Preventing the extinction of the Dinaric-SE Alpine lynx population through reinforcement and long-term conservation

LIFE16 NAT/SI/000634

Surveillance of the reinforcement process of the Dinaric - SE Alpine lynx population in the lynx-monitoring year 2020-2021

Action C.5

Including data collected within Slovenian national large carnivore monitoring scheme

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* LD - hunting club (in Slovenia), LPN - The special purpose state-owned hunting grounds (in Slovenia), NP - national park, PP - nature park, PLI - Progetto Lince Italia, CUFAA - Carabinieri Command of Units for Forestry Environmental and Agri-food protection, SF = Stazione Forestale, ÖBF = Österreichische Bundesforste, RC T-M = Riserva di Caccia Tarvisio-Malborghetto

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1. INTRODUCTION

The main goal of the LIFE Lynx project (LIFE16 NAT/SI/000634) is preventing extinction of the Dinaric – Southeastern Alpine lynx population through reinforcement. Monitoring of the reinforcement process is fundamental in order to be able to fine-tune the process over the years and to choose and implement the optimal solutions for the upcoming lynx releases. It will be also essential in order to gain a good understanding of the process, upon which long-term lynx conservation strategy will be based, and to share experiences from our project with the broader expert community involved in lynx conservation efforts across the species range and potentially other felid species worldwide. Within the C.5 action, we are annually surveying the lynx population and impact of the reinforcement activities over its entire project range in Italy, Slovenia, and Croatia, using methods that allow us to assess its size, distribution, genetic structure, and several other important population and ecological parameters.

However, we could not have presented such a detailed status of the lynx population if we had not also included the data obtained through funding from other international or national projects (see the acknowledgments). Combining different resources allowed us to produce a result that surpasses any of the individual project's or program's goals. For example, roughly half of the camera traps in Slovenia were purchased and maintained with funding from the national large carnivore scheme (Ministry of Environment and Spatial Planning of Slovenia) and thus significantly contributed to the level of accuracy of the data collected and presented in this report. Therefore in Slovenia, the field design used for camera trapping surveillance allows us to collect data which can be used to make more robust conclusions about the lynx abundance at a national level. Consequently, all these additional data importantly support the decisions made regarding future lynx translocations which is the core activity of the LIFE Lynx project.

This report describes the progress of the reinforcement of the lynx population in the Dinaric Mountains and Southeastern (SE) Alps. It builds on the first annual report within C.5 action (Krofel et al. 2021), where the results of the first lynx translocations to the Dinaric Mountains were described, together with an updated status about the remnant lynx population. The minimal population size of lynx in the Dinaric Mountains in the 2019-2020 survey season was 101 adult lynx, including two translocated lynx from Romanian Carpathians (Goru and Doru). While Dinaric Mountains were the stronghold for this population, only a few records were available from the pre-Alpine area and no lynx was detected in the SE Alpine area in the previous year (Krofel et al. 2021), while one female was still reported in Italy in 2018-2019 (Slijepčević et al. 2019). The highlight of the last annual report of C.5 action (for lynx year 2019/2020) was the confirmed reproduction of one of the two translocated lynx (Goru), who reproduced immediately after translocation within his established home range in Mala Gora, Slovenia. In total, 15 reproductions were detected in the entire survey area that year (Krofel et al. 2021).

The potential of further inclusion of translocated animals and their offspring to the remnant lynx population is high: if they will form 15% of the total population, the inbreeding estimated from expected heterozygosity would drop to 0.21 which is within the range we observed in the 1980s (around 0.18) when population still seemed viable (Krofel et al. 2021). We expect that long-term improvement of genetic status will start showing only after translocated animals will continue to transfer their genes into the population. In this report, we describe the events that further indicated that reinforcement of the inbred population is under way and that it would help prevent the extinction of the Dinaric SE-Alpine lynx population.

The baseline demographic survey of lynx year 2018/2019 allowed us to detect areas which were the most suitable for the first releases. According to the results obtained, we released lynx into the inbred population in Slovenia and Croatia (Slijepčević et al. 2019; Hočevar et al. 2021). The surveillance data collected in the year 2019-2020, provided us with optimal locations for releases in the year 2020-2021.

We have been monitoring the progress of the reinforcement with several complementary methods, i.e. camera trapping, non-invasive genetic sampling, GPS telemetry and collecting mortality records. We adjusted some aspects of their implementation, e.g. choosing new locations for camera traps, according to the new experiences to increase the monitoring efficiency. We also continued with collecting opportunistic data and categorizing them into SCALP categories (Molinari-Jobin et al. 2021), which gave us additional information about lynx population distribution and helped to fine-tune camera trapping and non-invasive genetic sampling. Furthermore, collaboration with hunters was enhanced and expanded into the new hunting grounds not included in the systematic lynx surveillance in the previous years.

With this report, we fulfil the second objective of the C.5 action by providing the information about the basic demographic parameters (e.g. lynx distribution, minimum number of adult individuals and minimum number of reproductions) and the key parameters describing the genetic status (e.g. inbreeding coefficient) of the lynx population during reinforcement process, as well as detailed information about the history and current status of all the translocated animals after their release. In this report, we additionally provide the first estimates of lynx population density in the core Dinaric range for years 2019-2020, using the spatial capture recapture framework (Royle et al. 2014).

The surveillance results presented in this report focus on "lynx-monitoring year" 2020-2021 (i.e. 1st May 2020 until 30th April 2021), which is in accordance with the SCALP methodology as an international standard for assessing and reporting the lynx status (Molinari-Jobin et al., 2021). However, we also report some of the data collected outside this time frame (i.e. collected after 30th April 2021), when they were relevant for the further release plan and to obtain a fuller picture of the current situation. Whenever this was done, we noted the extended surveillance period of the shown data.

Chapters of this report are structured so that we first describe the effort and the data obtained with each of the method used (chapters 2.1-2.5) and then we synthesize and interpret the current status of the lynx population for each specific region within the population according to combination of all data obtained from all methods (chapters 3.1-3.4). Based on the results of the surveillance, we also provide recommendations for further lynx releases at the end of the report.

2. METHODOLOGY AND RESULTS

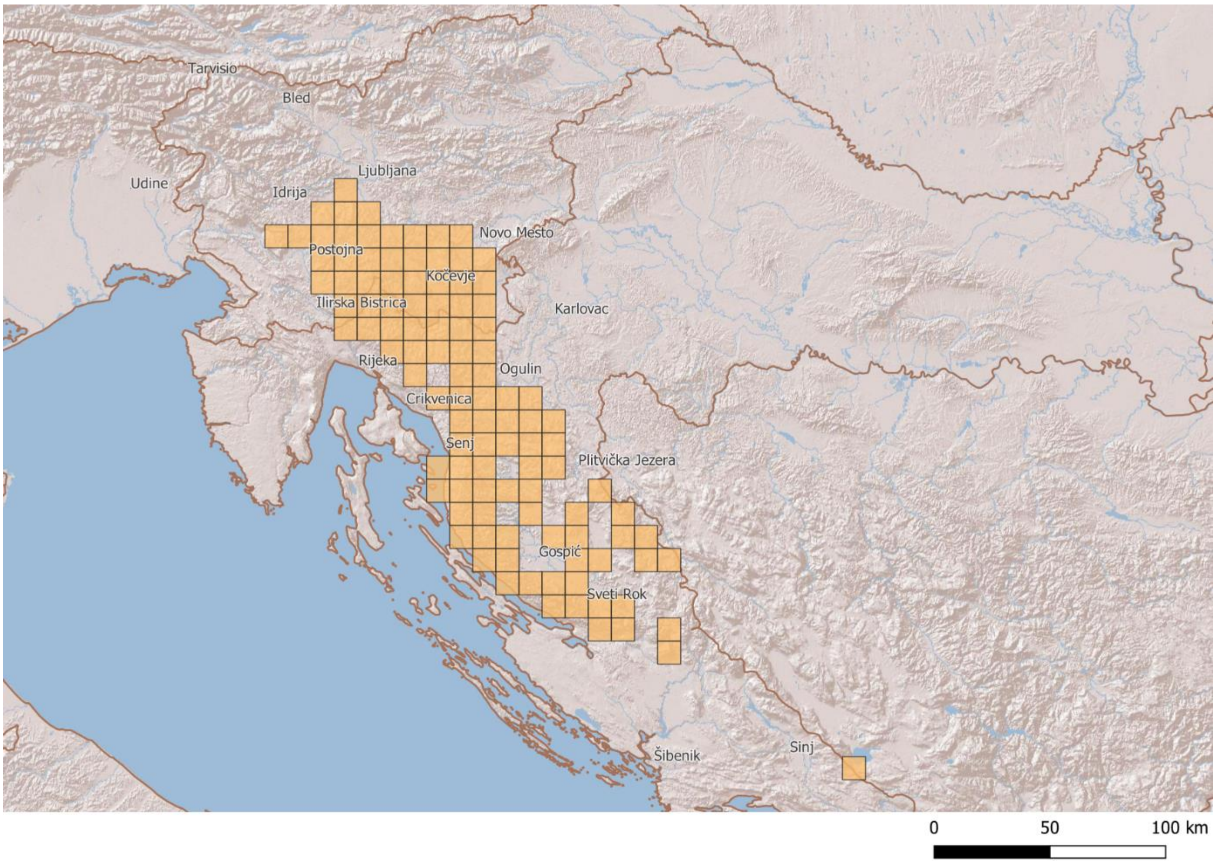

Figure 1. Confirmed lynx distribution in the Dinaric-SE Alpine area based on available data from Italy, Slovenia and Croatia in 2020-2021. Grid cells were colored on the basis of confirmed records of lynx in a standard European 10 × 10 km grid net. Four types of data were considered as confirmed lynx records: opportunistic data categorized as C1 or C2 record, GPS locations from collared animals, camera trapping records and genetic records.

2.1 Opportunistic data collection

Opportunistically-collected data represents the basic information available for lynx presence across the three countries (Italy, Slovenia and Croatia) and is an important guide for all further efforts aiming to evaluate lynx population parameters in a more coordinated and systematic way. The categorization of opportunistically-collected lynx presence data follows an international standard (Molinari-Jobin et al. 2003), making these data comparable over different habitats, regions, and countries. It recognizes three levels of opportunistic data reliability, so called SCALP ("Status and Conservation of the Alpine Lynx Population") categories: unconfirmed records (C3), records collected or verified by lynx experts in the field (C2) and hard facts with material evidence (C1). The data is usually presented in a grid with 10×10km cells, e.g. (KORA 2017, Molinari-Jobin et al. 2020). Traditionally, SCALP reports were produced on an annual level following calendar years, but since 2017 it has been agreed that the data is summarized per "biological lynx year" (i.e. from 1st May of the given year till 30th April of the following year), which is also a standard used in this report.

In north-eastern Italy, no opportunistic lynx records were available, further confirming that lynx are possibly locally extinct in this region (Krofel et al. 2021). However, two scats presumably from lynx were collected in the Veneto region (Figure 2), but species or individual identity could not be confirmed with subsequent genetic analyses. We therefore cannot confirm lynx presence anywhere in north-eastern Italy. In the Slovenian Alpine region (Julian and Karavanke/Kamnik-Savinja Alps) there were no (confirmed) records about remnant lynx presence in the previous season, suggesting that remnant lynx were not present in that area. We can also suspect that absence of resident females in these regions was the cause why Maks, male translocated from Slovakia and released in Slovenia in 2020, did not stay in the Slovenian Julian Alps (see telemetry chapter for details), where he moved to in December 2020. However, translocations of Carpathian lynx to the Slovenian Alps in April 2021, are changing the status of lynx in SE Alps (for details, see chapter 2.5). Encouragingly, the pre-Alpine region seems to foster persistent presence of remnant lynx as non-invasive genetic samples again confirmed the presence of at least one remnant male lynx in Hrušica plateau and further opportunistic C1 records were collected in the adjacent Trnovski gozd (Figure 2, chapter 2.2 for more details).

In Croatia, opportunistic records confirmed the main lynx distribution area in Gorski kotar, Lika and northern Dalmatia. Lynx mortality was recorded in Split county, south of Sinj, which is the southest ever recorded C1 sign of lynx presence in Croatia. In previous years we had several C3 records of lynx presence in Split county and Pelješac peninsula. We assume individual lynx occasionally disperse to this area (either from Lika and northern Dalmatia, either from Bosnia and Hercegovina) but poaching is an obstacle to permanent residence.

Widespread and effective collaboration with hunters in Slovenia provided again most of the opportunistic data. In addition, within the framework of the national large carnivore monitoring scheme, we sent out questionnaires twice per year (in May and August) to the Slovenian hunting grounds which are located areas with potentially suitable lynx habitat (n=215). Each hunting ground answers the questions about the lynx presence, whether that was regular or occasional. We pooled the responses from both surveys, assuming lynx presence if it was reported at least once. 72 hunting grounds (33.5%) reported positively; out of those 24 with regular lynx presence; 156 (49.5%) reported no lynx in their area and 9 (4.2%) did not respond. The questionnaires are a cost effective and easy-to-implement method which gave valuable information about lynx presence in a certain area already for the third time (Krofel et al. 2021, Slijepčević et al. 2019). We received responses that overlap other opportunistic data collected in most of the country. Interestingly, a discrepancy between single opportunistic records and questionnaire responses appeared outside the core distribution of lynx in Slovenia, i.e. in the northeast, east and southwest of the reported lynx presence. Two lynx records of different quality (one C1) were reported in the easternmost range of reported lynx presence, however this was not reflected in the responses in the questionnaires. Furthermore, two unconfirmed records were reported northeast from Kočevsko, where no questionnaire response was received. On the other hand, questionnaires' responses indicate lynx presence in the southwestern part of the country, but no confirmed lynx records are available from the area. Nevertheless, the indications about potential lynx presence provided through questionnaires represent an important source of information to be considered in further exploration of lynx presence in Slovenia.

Table 1. Opportunistically-collected data about signs of lynx presence, categorised according to SCALP criteria, in lynx-monitoring year 2020-2021.

