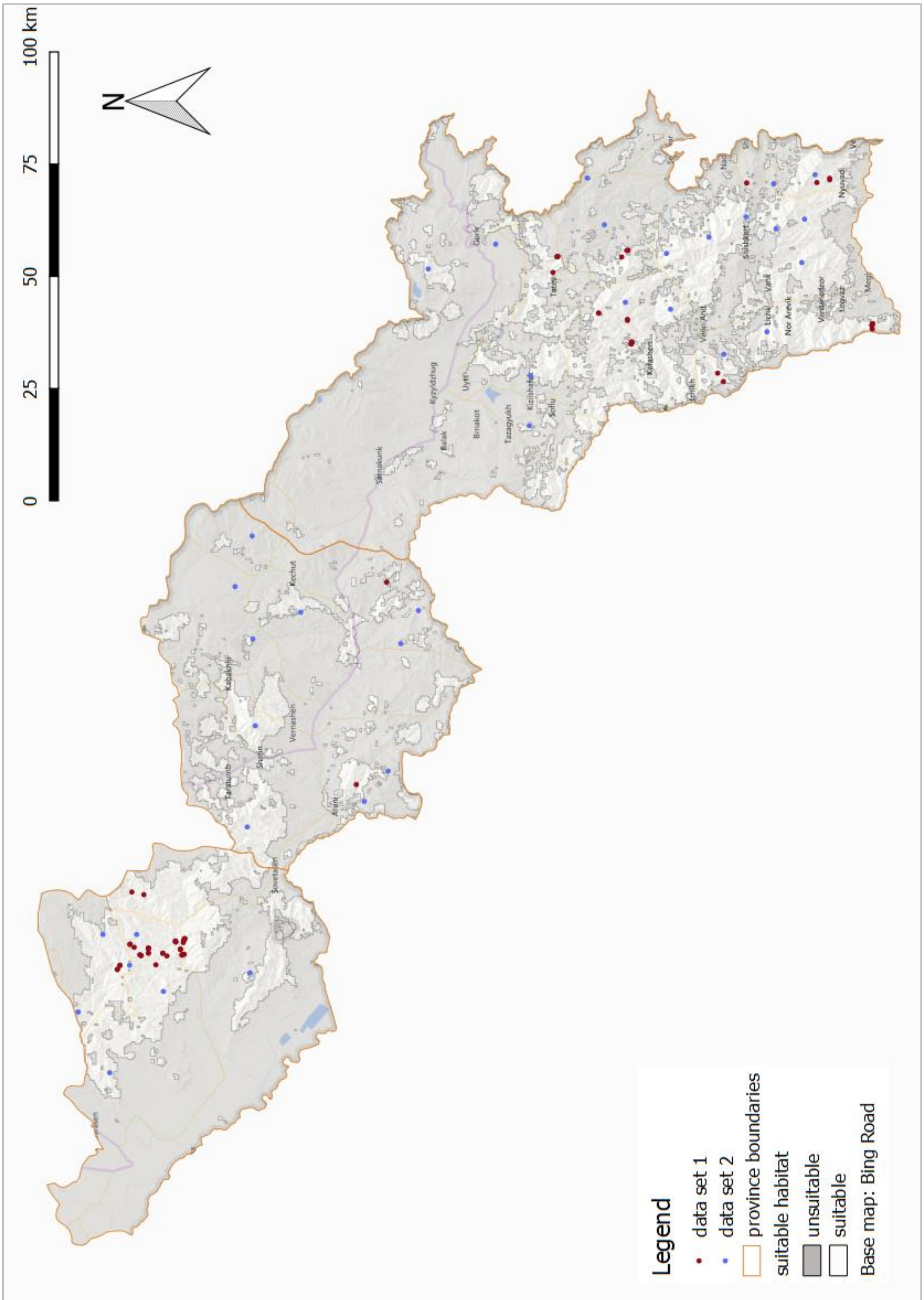


Figure 5: gaps of study

Figure 5 shows the gaps of study in southern Armenia. The light areas are suitable habitat, the darker habitat is unsuitable. Suitable habitat was determined from the habitat suitability map for all areas with a probability higher than the maximum true positive vs. true negative rate (max.TPR+TNR). In Ararat region, there is suitable habitat outside of Khosrov state reserve, which should be further explored. In Vayots Dzor, the biggest patches of suitable habitat are in the north-western part, but also the other, smaller patches should be further investigated. In Syunik, most suitable habitat is in the south of the province, but relatively little research was done there. Most presence points were sampled in Khosrov, why I would suggest focussing on the other national parks and suitable areas indicated by the map.