	Slovenia	Croatia	Italy	All countries
C1	34	50	0	84
C2	36	29	0	65
C3	17	51	3	68
total	87	130	3	220

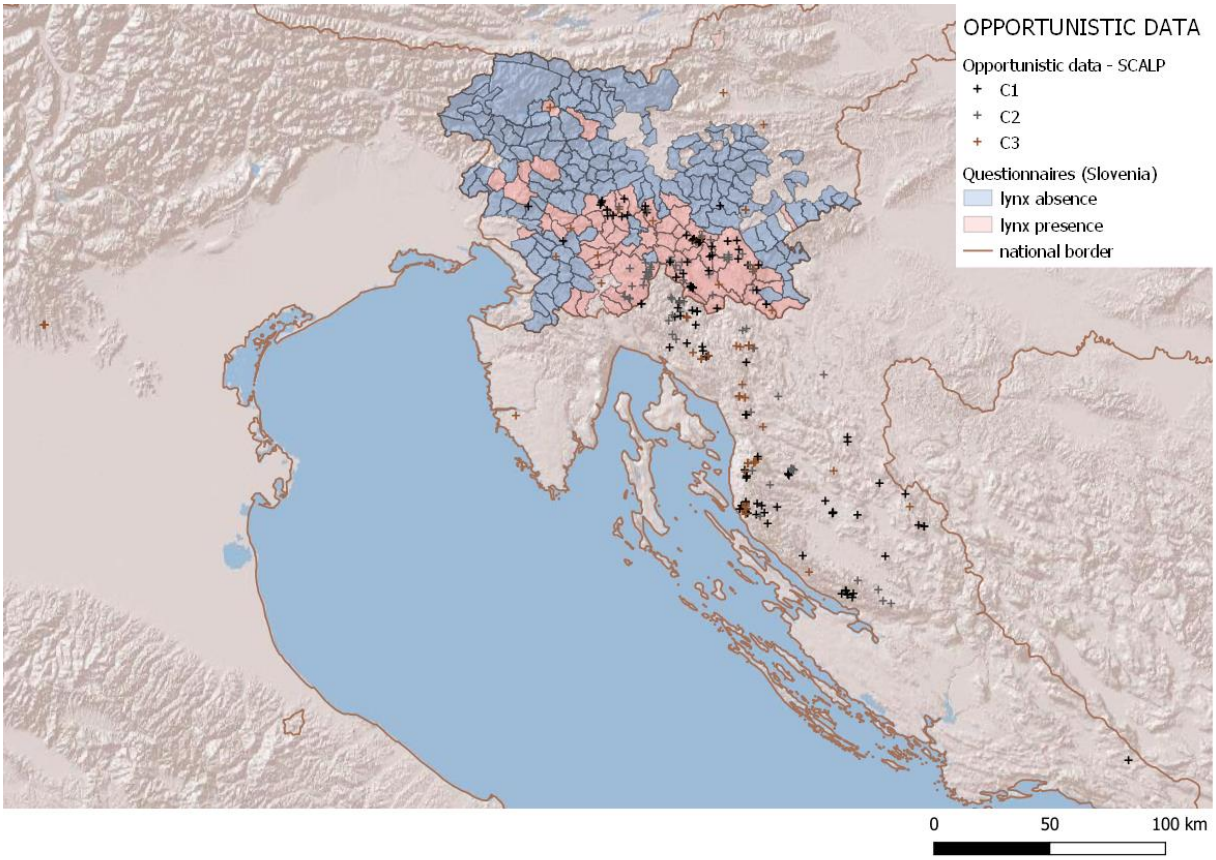

Figure 2. Opportunistically-collected data categorised in three SCALP categories shown together with responses received from the questionnaires sent to Slovenian hunting grounds.

2.2 Systematic camera trapping

Camera trapping is currently recognized as the most effective method for monitoring lynx abundance and distribution in Europe (Hočevar et al. 2020; Rovero & Zimmermann 2016; Palmero et al. 2021). It often allows individual identification based on the distinctive coat pattern of each individual animal (although the identification process can be more difficult in case when lynx pelage has rosettes or is unspotted). Camera trapping and individual identification allows a straightforward and robust estimation of the minimum number of individuals in the study area or, with appropriate data, also an estimate of abundance and density using a (spatial) capture-recapture approach (Royle et al. 2014).

We covered roughly 9,800 km2 with an extensive network of camera traps over the core area of potential lynx distribution in Slovenia, Croatia and Italy (Figure 3). We placed one or two (exceptionally three) camera traps per location (i.e. camera trap station), either at the same locations that we already surveyed in the 2018-2019 lynx-monitoring year (Fležar et al. 2019, Slijepčević et al. 2019), in the 2019-2020 lynx-monitoring year (Krofel et al. 2021), or at new locations. The main population parameters that we obtained through camera trapping are the minimum number of adult lynx and the minimum number of reproduction events with the number of kittens per such event (Table 2). The sex of the identified animals could not be determined in all cases.

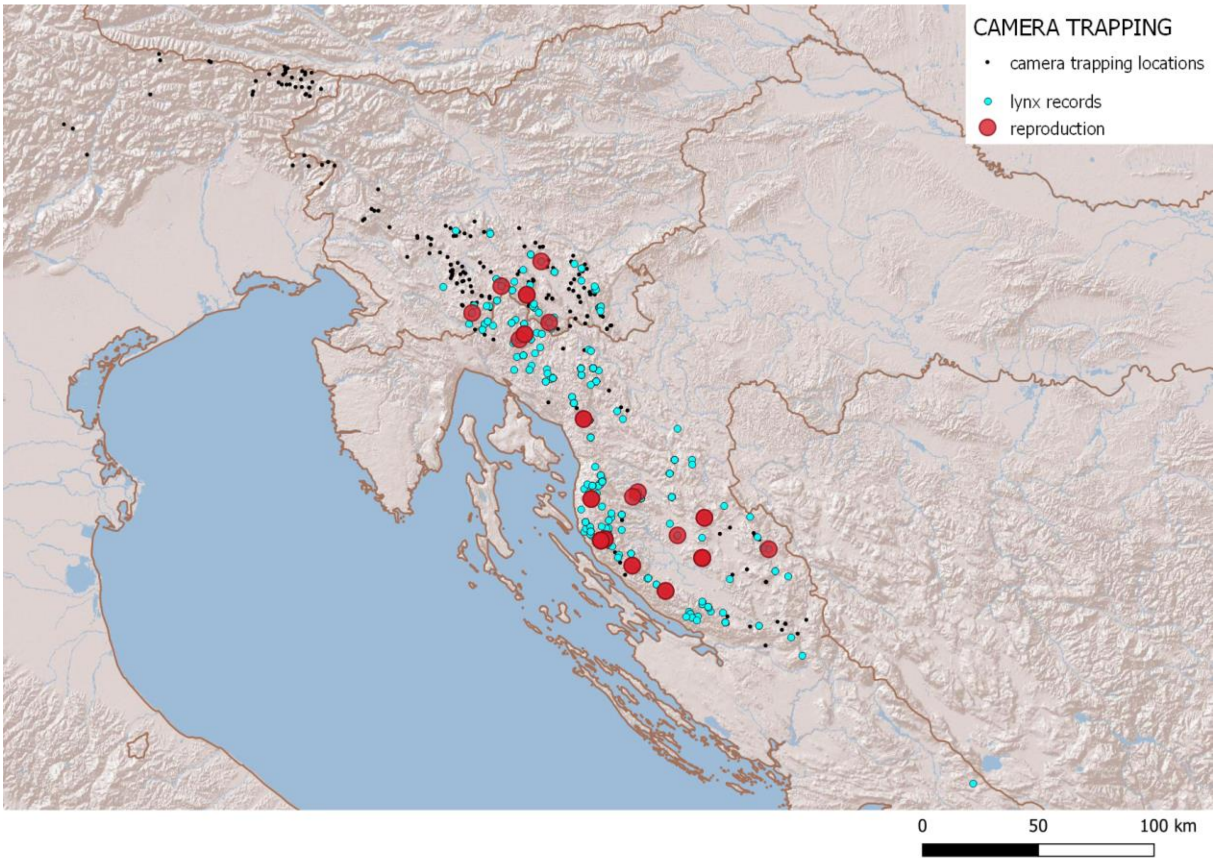

Figure 3. The camera trapping effort and main demographic results from the 2020-2021 survey season. The locations of all camera traps used for camera-trap monitoring are shown as black points. The locations where at least one lynx was recorded are shown in blue and single reproduction events marked additionally with red points (we show each individual female with kittens as one data point, not accounting for possible multiple detections).

In Slovenia, a vast majority of the systematic camera trapping involved help provided by the hunters from the Special purpose state-owned hunting grounds (LPN) or by local hunting clubs (LD). Exceptions to this are three camera-trapping sites, where other volunteers are operating the cameras and retrieving the data and some of the sites that were operated by the project staff. Most of the funding for systematic camera trapping in LPNs was ensured by the national large carnivore monitoring scheme (two-thirds of all LPN locations; n=46), while the funding for the rest of the locations in LPNs and all locations in LDs was funded by LIFE Lynx project (in total 113 locations; Table 2). In total, camera trapping involved 5 LPNs and 44 LDs, covering 31% of the entire country. Due to the combination of funding to implement camera trapping over the entire permanent lynx distribution area in Slovenia (Figure 1), we can conduct it in a systematic way on a national level.

For the new locations, we followed the same approach as in the first survey year: we held informative meetings with hunters or other camera trap operators and discussed the potential best locations for lynx camera trapping and visited them together in the field to choose the micro-locations using criteria described in Stergar & Slijepčević (2017) and set up the camera(s). Afterwards, most of the camera traps were operated (i.e. regular maintenance and changing of SD cards and batteries) by hunters and other non-project staff. Prior to the start of the new camera trapping season, we held informative meetings with 76 hunters (2 in areas not included in the previous year). In Croatia, camera trapping was conducted all year in 39 different hunting grounds, 3 national parks and one nature park. In Italy, the grid covered 10 hunting grounds, and several meetings were held to build on existing connections with hunters.

A vast majority (n=138) of the camera trap stations in Slovenia were set up at locations where we expected lynx to move through, i.e. ridges, stone walls, logging trails, forest roads, or animal paths. The remaining stations (n=21) were set up at potential or confirmed lynx scent-marking sites, which included active or abandoned forest cabins, ungulate feeding structures, bunkers, conspicuous trees or rocks, and other similar objects frequently used by lynx for territorial scent-marking in this region (Allen et al. 2017). The cameras were mostly set to take one photo and one video when triggered by movement. One type of the camera traps used (StealthCam G45NGX) could not record both photo and video, so we set it to only record photos to standardize data collection with the other two types of camera traps used (Moultrie M40-i and Cuddeback X-Change). Also the Cuddeback camera traps with white flash illumination only collected photos during the night, while also videos were recorded during the daytime. In addition to recordings made upon detection of movement, camera traps in Slovenia were programmed to take an additional one photo per day using the 'time-lapse' function for operability check-up. In Italy cameras are set to take 3 photos in a burst each time the camera trap is triggered.

The cameras in Slovenia were deployed in August or September when project staff from Slovenia Forest Service (SFS) and University of Ljubljana (UL) joined the camera operators at the initial setup of the camera trap stations. Camera operators alone checked the cameras, retrieved the SD cards and handed the data to the local coordinators from the project team who then checked the photos collected and saved and annotated them on an internal server (software Camelot). This was mostly done monthly until January, based on recommendations from Zimmermann et al. (2013). After January, the cameras were left recording until April, but they were not maintained nor the data retrieved until the withdrawal of the equipment. In Italy and Croatia, the camera trapping stations were operative over the entire year. In Croatia, 80 camera traps are maintained by project personnel, 18 by nature and national park rangers and 4 by hunters from collaborating hunting grounds. In Italy, 29 cameras are maintained by project personnel, 9 by Corpo Forestale Regionale staff and 6 by Polizia Provinciale di Belluno.

In total, we identified a minimum of 95 different adult lynx from the obtained photo/video material in the 2020/2021 monitoring season. Three individual lynx were detected in both countries (Slovenia and Croatia) and this was accounted for in the summarised data (Table 2). To find the individual adult lynx which could have potentially been recorded in Slovenia and Croatia, we compared all records of adult lynxes since 2018 in a 15-km buffer from the national border. We assumed that the probability of recording an adult resident lynx on both sides of the border outside this buffer is low.

No lynx was detected in Italy in the second survey season, thus we cannot confirm lynx presence there (see also chapter 2.1). In Dinaric Mountains, the minimum number of adult lynx identified this year (95 adult lynx) was similar to the previous survey season (101 adult lynx; Krofel et al. 2021). In Slovenia, three out of five lynx wearing a telemetry collar during most of the camera-trapping season were also detected with camera traps. Both lynx that were missed were non-territorial and were spending extended periods outside of the systematic camera-trapping grid. However, one of the lynx not recorded on systematically-set camera traps (lynx Maks) was recorded opportunistically on camera traps set at the highway under- and over-passes (shown as C1 data points on Figure 2). In Croatia, two out of three collared lynx (Alojzije and Boris) were detected by camera traps on their territories within systematic camera trapping. Since the start of the surveillance of the reinforcement process (lynx year 2018-2019), 95 (53%) individual adult lynx were recorded only in one season, 55 (30%) in two and 28 (15%) in all three seasons. The trend of individual transience over the years is shown in Figure 4.

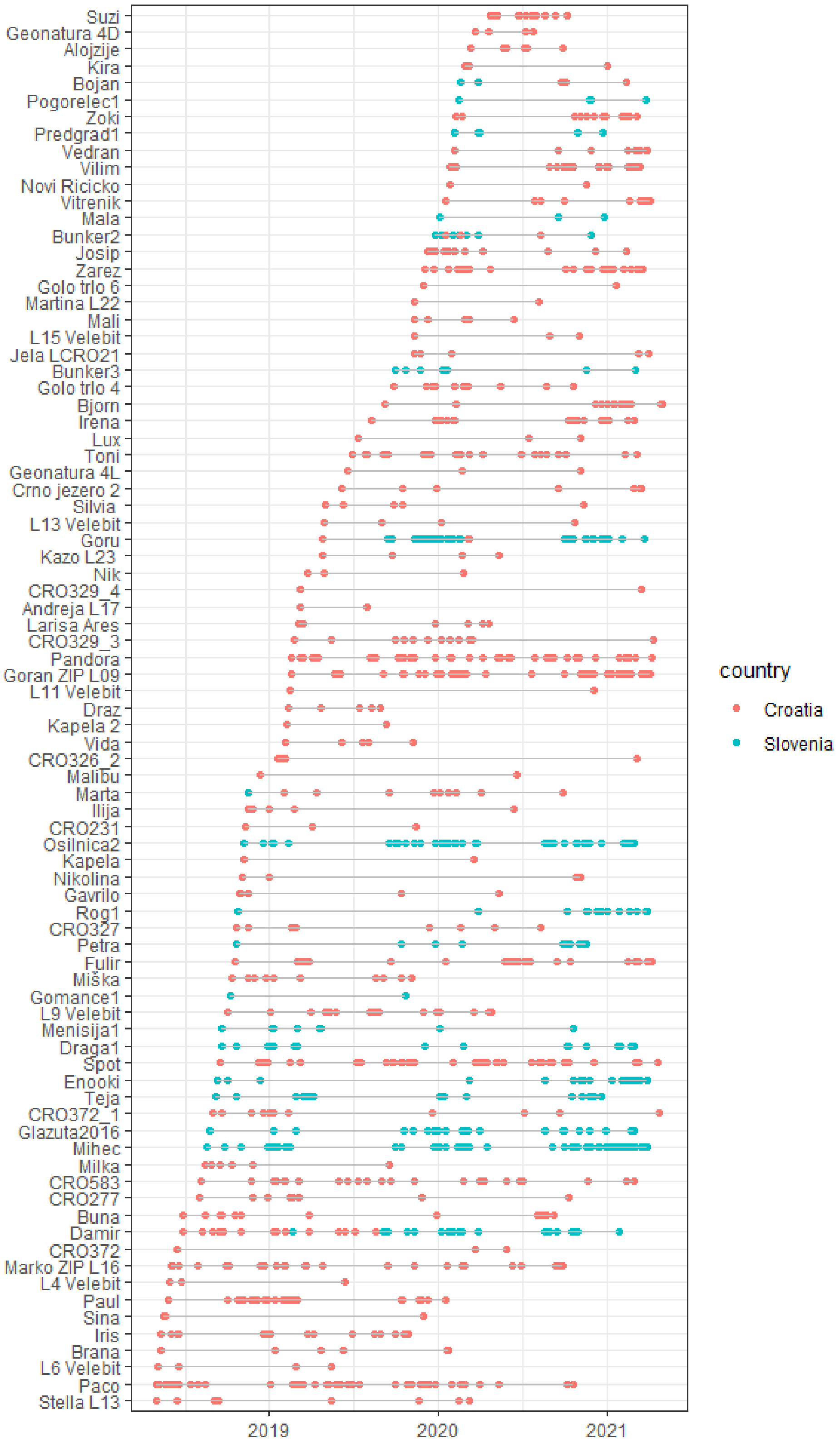

Figure 4. Transience of individually identified adult lynx in Slovenia and Croatia between lynx years 2018-2019, 2019-2020 and 2020-2021. 95 lynx that were detected only in one of the lynx years are not shown on the figure.

In 2020/2021 we detected a minimum number of 19 reproductions and 30 kittens, which is more than the previous season (15 reproductions and 25 kittens, respectively; Krofel et al. 2021). Number of detected reproductions especially increased in Slovenia (5 reproductions and 8 kittens this season compared to 2 reproductions and 2 kittens in the previous season), including the second successful reproduction of at least one of the translocated lynx (Goru), which is a promising development for further population recovery. Detected reproduction in Croatia (14 reproductions and 22 kittens) is similar to the previous year (13 reproductions and 23 kittens; Krofel et al. 2021), where some could be a consequence of mating with translocated lynx Alojzije, but at the moment we do not have genetic proof for this. Spatial distribution of reproductions in both countries remains more or less similar to the previous years.

Table 2. Summary of the photo/video data obtained per country in 2020-2021 lynx-monitoring year. The minimum number of adult lynx in the Dinaric-SE Alpine region takes into account the fact that two animals were detected both in Slovenia and Croatia. The minimum numbers summarise all photographic data collected (camera trapping and opportunistically collected photos/videos, i.e. SCALP C1 data). Sex of some of the animals could not be determined (these lynx are included in the min. no. of adult lynx, but not included in the min. number of males or females).

	Slovenia	Croatia	Italy	Dinaric-SE Alpine area
Total no. of systematic camera trapping sites (funded by LIFE Lynx)	159 (113)	102 (102)	45 (45)	307 (238)
Area monitored (km^2)	4000	4900	1900	9800
Density of camera trapping sites per 100 km^2	4.0	2.1	2.4	3.1
Min. no. of adult lynx	24*	74	0	95**
Min. no. of females	11*	22	0	33
Min. no. of males	11*	30	0	38*
Min. no. of adult lynx of unknown sex	2	22	0	24
Min. no. of kittens	8	22	0	30
Min. no. of reproductions	5	14	0	19

*does not include 5 lynx (2 males, 3 females) translocated to the Alps at the end of April 2021
**includes three transboundary lynx (Bojan, Bunker2 and Damir) and 5 translocated lynx (Katalin, Boris, Goru, Emil and Alojzije).

2.3 Spatial capture-recapture population density estimates

2.3.1 Introduction

Minimum population size is the easiest and most straightforward population parameter about the lynx population we can extract from camera trapping data. It is a count of all animals from camera trapping records, which can be identified as distinct individual independent animals with absolute certainty. This parameter can give us some insight into the trends occurring in the sampled population, if we keep the sampling effort constant over survey years. However, this is not a demographic parameter which could allow for an evaluation of the true status and the dynamics of a sampled population, mainly because it does not account for spatial and temporal extent of sampling (Rovero & Zimmermann 2016).

To overcome these deficiencies, capture-recapture models (hereafter CR models) can be used, which enable estimating the population size and use changes in probability of detecting lynx during a specific survey as one of the parameters (Borchers et al. 2002). CR models make use of individual encounter history data, i.e. data about whether an individual was captured or not during sampling over a certain time period. Traditional CR models can only accommodate heterogeneity at an individual and/or temporal level and are thus strongly limited by not incorporating any information about the spatial aspect of sampling or the population, e.g. the size of area sampled, the spatial effects of trap setup (baited vs non baited traps) or landscape or ecological differences within the sampled area. CR models assume that the studied population is geographically closed, consequently being capable of providing estimates of population size, but not density. However, we know that the probability of capturing an individual inherently depends on the location of their home range within the array of our sampling devices (camera traps); an individual animal has a higher probability to be captured in traps closer to its home range center, and vice versa (Royle et al. 2014).

Due to these constraints, CR models have undergone an important upgrade which has improved the way we study populations of many wildlife species. The development of *spatial* capture-recapture models (hereafter SCR models) enabled incorporating all levels of spatial information into a traditional CR framework, making them suitable to estimate also population density, i.e. the number of animals per certain spatial unit (Royle et al. 2014).

In SCR models, it is vital to describe all possible locations of the activity centers, i.e. "state-space" which defines the effective sampling area. The extent of the state space is a buffered area around our camera trapping grid with the buffer width inferred from the data (Royle et al. 2014) through the mean maximum distance moved (MMDM; maximum distance moved is calculated per individual lynx by measuring the Euclidean distance between the furthest traps where an individual lynx was recorded; all the maximum distances moved are averaged to get the mean maximum distance moved). Moreover, the extent of the state space needs to be adjusted to omit potentially unsuitable habitat patches, e.g. the sea or urbanized areas. Therefore, the state space needs to be sufficiently large to include all animals with non-negligible probability of encounter but do not include areas where lynx cannot live (Royle et al. 2014).

2.3.2 Data collection and analysis

We used data from 228 camera trapping sites distributed over the core area of the Dinaric lynx population (Figure 1, Figure 6); 166 locations in Slovenia, covering the North Western part of the Dinaric mountains and 62 locations in Croatia, covering Gorski Kotar and most of the Velebit mountain range (see Krofel et al. 2021 for details on the total camera trapping effort). Camera trapping locations which were "biased" (Iosif et al. 2020) were not included in the model, i.e. camera traps in areas where i) we did not have prior knowledge about lynx presence or collaboration with local hunters was poor or ii) habitat type changed and we did not have prior experience with finding suitable camera trapping sites. For each of the unbiased camera trapping sites, we defined "location type" as we know from previous studies that lynx movement can change at some landscape features. Camera trapping sites were defined as i) *road* at locations where camera trap was set on an unpaved forest road or a logging trail, ii) *marking site* at locations used by lynx for scent-marking their territory and iii) *other* at locations at other landscape features; mostly ridges, rocky terrain or other suitable sites. We included location type as a covariate for the detection probability. Similarly, we included sex as the second covariate and ran different SCR models with all possible combinations of covariates on the p0. We choose the most parsimonious model by comparing the model AIC values.

The camera traps were set up between August 15th 2019 and April 15th 2020 to ensure maximum possible exposure to capturing individual lynx, resulting in 245 camera trapping days per trapping site. For each camera trapping site, we defined camera operability to account for periods when cameras failed or had other operability issues. In total, encounter histories of 54 individual adult lynx were considered for the modelling, with an average capture rate of 4.52. On average, an individual was recaptured on 2.15 locations.

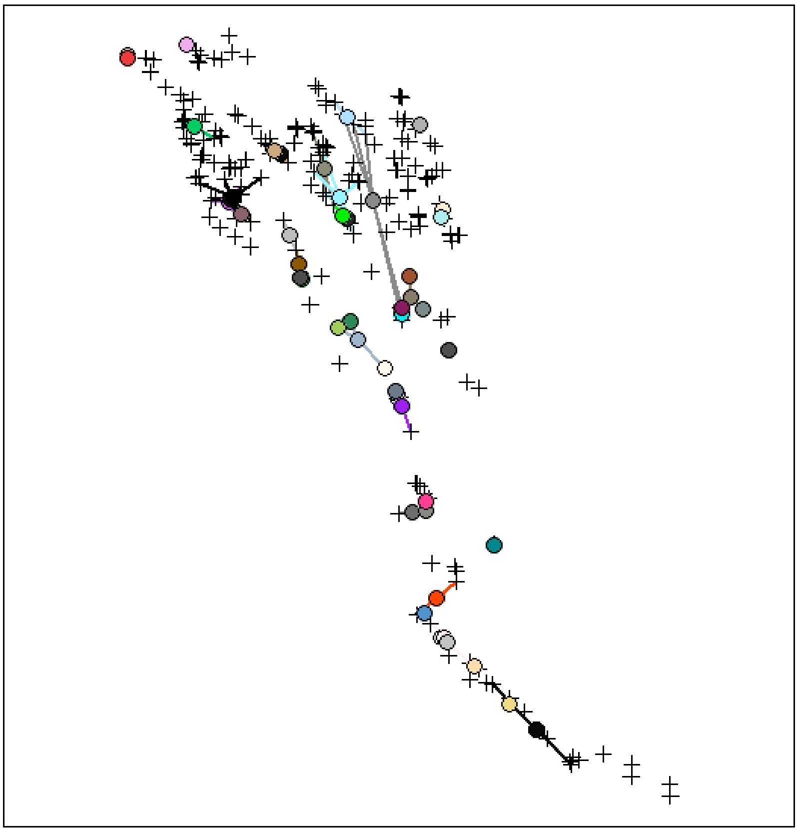

Figure 5. Visualization of the spatially explicit individual encounter histories for the Dinaric lynx in 2019-2020 survey year. Each filled circle represents the spatial average of all detections of an individual and lines join average locations to the traps in which individuals were captured. Each unique color (circle and lines) is a unique individual. Crosses (+) are trap locations, and circles without lines are individuals

that were detected at only a single location (figure interpretation extracted from Sutherland et al. 2019).

The mean maximum distance moved (MMDM) calculated from the data provided to the models was 11.5 km. The guidelines for buffer width of the state space is 1.5-2 times MMDM while the resolution of the pixel cells that make up the state space has to be sufficiently small, i.e. the same or smaller than half the MMDM value. We therefore defined the buffer of 18 km around the camera trapping grid with the resolution of the cells being 4x4 km^2. We used the habitat suitability model from Skrbinšek et al. 2007 to define and exclude all cells of the state space which were located in unsuitable habitat (Figure 6).

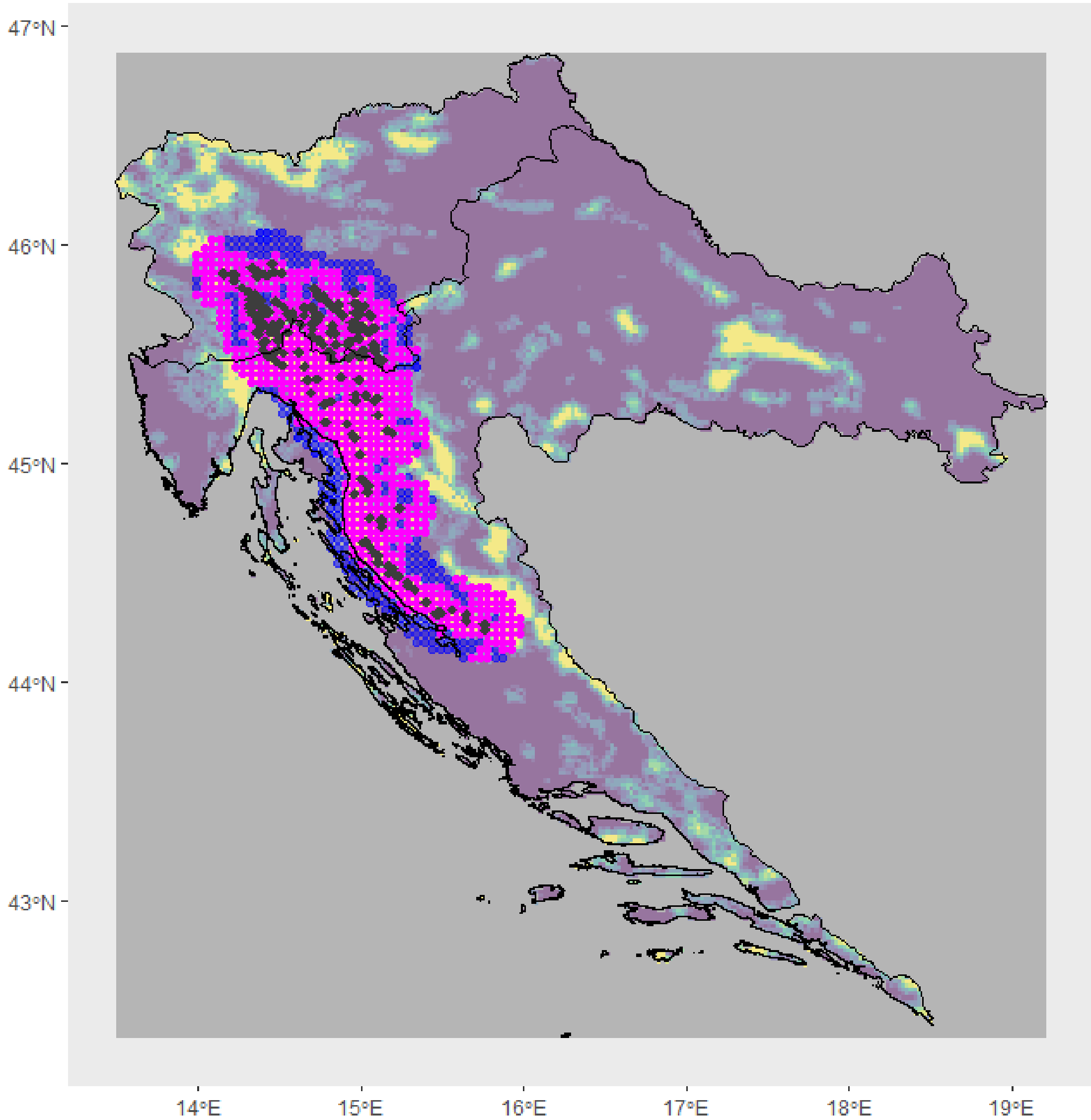

Figure 6. The state space defined by buffering the camera trapping grid (camera trapping locations: black dots, state space suggested by the model: blue dots, adjusted state-space with cells in unsuitable habitat removed: pink dots). Habitat suitability model for Slovenia and Croatia (outlined with black) is shown as a base map, with yellow areas indication habitat of highest suitability and purple cells indications unsuitable habitat.

While SCR models were originally described in a Bayesian framework (Royle et al. 2013), functions for R programme (R Core Team 2020) using likelihood based framework were also developed recently by the same authors (secr; Efford 2020, oSCR; Sutherland et al. 2019). In this report, we describe the SCR derived estimates of Dinaric lynx population density using oSCR package in a likelihood-based framework (Sutherland et al. 2019). All GIS processing of spatial data was performed in QGIS (QGIS Development Team, 2018).

2.3.3 Results and interpretation

The density of the studied Dinaric lynx population is estimated to on average 0.74 lynx/100 km^2 and seems to be comparable with SCR-derived lynx densities in the French Jura Mountains (0.58 lynx/100 km^2; Gimenez et al. 2019) or Western Carpathians (1.06 lynx/100 km^2 Dul'a et al. 2021) but is clearly lower compared to Romanian Carpathians (1.83 lynx/100 km^2; Iosif et al. 2020). What is noteworthy is that the CI for female and male density is overlapping however, the estimates are clearly higher for females than males.

Table 3. Estimates of population density with 95% confidence intervals (CI) extracted from the most parsimonious model.

Demographic parameter	sex	Estimate (CI)
density per $100km^2$	female	0.440 (0.295-0.655)
density per $100km^2$	male	0.302 (0.200-0.456)
density per $100km^2$	**total**	**0.742 (0.563-0.977)**

The most parsimonious (best) model according to the AIC criteria included both location type and sex as covariates on detection probability. The highest was detection probability for males at marking sites, and lowest for females at “other” type of locations. In general, the detection probability is higher for males than females and highest at marking sites for both sexes (Figure 7).