Population size in Khosrov State reserve

Due to the data quality, the determination of the population size can only be a rough estimate. Usually population size is estimated with the capture-recapture method. As for this study only single photos were available, allowing for the determination of a presence, but not for distinguishing individuals, estimated the population size according to available suitable habitat in the reserve and typical home range sizes. Breitenmoser et. al. (2008) distinguish between the home range and the roaming area. In their home range, lynxes usually don't accept any other lynx of the same sex, except for mothers with their children. The roaming area is the maximum distance a lynx walks from time to time, but not regularly. Roaming areas of individuals can overlap, so I took the home range as a basis for estimation. In telemetric studies in Switzerland, home ranges of different individuals varied significantly. For female lynxes, the minimum home range was 30km², the maximum 360km² with an average of 147km². For male lynxes, the home ranges varied between 102km² and 538km² with an average of 236km². According to the habitat suitability map, 204,93km² suitable habitat is available in Khosrov. For this estimation, a threshold was set at 0,27, which is the maximum true positive plus true negative rate (max TPR+TNR) of this maxent model. This area could support 1-7 female lynxes or 1-2 male lynxes, supposed the home ranges of the Caucasian lynx are of similar size compared to those in Switzerland. Numbers are round up, because the Khosrov has no clear physical boundary, and the surrounding habitat is also suitable. Therefore, depending on the gender ratio, 2-7 lynxes could live there. As juveniles usually share the home range of their mother, there could also be some juveniles, depending on the number of female lynxes. Usually there are 1-3 juveniles that stay for the first year with their mother and are left behind by her during the mating season in spring (Breitenmoser et.al. 2008). If the maximum density in this area was already reached, they would disperse to a further place and therefore not contribute to the number of individuals in Khosrov. Nevertheless, this can only be a rough estimate, as home range sizes vary significantly depending on environmental productivity and prey availability (Herfindal et.al. 2004), which is not known for Khosrov.

Discussion

This can only be a preliminary study, for several reasons. First, as already mentioned in methods, the presence points are most likely spatially biased. Half of the used presence points were only sampled in national parks, without sampling other areas. Spatial bias is a problem for model building, because MaxEnt uses the density distribution of the conditions at presence points to derive the optimal conditions for the species. The algorithm assumes that conditions are represented according to their suitability. Thus, if presence points in a certain habitat type are more abundant, this habitat type is considered more suitable. If the abundance is not due to better habitat suitability though, but due to more intense sampling, the model is distorted, predicting a higher suitability for a habitat that isn't truly better than other habitat types.

Second, data set 2 was of unknown derivation, with neither the time nor the method of sampling known. Especially the unknown time of sampling might pose a problem. If data are too old, critical conditions, e.g. land use and therefore prey availability, might have changed. Running the model with old presence points but recent predictor layers can produce false predictions. All in all, the reliability is questionable, as certain response curves to predictors were completely opposite when testing with both data sets independently. Nevertheless, they were included, trying to compensate the spatial bias.

Thirdly, only one prey species with a limited distribution was included in model building. The model output for lynxes therefore corresponds very closely to the one of bezoar goats, if not to say it is the same. This is anything but optimal, but these were the only data available. There are other prey species, for example hares or roe deer, that are probably more likely to occur more widespread than the included bezoar goats, probably extending the possible range of lynxes and should be included to attain a refined and more precise model.

The drop in AUC when the second set of presence points is explained by the shortcoming of only including one prey species. The AUC compares the false negative rate to the false positive rate. The presence points from data set 1 were probably sampled in the same way as the ones for bezoar goats, leading to a strong correlation and a high AUC. The presence points for data set 2 were sampled in a different way, falling outside the range of bezoar goats. Since bezoar presence was still the strongest predictor, the points from data set 2 didn't contribute much to the model, but were then counted as false absences, leading to the drop in AUC.

Still, this model also has its strength. When testing with different variables and with the different data sets, the visual output of predicted suitable habitat was very similar. This suggests that these predictions are, against all drawbacks, still robust and contain valuable information for further research on lynx in Armenia.

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Awareness raising materials distribution and education

Manush Abrahamyan

1. Public opinion polls and interviews

We have implemented study for exploring attitude of local people towards the main carnivores (focusing on Lynx) and getting additional data about possible presence of Lynx. The methodology included interviews with local people and measures of public opinions with surveys. The specifically designed questionnaire was used for surveys with the aim to know intensity and pattern of human-lynx conflict, and for future to assess the effectiveness of conflict mitigation measures. The public opinion surveys and interviews were carried out in 8 villages (Khndzoresk, Hors, Taratumb, Yeghegis, Artavan, Jermuk, Areni and Khachik) among 286 residents. As a result of our study, we have revealed following:

- There is no specific human-lynx conflict and registered attacks on livestock in the target areas.
- In general, local people have positive attitude towards Lynx. However, we have indicated human-bear and human-wolf significant conflicts.
- Only few respondents observed Lynx in the wild. Majority of them misidentify Caucasian Lynx with Caucasian Leopard, which is very rare species in this area.

2. Seminars for schoolchildren and distribution of materials

3 seminars were organized at two schools of Syunik and Vayots Dzor provinces. We proceeded to organization of a series of works to the educational and awareness-raising activities among the locals. In Syunik and Vayots Dzor regions were conducted lectures for schoolchildren (school of Khndzoresk and Taratumb). The main goal of seminars was to introduce them the information about Lynx, talk about the importance of its conservation in the wild and to promote a friendly attitude of local residents towards wildlife. The theme of the lectures was to familiarize children with biodiversity rich area of their settlements. Schoolchildren have been informed about the importance of wild animals and the issues of their conservation through lectures and group discussions

We designed and published the 100 wall calendars where half of area of page contains the pictures of the Lynx and message of conservation. We distributed calendars among local people in the target communities.