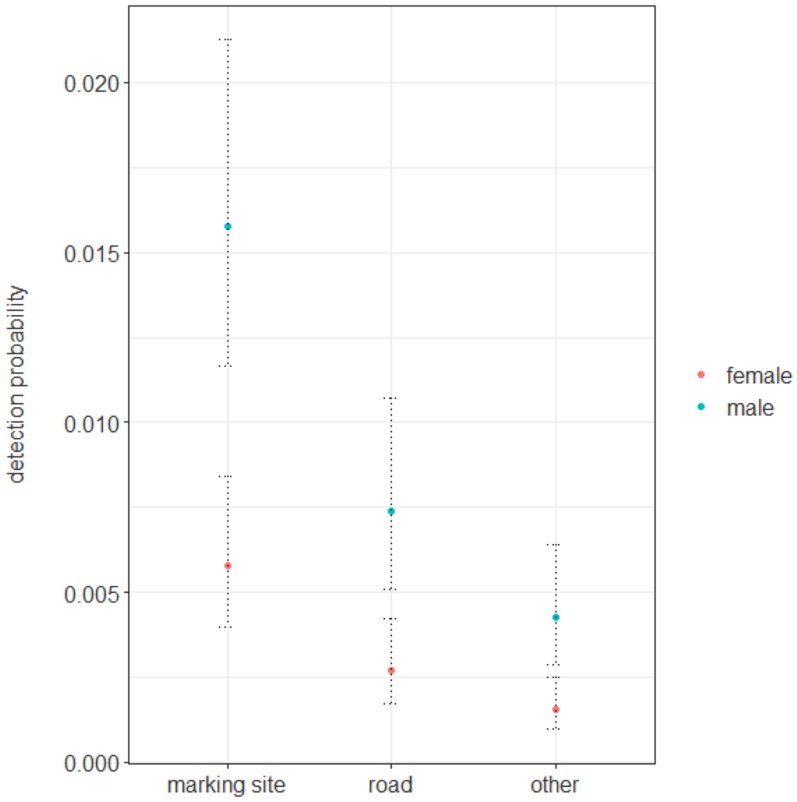

Figure 7. Detection probabilities for males and females at different types of location; marking sites, roads or other.

Further exploration of potential covariates on density (landscape covariates) is needed to account for potential effects of different intensity of sampling in each country (average number of traps per 100 km^2 was twice as high in Slovenia as in Croatia; Krofel et al. 2021). Based on sampling recommendations from (Zimmermann et al. 2013, Weingarth et al. 2015) we should also explore potential differences in densities during non-mating season (autumn-early winter) vs entire survey season (autumn-spring).

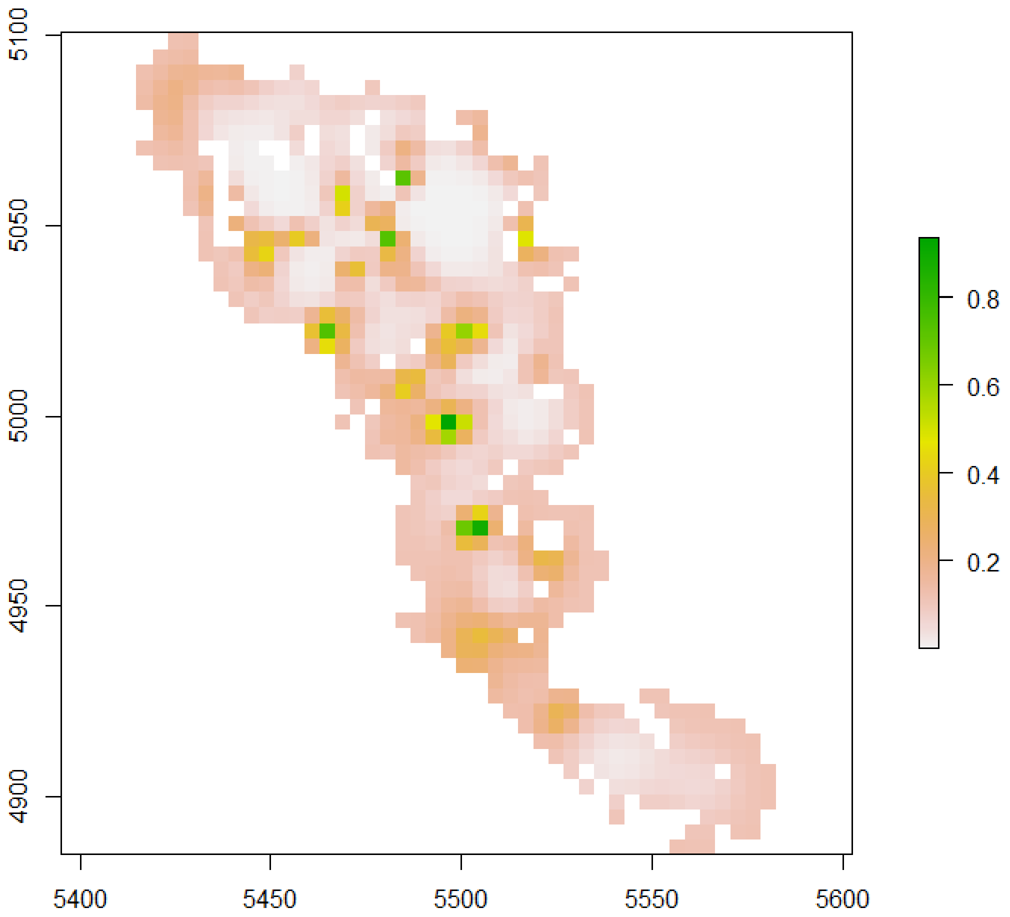

Figure 8. Expected density of the Dinaric lynx population. Densities are shown for an adjusted state space with a 4x4km² resolution therefore indicating areas with higher vs lower expected density.

2.4 Non-invasive genetic sampling

For genetic analysis, several types of non-invasive samples were collected: scat samples were stored in 95% non-denatured ethanol, urine samples (collected in snow) were stored in DETs buffer, hair samples were stored in sealed bags with desiccant (silica) and saliva samples were collected with forensic swabs. Tissue samples were stored in 95% ethanol and blood samples (on WTA cards) were taken from animals captured for telemetry. The number of collected samples is provided in Table 4.

DNA in non-invasive genetic samples is of very low quality and quantity, and contamination (especially with PCR products) is a serious issue. Therefore we used a dedicated laboratory for non-invasive genetic samples for DNA extraction from non-invasive samples and PCR setup. For all non-invasive samples, we used MagMAX DNA Multi-sample Kit (Thermo Fisher Scientific) with the "whole blood" protocol. The extraction protocol is implemented on a liquid handling robot (Hamilton Starlet) to achieve reliable, error-free, and fast DNA extraction (Skrbinšek et al. 2017). DNA extraction from tissue and blood samples is done in a separate laboratory, using manual DNA extraction kit (Sigma GenElute Mammalian Genomic DNA Miniprep Kit) following the manufacturers protocols.

We used ten microsatellite markers for individual ID run in a single multiplex: Fca132, Fca201, Fca247, Fca293, Fca391, Fca424, Fca567, Fca650, Fca723, Fca82. The best (reference) sample of each detected animal was amplified using 9 additional markers (F115, F53, Fca001, Fca132, Fca161, Fca369, Fca559, Fca742, HDZ700 (Menotti-Raymond et al. 1999; Menotti-Raymond et al. 2005; Williamson et al. 2002), bringing the total number of studied microsatellites to 19. SRY locus was used to determine sex of the animal. Microsatellites were amplified in 3 multiplexes, using Platinum multiplex PCR Master Mix (ABI). Protocols from Polanc et al. (2012) were adapted according to the Platinum kit user guide. The SRY sex marker amplifies also in non-felid species and it is used for sex identification also for other carnivores, so prey DNA (like fox) in a scat could cause problems. Also slight contamination from different animals in a sample (urine, hair, saliva from an object), can make the sex determination difficult. That is why in some cases we additionally analysed the sex of the animal with amelogenin genetic marker (Pilgrim et al. 2005).

Good quality tissue and blood samples were re-amplified twice. For non-invasive samples, we used a modified multiple-tube approach (Taberlet et al. 1996; Adams & Waits 2007) with up to 8 re-amplifications of each sample according to the sample's quality and matching with other samples. In the first screening process, each sample was amplified with the 10-marker panel (multiB panel) protocol twice and analyzed on an automatic sequencer (Applied Biosystem ABI 3500 Genetic Analyzer). Results were interpreted using GeneMapper v.6.0. software (Applied Biosystems, USA). Samples that provided no specific PCR products at that stage were discarded. Consensus genotypes were determined using an Access database application programmed by T. Skrbinšek (MisBase, unpublished).

Genetic data were prepared in a laboratory database (MisBase), which we use to keep a record of the field data (T. Skrbinšek, unpublished). All non-GIS analyses were run in R (R Development Core Team 2020).

Table 4. Genetic samples collected from 1.5.2020 until 30.4.2021 and genotyping success

Sample type	Sampling season 2020/2021	Successfully genotyped	Genotyping success
tissue	2	2	100%
blood	4	4	100%
scat	29	18	62%
urine	28	13	46%
hair	82	32	39%
saliva direct	2	2	100%
saliva from prey	2	0	0%
TOTAL	149	71	48%

Vast majority of non-invasive genetic samples were collected in winter during snow tracking or by visiting known marking sites, while hair trapping attempts did not prove successful in Slovenia. The effort needed to find lynx tracks in the snow is high and must be recognized to help understand the manpower needed to collect precious genetic data about the inbred remnant lynx population and inclusion of the newly introduced lynx in the genepool. Therefore this year we also collected data about the snow tracking effort in Slovenia throughout the entire season with suitable snow conditions. We asked everyone collaborating in snow tracking activities (mostly the project team but also some independent volunteers and a local NGO, Dinaricum society) to report the distance, time and success of each field visit. The results presented in Table 5 are thus approximations based on individual reports, however we trust that they fairly represent the effort needed for the amount of samples collected.

Table 5. Summary of the effort needed to collect the non-invasive genetic samples for lynx in Slovenia. The numbers are approximations, based on individual reports; however, the number of samples is accurate.

	without lynx tracks found	**with lynx tracks found**	**total snow tracking***
no. of field visits	33	25	85
searching - walking (km)	186.5	211.7	550
searching - driving (km)	284	386.9	1113.9
searching - total (km)	599	598.6	1792.4
searching (hrs)	139.5	108.5	362.5
snow tracking (km)		53.6	53.6
snow tracking (hrs)		53.8	53.8
no. of samples collected		61	61

*includes also effort when only wolf tracks were found

The areas with the most collected samples were priority areas defined based on the presence of translocated animals and lack of genetic data from other lynx in the area, e.g. the area south of Ljubljana marshland (Menišija, Mokrc), or based on expected offspring of translocated animals, e.g. area of Mala Gora. The areas where new individual lynx (either adult or kittens) were detected via camera trapping were also intensively searched, especially in Kočevsko (Goteniška Gora, Stojna, Kočevska Reka and Kočevski Rog) (Figure 9). Although, we made approximately 100 km in search for lynx tracks in the Javorniki, none were found in this area (Figure 9), where no lynx was detected already in the previous survey year (2019-2020), which is in line with the results obtained with camera trapping.

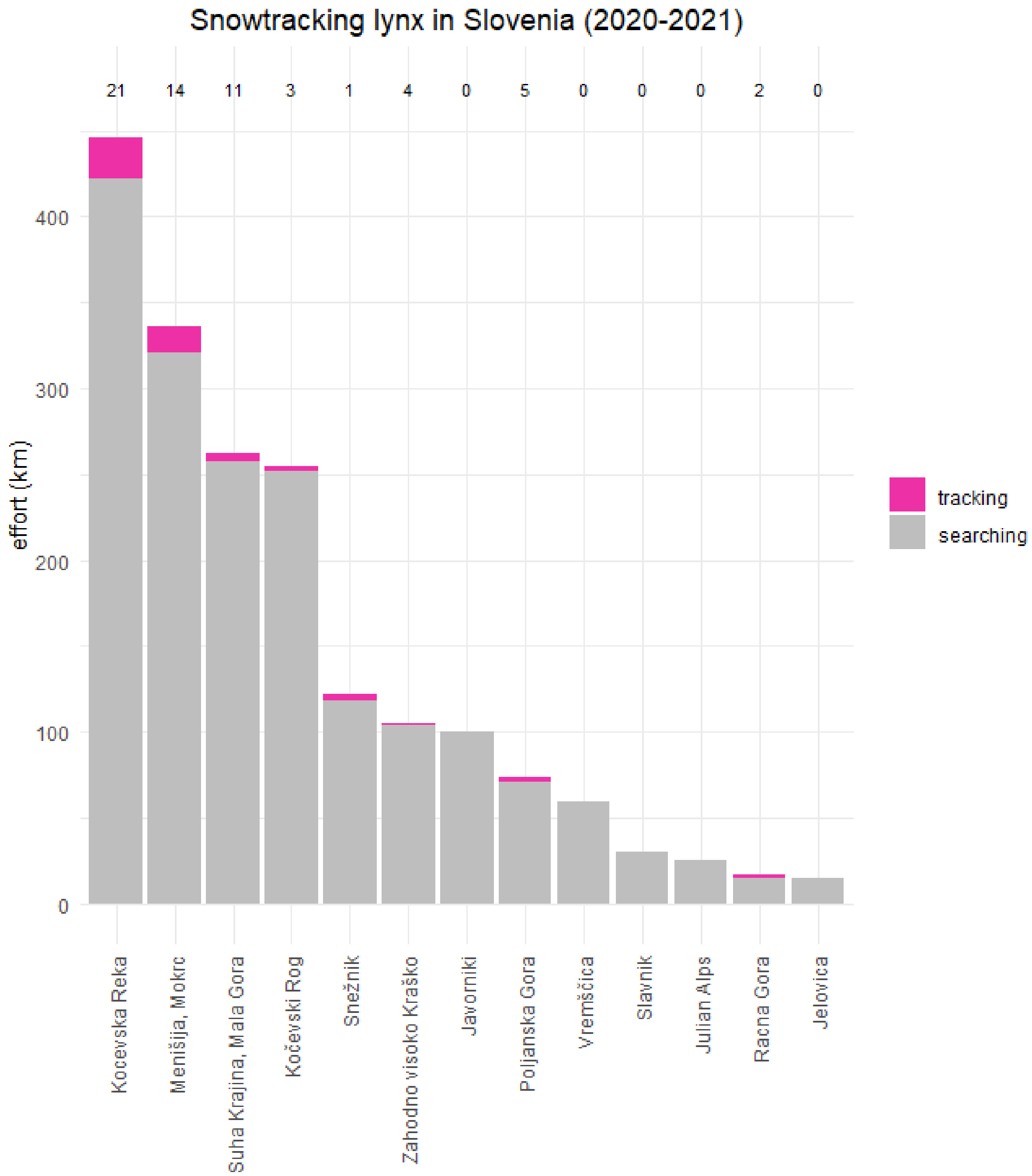

Figure 9. Summary of snow tracking effort in kilometres divided to searching for (grey) or tracking (pink) lynx. Each area outlines a potential home range of known or unknown lynx. The numbers above the bars indicate the number of non-invasive samples collected.

A total of 149 genetic samples were collected in the lynx-monitoring year 2020-2021 in Dinaric Mts. and SE Alps, 141 of them non-invasive. Out of all collected samples, 71 could be used for individual recognition of the animal (48% genotyping success). 16 samples could not be genotyped, but were only confirmed to be lynx; also the sex of the animal could not be determined in these cases. The rest of the samples were discarded (62).

Genotyping success of non-invasive genetic samples was highest with scat samples, followed by urine samples. In comparison with the previous monitoring season, the snow conditions enabled more snow-tracking and consequently we collected more urine samples found in snow. It is possible that some of the discarded scat and urine samples are from non-target species, because only the sex marker amplified, but we would need different methods to reliably confirm that.

As in previous year, most of the collected samples were hairs (n=82). The overall genotyping success of hair samples was 39%. 19 samples from Croatia were collected from hairtraps and considering only these samples, the percentage of successfully genotyped samples was 53%. The part of the hair that has DNA is the follicle, a bulbous end of a pulled-out hair. Not all hairs found in the field have follicles and they're often difficult to observe without a magnifying lens. Often, the hair collected is thin and short coming from the animal undercoat and difficult to work with. In such cases, we took all the hair in the extraction protocol, without cutting off the follicles. While preparing these samples in the laboratory, we record how many hairs and how many hair follicles we saw in the sample (Skrbinšek 2017). After genotyping it was clear that discarded samples mostly had less than 3 hair follicles. In the cases where more hairs were present in the sample (i.e. around 7), and the sample was discarded, we noted that they were i) without hair follicles (cut off hair), ii) the sample was more than 14 days old or iii) the hair sample collected may not belong to lynx. In good quality hair samples, there were at least 4 hairs, but at least in one case a sample with 2 hairs also could be genotyped.

From this data we learn that: 1) entire hair is valuable as it contains the hair follicles and cut-off hair is useless to genotype individuals, 2) the hair has to be collected as fresh as possible thus is crucial to record the sample collection date and 3) the samples must be properly stored, the bag with desiccant and sample envelope tightly sealed in and delivered to the laboratory as soon as possible. We store the envelopes with hair samples at room temperature in a dry and dark place. The hair itself is not very important so its length doesn't matter, it's the follicle that has the DNA; therefore it makes sense to collect as much hair as possible (Skrbinšek 2017). By following these guidelines, we can improve the genotyping success of hair samples, which are the most important source of non-invasive genetic material in lynx monitoring.

Among the 71 successfully genotyped samples we recognized 31 individuals (17 males, 14 females), out of which 15 were already known from the previous sampling seasons. Among them were two translocated lynx (Goru and Katalin) and Goru's offspring Niko and Mala. While snow-tracking the remnant female Teja (who is no longer collared), we were looking for samples from the other two kittens from her 2020 litter, but we could not genotype any of them. Combining the data from genetic sampling, telemetry and camera trapping we could already connect many of the genetic samples to the animals recognized on cameras or captured.

Generic analysis also provided some new information on collared individuals. The female Petra captured for telemetry is known already from saliva samples taken from prey in 2017. Collared ynx Niko was confirmed to be offspring of remnant female Teja and translocated lynx Goru (see chapter 2.5). Female that was collared but was found dead soon afterwards (see chapter 2.6) matches with a scat sample collected in 2011 in the Snežnik area and three hair samples collected last year in Kočevsko. We also analysed two tissue samples from Croatia and two blood samples from animals captured within the scope of other projects in Croatia.

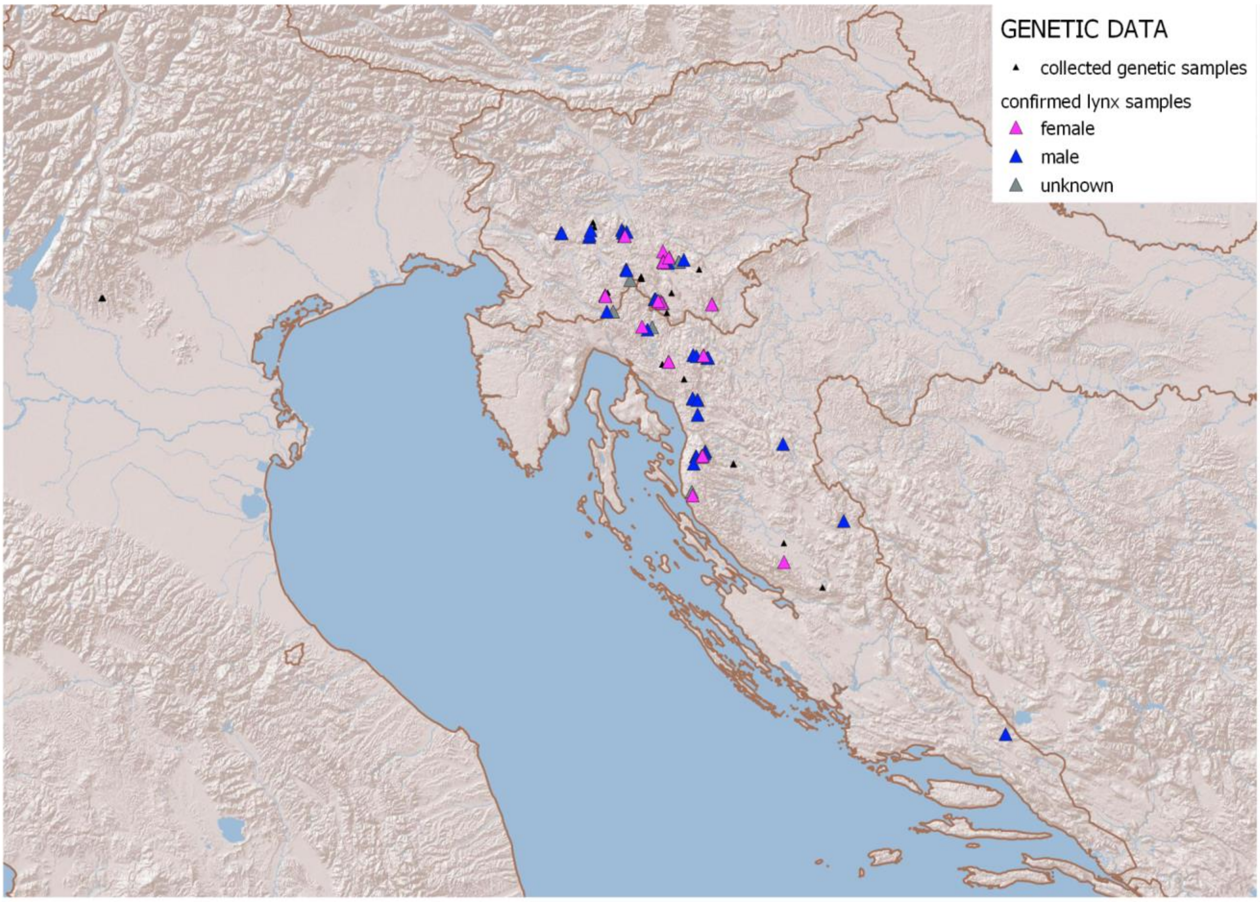

Figure 10. Genetic samples collected from 1.5.2020 to 30.4.2021. Samples which were confirmed to belong to lynx are categorized by those belonging to females (pink triangles) and males (blue triangles) or those for which sex could not be determined (grey triangles). Collected samples that did not yield results are marked with black triangles.

2.5 Population genetics - further genetic erosion and first effects of population augmentation

Our baseline population genetics study (Skrbinšek et al. 2019) showed how the Dinaric lynx population deteriorated genetically since the 1973 reintroduction, with the population approaching severe levels of inbreeding relative to the source population in Slovak Carpathians. New samples of the remnant lynx population in the Dinaric mountains (excluding the animals translocated from Romania and Slovakia in this project, and their offspring) allow us to further track this development. On the other hand, the genotypes of the translocated animals and their offspring allow us to catch a glimpse of how we can expect the population to develop if the translocated animals manage to successfully reproduce and include their genes into the population.

We analysed the additional samples of the remnant Dinaric lynx, which were collected since our last analysis (Krofel et al. 2021) to track the further population deterioration. On the other hand, since the newly translocated lynx and their offspring are now physically a part of the Dinaric population, we re-ran the analysis with samples of these animals and their offspring included, to explore the effect they may have on the population assuming their successful integration (reproduction) within the population. During these analysis, samples from the lynx reintroduced to the Alpine stepping stone were excluded since we don't know how well this newly established population will exchange individuals with the lynx in the Dinaric Mountains.

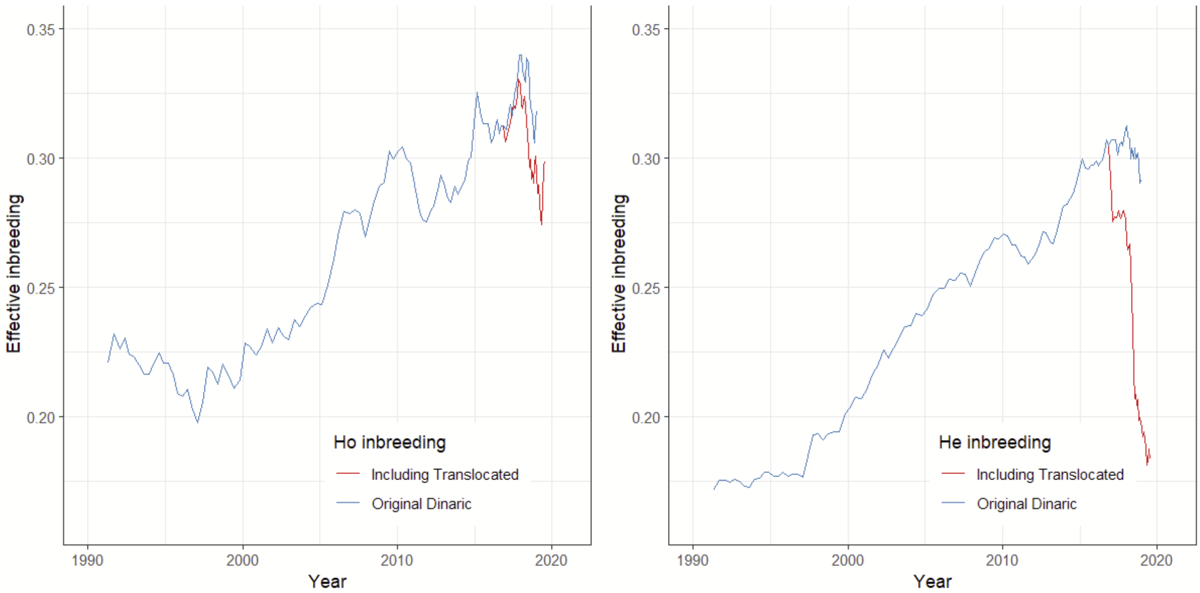

Figure 11. Effective inbreeding of Dinaric lynx relative to the source population in Slovak Carpathians, calculated from observed (left) or expected (right) heterozygosity, with (in red) and without (in blue) including translocated animals and their offspring, calculated with 60-sample travelling window. As expected the effect of the introduced animals is much higher with expected heterozygosity (right) due to the Wahlund effect (direct immigrants in the population), while the actual current effect is better estimated from the observed heterozygosity (left). However, large increase in expected heterozygosity indicates the potential for rapid inbreeding decrease if the introduced animals continue to successfully reproduce.

Since not much time has passed since we last explored the inbreeding status of Dinaric lynx (Skrbinšek et al. 2019, Krofel et al. 2021), the change in inbreeding in the remnant lynx population is not very different from what we described before (between 0.31 and 0.34), just reaffirmed by more data. However, when including the translocated animals and their offspring, the picture improves significantly. If the introduced animals and their offspring would form 15% of the total population (simulated in the graph above), the inbreeding estimated from expected heterozygosity would drop to 0.18. While this is still high, it is already within the range we observed in the 1980s when population still seemed viable.

In the next few years, a lot will depend on the reproductive performance of the translocated animals. In the Florida panther (*Puma concolor*) population reinforcement there seemed to be considerable heterosis (fitness advantage of outbred animals) in the first generation (F1) crosses between remnant and introduced animals which contributed to rapid expansion of introduced genes in the population (Johnson et al. 2010). There is a good chance that this will also happen in the Dinaric lynx, and we will continue monitoring the situation closely over the following years to keep track of that. The introduced lynx bring many private alleles that were not present in the Dinaric lynx population prior to the translocations (Table 6), which makes the offspring of these animals very easy to detect.

Table 6: Alleles found in translocated lynx that were not previously detected in the Dinaric lynx population. These "private" alleles make offspring of the translocated lynx very easy to detect.

Locus	F115	F115	F115	F115	Fca123	Fca132	Fca132
Allele	240	244	248	252	140	179	175
N observations	1	1	6	2	7	6	5
Locus	Fca001	Fca001	Fca001	Fca001	Fca001	Fca650	Fca650
Allele	177	181	191	187	193	131	129
N observations	1	4	1	1	1	2	2
Locus	Fca161	Fca293	Fca424	Fca424	Fca559	Fca559	
Allele	184	172	168	180	110	114	
N observations	1	2	4	2	2	3	
Locus	Fca723	Fca723	Fca723	Fca742	HDZ700	HDZ700	
Allele	179	187	191	131	141	145	
N observations	4	1	1	1	5	1	

2.6 Telemetry

Important part of surveying the reinforcement process is GPS-telemetry tracking of all translocated animals, some of their offspring and remnant lynx. GPS-telemetry can be used for studying lynx behavioral patterns, such as habitat use, dispersal, movements, predation, feeding and reproduction (Krofel et al. 2013, Heurich et al. 2014, Hočevar et al. 2020, Ripari et al. 2022). The main focus of our tracking of the translocated animals is on lynx survival, territory establishment, movement patterns, and reproduction. We also gathered information about prey species, sex and age structure of the prey and calculated the kill rates. Locating fresh kill sites further enabled us to record lynx with the help of video camera traps to assess lynx physical condition. We also recorded the presence of the scavengers at the kill sites and their influence on prey consumption by lynx.

In 2020/2021, in addition to the translocated lynx, we also collared three remnant lynx and two offspring of translocated and remnant lynx as part of the LIFE Lynx project. Collars of some of the animals collared in previous years dropped-off during this season (Table 7).

Table 7. Overview of all GPS-collared lynx tracked within the LIFE Lynx project with basic information.

Lynx name	Origin	Date released	End of tracking	Current status	Home-range size [100% MCP, km^2]
Goru	Translocated (Romania)	14.5.2019	Still tracked	Established territory on Mala gora	144
Doru	Translocated (Romania)	4.5.2019	30.1.2020	Signal lost	130
Catalin	Translocated (Romania)	31.3.2020	Still tracked	Established territory on Menišija/Rakitna	258
Boris	Translocated (Romania)	28.5.2020	Still tracked (only VHF)	Established territory on Mala Kapela	280
Maks	Translocated after rehabilitation (Slovakia)	23.6.2020	27.9.2021	In process of establishing territory on Hrušica, but then the signal was lost	N/A
Pino	Translocated (Slovakia)	30.5.2020	30.5.2020	Signal lost	N/A
Alojzije	Translocated (Romania)	13.3.2020	Still tracked	Established territory in Southern Velebit	167
Emil	Translocated (Slovakia)	14.5.2021	Still tracked	Unclear (possibly established territory on central Velebit)	N/A
Teja	Remnant	12.2.2019	9.2.2020	Collar dropped-off (established territory on Mala gora)	60

Lynx name	Origin	Date released	End of tracking	Current status	Home-range size [100% MCP, km^2]
Mihec	Remnant	21.3.2020	24.7.2021	Collar dropped off (established territory on Racna gora/Snežnik)	343
Mala	Offspring of remnant and translocated lynx	19.1.2020	1.7.2020	Collar battery exhausted (confirmed alive in 2020/2021)	78
Niko	Offspring of remnant and translocated lynx	6.12.2020	Still tracked	Unclear (possibly established territory in Gorski Kotar)	N/A
Bojan	Remnant (tracked within 3Lynx Project)	1.12.2019	3.3.2021	Established territory in Gorski Kotar, signal lost	515
Petra	Remnant	1.3.2021	Still tracked	Established territory in upper Kolpa Valley	122
Martina	Remnant (after rehabilitation in Croatia)	1.3.2020	2.6.2021	Found dead near Pivka	N/A

2.6.1 Translocated lynx in Dinaric Mountains

So far, we successfully translocated eight lynx to Slovenian (n=4) and Croatian (n=4) Dinaric Mountains. Five of them were from Romania and three from Slovakia. Four lynx (Goru, Katalin, Boris and Alojzije) have already established their territories, while with Emil it is still unclear if he already established permanent territory. We lost signal from three collars, therefore the status of three individuals (Doru, Pino, Maks) is currently unclear. Two of them (Doru and Pino) are declared as lost and will be replaced in the following year (2022). Below we describe movements and current status of all translocated lynx that were monitored within the reporting period. In addition to translocation of eight lynx to Dinaric Mountains, at the very end of the 2020/2021 lynx monitoring season we also translocated five lynx to the Julian Alps in Slovenia. We briefly report their status at the end of this subchapter, while more details about their movements and updated status will be reported in next year's report.

Goru

Figure 12. Lynx Goru photographed with camera-trap on Mala gora, Slovenia.

Lynx Goru was captured in Romania in February 2019. He is an adult male, currently estimated to be around 7 years old. He was transported to Slovenia, where he was released from quarantine in Loški Potok on 14th of May in 2019. After release, he first crossed the national border between Slovenia and Croatia, but soon turned north and returned to Slovenia. 17 days after the release, he arrived to Mala gora in Kočevsko, where he established his permanent territory. In this area, a remnant collared female named Teja was present. Her home range completely overlaps with Goru's, which measures around 144 km^2. After the mating with Teja, on 1st March 2020, still during the lynx-mating season, Goru temporarily left his territory on Mala gora and went on a mating excursion towards Ravna Gora area in Croatia, up to 50 km from the edge of his territory. After a month in Ravna gora area, he returned to his territory on Mala gora in Slovenia on 7th April 2020. In July 2020, he was recaptured and his collar was replaced with a new one that will enable us to monitor him for additional two years. We can confirm that he is the father of at least two litters; one kitten (named Mala) in 2019 and 3 kittens in 2020 (one of them is collared male Niko). In mating season 2021, he probably mated again with remnant female Teja, who had three kittens in summer 2021. We are currently still waiting for genetic analysis to confirm Goru's paternity for the third consecutive year. After presumed mating with Teja in 2021, he went again on a mating excursion, this time towards the south-west (Snežnik and Gorski kotar), where he stayed for a month. So far we do not know yet, if this mating excursion resulted in any offspring. Goru was also recorded several times on cameras that were set within the regular national lynx monitoring in Slovenia and during the mating excursion in 2021 he was captured in a box-trap in Loški Potok, but was released without sedation.

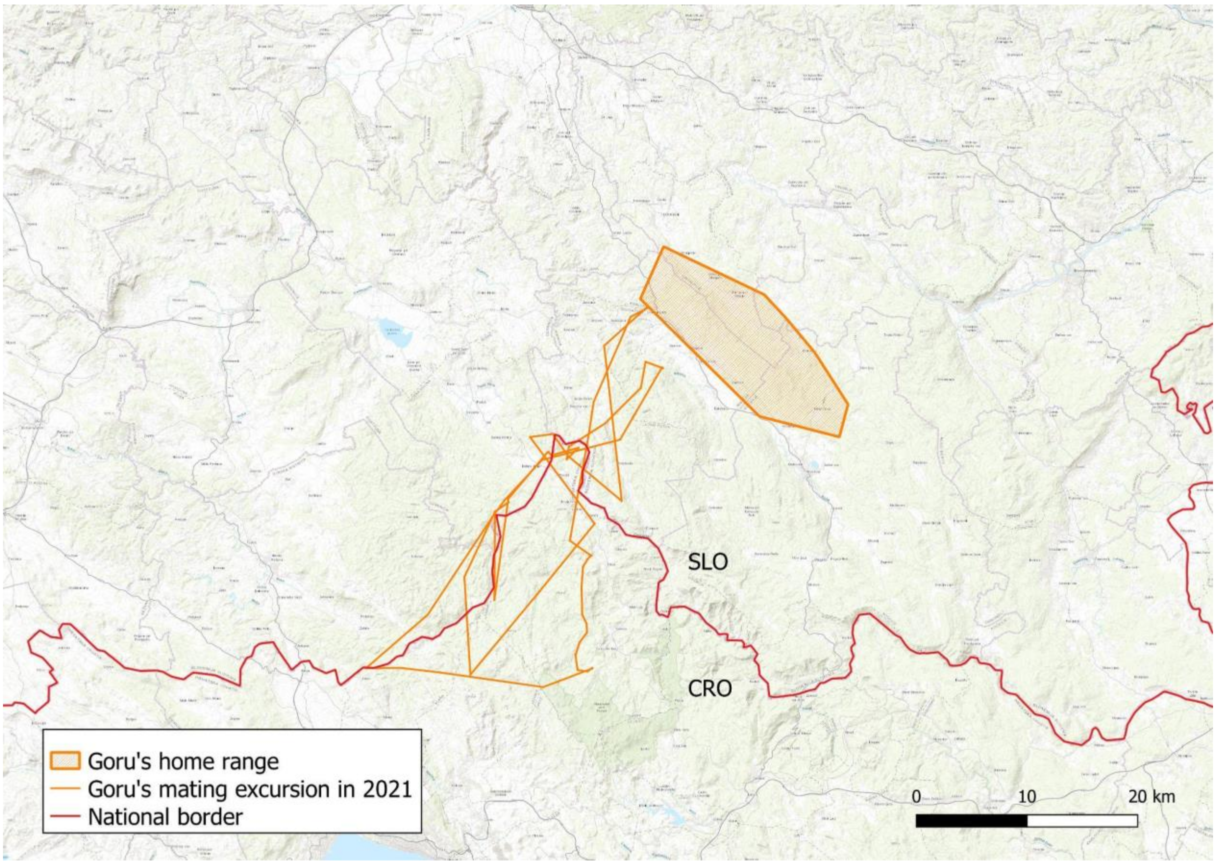

Figure 13. Map of Goru's home range (100% MCP) on Mala Gora, and temporary extra-territorial excursion in spring 2021 (orange).

Catalin

Figure 14. Lynx Catalin in a soft-release enclosure before release on Snežnik plateau, Slovenia.

Catalin was captured in Romania in January 2020 and released to Slovenia on 31st March 2020. He is currently estimated to be 5-6 years old and after release in Snežnik plateau, he first went south and crossed the border to Croatia, where he first visited Istra region. Then he turned west and crossed a large part of Gorski Kotar, until crossing the Croatian-Slovenian border again. In Slovenia, he first crossed Kočevsko and arrived at the vicinity of Mt. Krim on 19th April. There he established his territory, which covers Menišija, Logatec plateau, Rakitna and some parts of Mokrc. On the western side, his home range is limited by the Ljubljana-Koper highway, which he was so far not able to cross. In summer 2020 he was observed and recorded several times together with another lynx (known as “Menišija1” from the photo-monitoring), which we assume is probably a female. So far he is spending most of his time on Menišija and Logatec plateau, which correspond to this female’s territory, but is regularly making excursions via Rakitna to Mokrc, presumably to maintain contact with another remnant female that is resident in Mokrc. Size of his home range is currently 258 km^2. We regularly recorded him with camera traps when feeding on kill sites, among which at least two were shared with “Menišija1” and at least one also with her kittens. He appears in good physical condition. He was also photographed several times on camera traps within the lynx monitoring program, as well as other camera traps used in the region by hunters and as part of the InterMuc project for monitoring wildcats. In mating season 2021 he went on a short mating excursion to Kočevsko near the Croatian border, which lasted for three days. He went towards the same direction where lynx Goru and Mihec went, which indicates the presence of a female. In his territory, female ‘’Menišija1’’ was detected with kittens in the second half of 2021, who have the same coat pattern as Catalin, which is rare in Slovenia and therefore suggests that he might be the father. However, we still have to confirm this with genetic analyses.

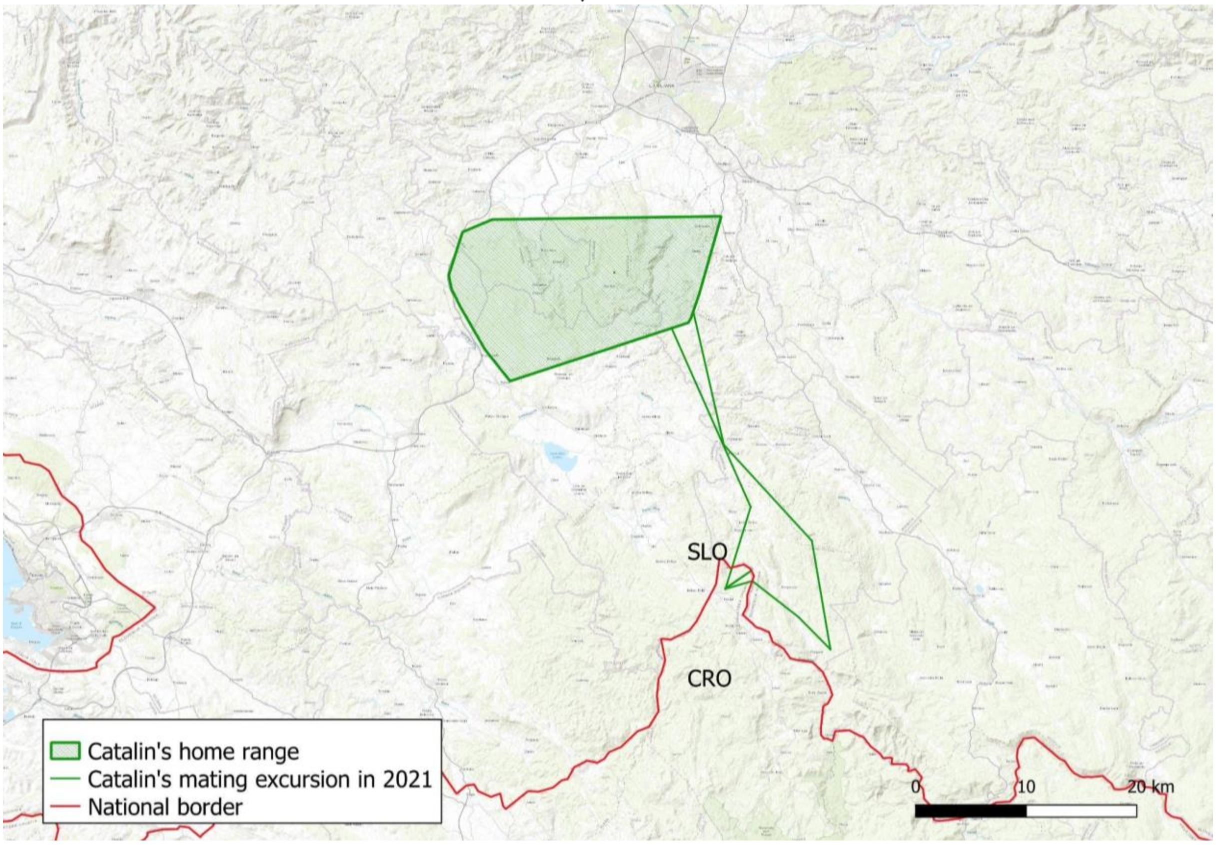

Figure 15. Map of Catalin's mating excursion in 2021 and his home range (100% MCP) established on Menišija, Logatec plateau, Rakitna and Mokrc.

Boris

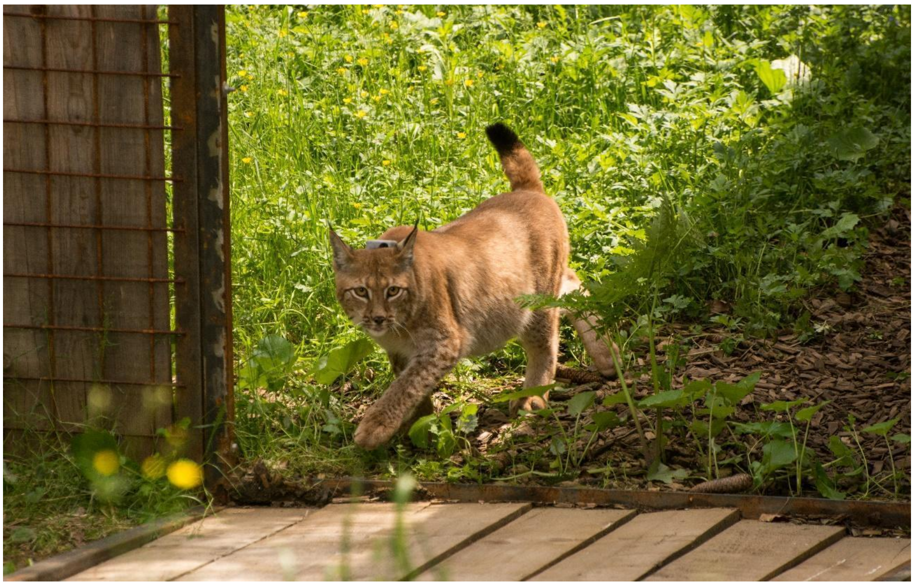

Figure 16. Lynx Boris during release from an enclosure in Loški Potok, Slovenia.

Male Boris is a 1-2 year old lynx that was captured in Romania in January 2020. He was translocated to Loški Potok enclosure on 30th of April and released on 28th of May 2020. Soon after the release, he went to Croatia and stayed around Gerovo for about 2 months, apparently establishing a temporary home range. Most likely due to the presence of adult male territorial resident lynx in the surrounding areas, he abandoned this area. Immediately before this move, we recorded a probable encounter with collared remnant territorial male Bojan, which apparently triggered this movement. He first moved south-east to Vrbovsko where he stayed for a month, and then moved further south to Ogulin and Mala Kapela area where he is present since October 14, 2020 and has apparently established a home range, which measures around 280 km^2. His collar stopped sending GPS locations on 25h of March 2021, but the VHF collar system is still working, which we are using to locate him since then. Box trap was activated in his current territory, on a marking location previously visited by Boris in an attempt to recapture lynx him and replace the collar. By the time of publishing this report he was not captured. The last time he was recorded with camera, he appeared to be in a good condition.

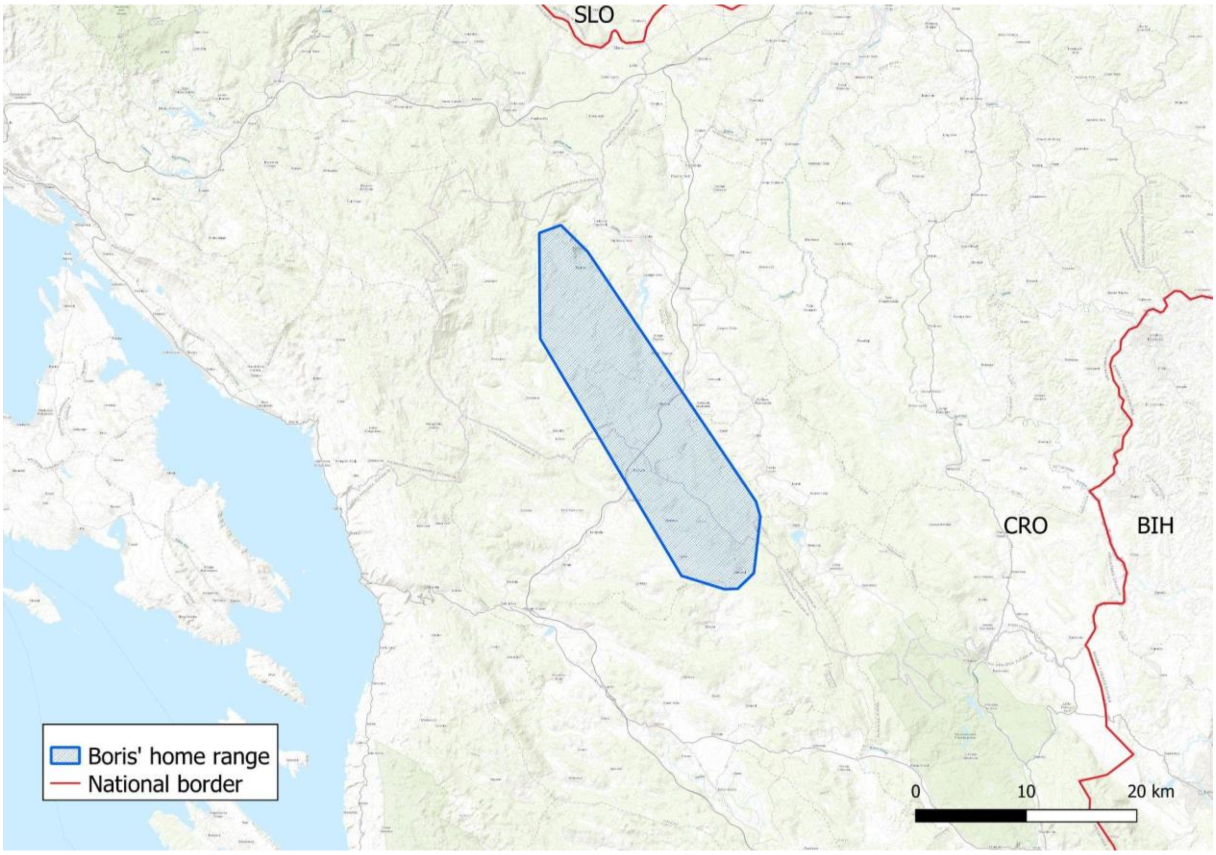

Figure 17. Map of Boris' home range (100% MCP) on Mala Kapela.

Maks

Figure 18. Lynx Maks during release from an enclosure on Snežnik plateau, Slovenia.

Lynx Maks was translocated from Slovakia to Slovenia. He was found as an orphan lynx in very bad health condition in Slovakia. He was rehabilitated and after he was vital again, he was transported to Slovenia in June 2020. He was released from the enclosure in Snežnik plateau on 23rd June. After release, he started his journey north towards Javorniki, where he arrived a few days after release and was apparently stopped by the Ljubljana-Koper highway. He stayed in the area for three months, apparently establishing his territory in the same area that was occupied by Doru the previous year. But then on 24th September he left this area due to unknown reason and moved to Menišija and Logatec plateau, where he stayed for two months, temporarily sharing the area with male Catalin, which arrived here few months earlier and another lynx ("Menišija1"), which is assumed to be a female. On 22nd November 2020, he left the Menišija region, crossed the Ljubljana-Koper highway, and first stayed a few days in forests around Logatec, from where he moved towards an Alpine area. Possibly this second shift could have been caused by the presence of territorial male Catalin on Menišija and Logatec plateau. He first crossed Cerkljansko hribovje, then Jelovica, Pokljuka, and reached Austrian border on Karavanke on 24.12.2020. From there he turned west and reached Kranjska Gora, which was the greatest aerial distance from the release location (104 km). He turned back on 31.12.2020 and followed almost the same path, except for a side trip around Bohinj lake in Triglav national park, and returned to Menišija on 15th of February 2021. There he stayed for around three months, again partly sharing the home range with Katalin, although he was regularly crossing the Ljubljana-Koper highway and using the area around Logatec outside of Katalin's territory. On 23rd of May 2021, he again abandoned Menišija and moved west to Hrušica and Trnovski gozd, where he was apparently establishing a territory. However, his collar stopped working at the end of September 2021 (before predicted battery lifespan) and his current status is unknown.

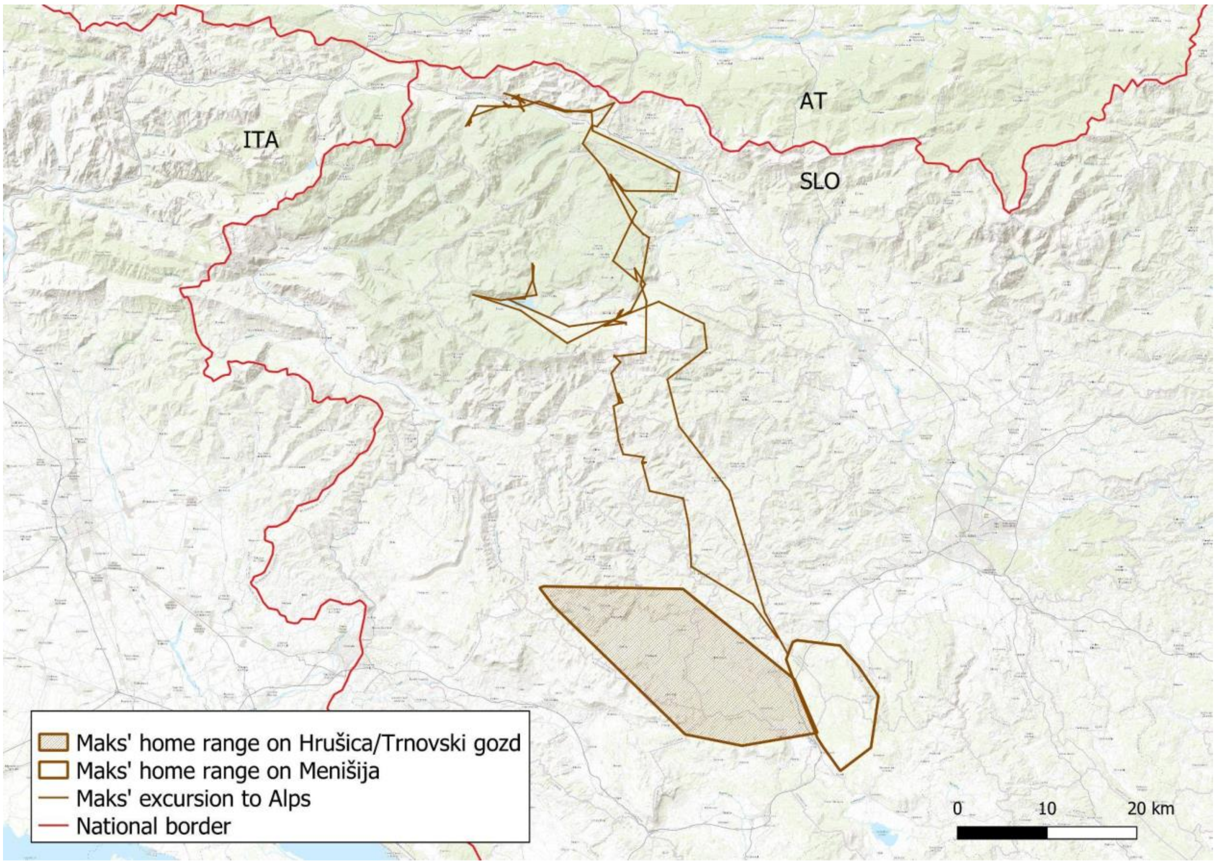

Figure 19. Map of Maks's movement after the release and his two temporary home ranges (100% MCP) on Menišija/Logatec plateau and Hrušica/Trnovski gozd.

Pino

Figure 20. Lynx Pino when released in Sjeverni Velebit National Park, Croatia.

Male Pino was captured in Slovakia in March 2020, when he was estimated to be currently 5 years old. He was released in Sjeverni Velebit National park in Croatia on 30th of May 2020. Pino's collar unfortunately did not send any location after his release on northern Velebit in 2020. He has never been recorded on photo traps and his fate still remains unknown.

Figure 21. Map of Pino's release site. No telemetry data was received after his release.

Alojzije

Figure 22. Lynx Alojzije when released in Paklenica National Park, Croatia.

Male Alojzije was captured in Romania on January 20, 2020 and is currently estimated to be 4-5 years old. Alojzije was released in Paklenica National Park on March 13, 2020. After the release, he first moved north-west on Velebit Mountains until Baške Oštarije, where he turned back towards the south-east and established his territory around Sveti Rok in southern Velebit where he continuously circulates since May 2020. In March 2021, a camera trap set in Alojzije's territory recorded 3 individuals in one event, which could arguably be a female with two kittens. As Alojzije was released on the 13th of March 2020, when the mating season was still going on, theoretically he could have mated in 2020. Furthermore, in September 2021, same photo trap photographed a lynx kitten. We did not register any other males in that area and Alojzije was staying on his territory during the mating season so it is very likely he is the father, but further genetic proof is needed to confirm this.

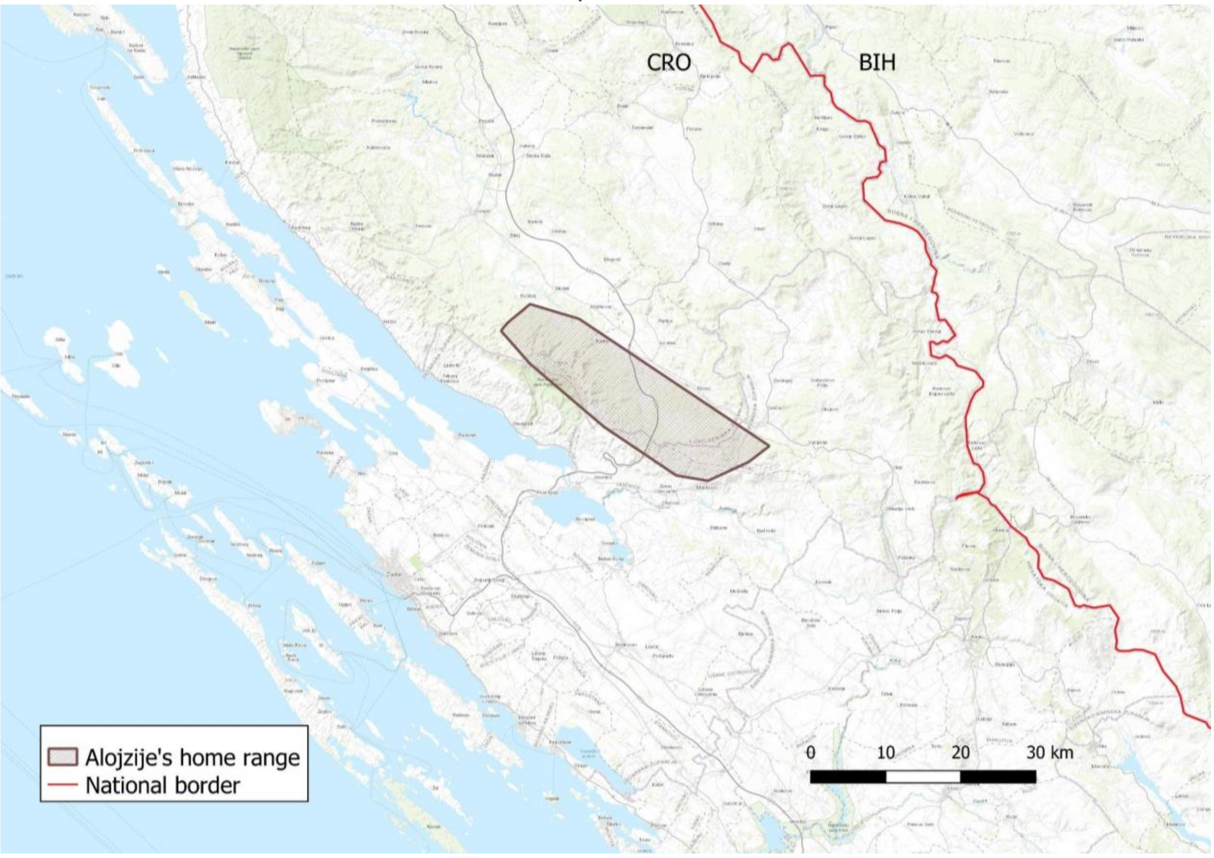

Figure 23. Map of Alojzije's home range (100% MCP) established in the southern part of the Velebit Mountains.

Emil

Male Emil is a 3-year old male captured in Slovakia in February 2021 and was translocated to Croatia, where he was released on 14.5.2021 near village Krasno in cooperation with Nature Park Velebit. After exploring northern and central Velebit, he moved southwards where he has been circulating an area of roughly 50 km^2 since the end of September. We located two of his kill sites after the release, first in May a female mouflon and later red deer remains in August. Unfortunately, due to poor satellite connectivity and low GPS-fix schedule we are getting Emil´s locations only every 2-3 months. His movements are monitored with an Iridium collar, while all other animals are equipped with a GSM collar. The collar is programmed to send the data every two weeks but if the satellite is not reachable at the moment of sending, the data is stored and sent with the next shipment in two weeks.

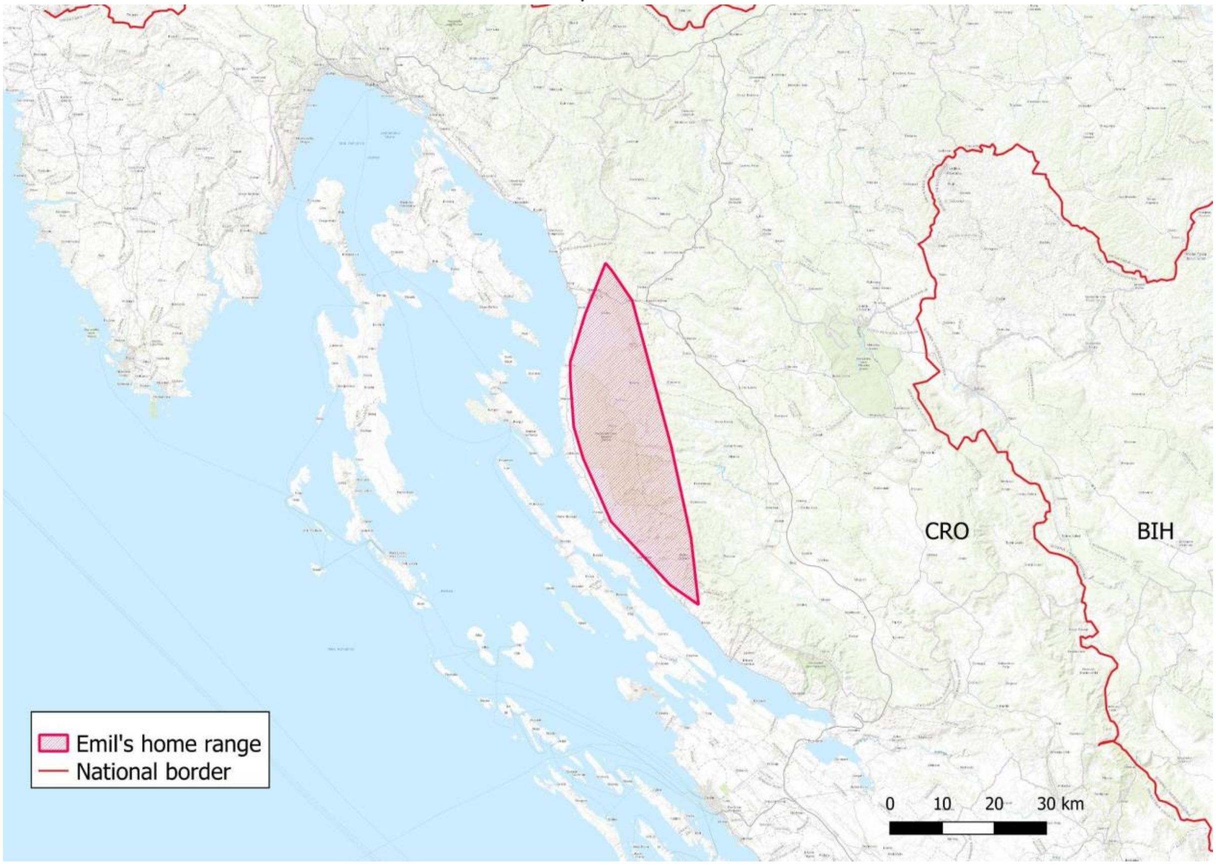

Figure 24. Map of Emil's potential home range (100% MCP) established in the southern part of the Velebit Mountains.

Reinforcement in Alps

At the end of April 2021, five translocations took place in the Slovenian Julian Alps, where two males (Zois and Tris) and three females (Julija, Lenka and Aida) were released into the forests of Pokljuka and Jelovica. All five lynx stayed in the release area and apparently established territories. One litter of three kittens from Aida was confirmed on Jelovica plateau (coincidentally found by hikers) and according to telemetry data, as well as absence of any other lynx in the area, the father is translocated male Zois. Lynx Julija was pregnant before the release and her subsequent movements suggested that she has given birth, but at the moment we cannot confirm the status of her kittens. We will describe the status, movements and reproduction of lynx in the Alps in detail in the next report (lynx monitoring year 2021/2022).

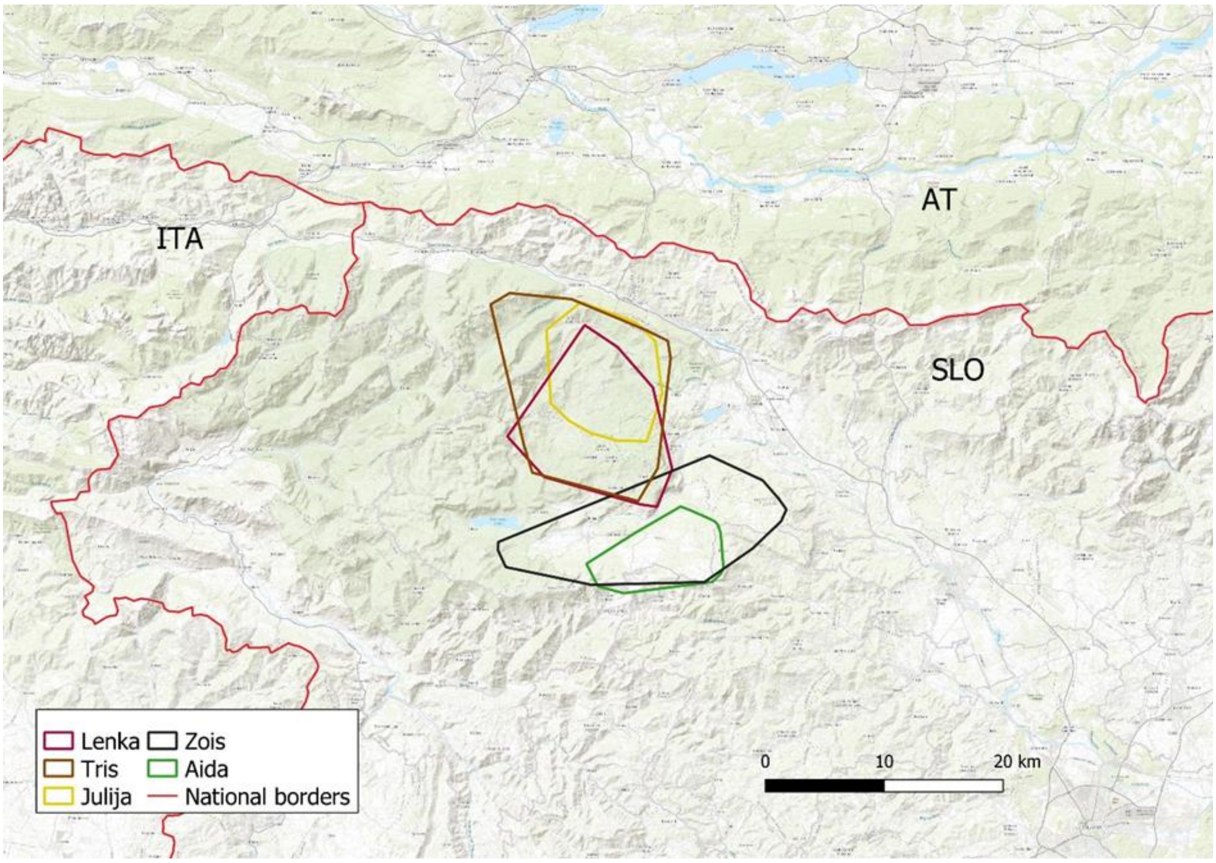

Figure 25. Home ranges (100% MCP) of five lynx released in the Julian Alps in Slovenia in April 2021.

2.6.2 Remnant lynx and offspring of translocated lynx monitored with telemetry

In addition to translocated lynx, we report on six additional lynx that were captured and collared in Slovenia (n=5) and Croatia (n=1). This will help us to better understand the territorial distribution of lynx in the current population and gain additional understanding of the reinforcement processes, such as mating with translocated lynx and potential reproduction, as well as destiny and dispersal of their offspring. So far we have captured two adult females (Teja and Petra), one adult male (Mihec) and three juvenile lynx, among which two were offspring of translocated lynx Goru and remnant lynx Teja (Mala and Niko), and one was rehabilitated orphan lynx found in Croatia (Martina).

Below we provide details on the movement of all individuals tracked during the 2020-2021 season. This includes information on a remnant male Bojan tracked within another project (3Lynx), but not remnant lynx that are tracked with telemetry in Croatia within other projects. Since we were not able to obtain permission to show their data, this is not presented in this report, but we took this information in account when writing synthesis of the current situation (chapter 3).

Mihec

Figure 26. Lynx Mihec photographed after his collar dropped off, Slovenia.

Remnant male lynx Mihec was first captured on December 23, 2010 as a 12 kg yearling in the Snežnik area. He was a kitten of GPS-tracked female Snežka. In April 2011 he dispersed from mother's territory to the north-west and established his own territory on Javorniki, where we tracked him until October 2011, when his collar stopped working (Krofel 2012). The male was spotted in that area several times until 2013, when his collar was found (passively dropped-off). Since then we didn't get any new data about his presence, probably because he became more difficult to identify without a collar. His survival was confirmed in the 2019-20 lynx monitoring season, when he was photographed several times and identified based on a coat pattern. On March 21, 2020 we captured him and genetic analysis confirmed his identity. Telemetry data revealed that sometime during the previous eight years, he shifted his territory from Javorniki to a new territory stretching from north-eastern part of Snežnik plateau, over Racna Gora to the western part of Goteniška gora region. His home range covers around 340 km^2 (MCP 100%). He is sharing his territory with at least two female lynx. In 2020 we photographed one of these females with her offspring and there is a good chance that Mihec is the father, although this needs to be confirmed with genetic analysis. We regularly obtain records of Mihec through camera-trapping, with over 20 photos from him, especially from hunting grounds Iga vas and Babno Polje. Despite being one of the oldest known lynx in the Dinaric Mountains, Mihec appears to be in good shape. His collar dropped-off on 23rd July 2021, but we continue to detect him with camera traps.

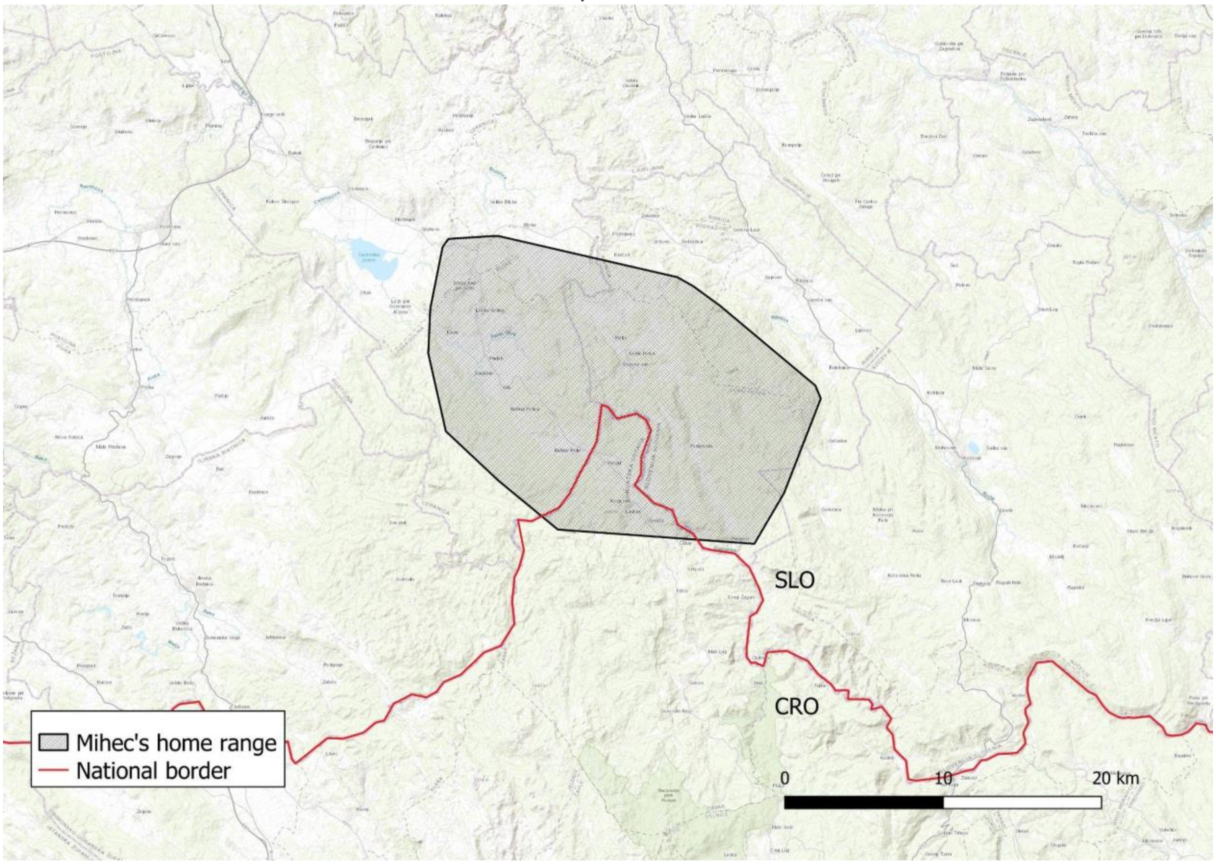

Figure 27. Map of Mihec's home range (100% MCP).

Petra

Figure 28. Lynx Petra after collaring in Kočevsko

On 1st of March 2021, an adult resident female lynx named Petra was captured in Kočevsko area, in the upper Kolpa valley in Slovenia. Her estimated age is between 5 to 6 years old. She weighed 16 kg and was in good physical condition at the time of the capture. Her home range is estimated to be around 122 km^2. Petra had raised one kitten in the season 2020/2021 who had already dispersed outside of her home range. In the mating season 2021, she was seen and recorded with a local territorial male with whom she probably mated. In mid May 2021, she gave birth to four kittens, among which three were still confirmed alive in December 2021. She was regularly recorded on the kill sites, where she appeared in a good physical condition. Her prey was mostly roe deer, but we also found remains of chamois and red deer.

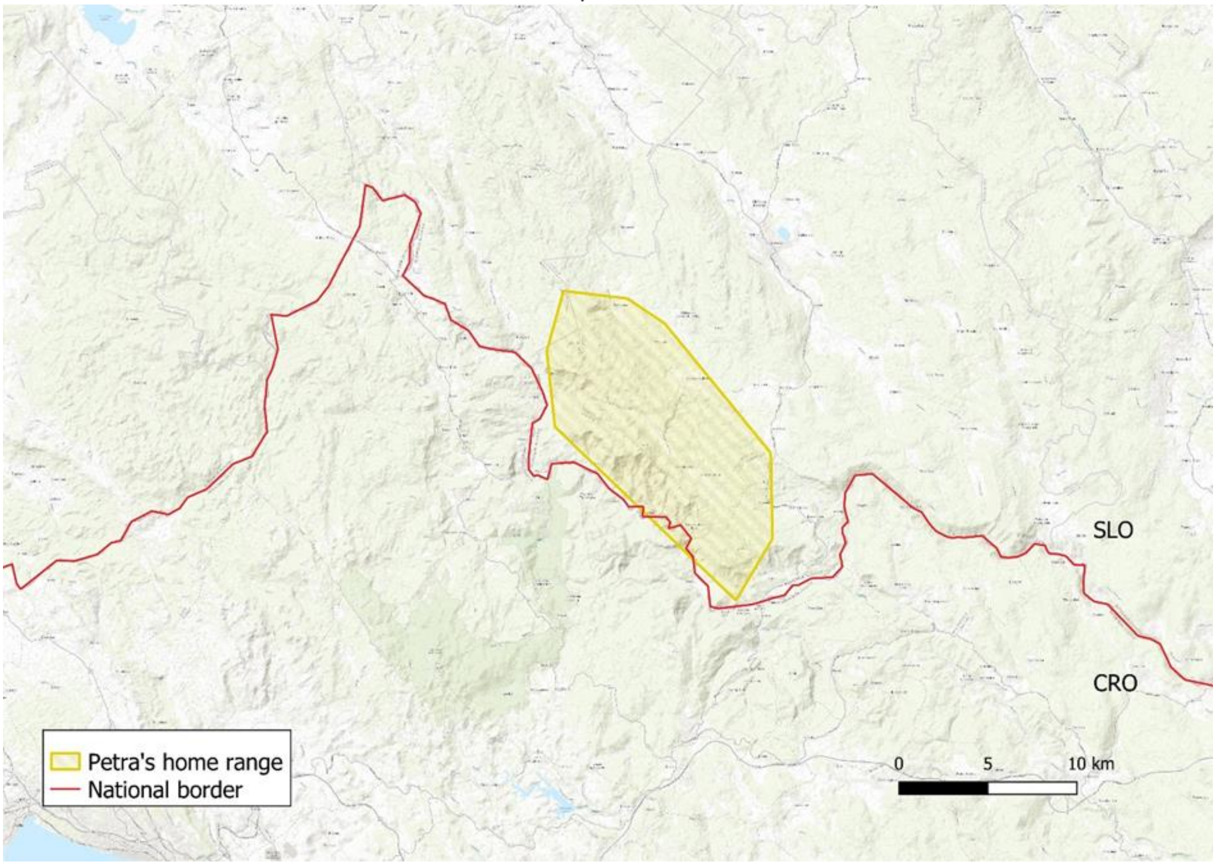

Figure 29. Petra's home range (100 % MCP)

Bojan

Figure 30. Remnant lynx Bojan after collaring near Kolpa river, Slovenia.

Lynx Bojan is a remnant lynx that was collared within the Interreg 3Lynx project on December 1, 2019. He weighed 24 kg and was estimated to be four years old. He was captured in Slovenia, close to the border with Croatia in the hunting ground Osilnica. He stayed in Slovenia for a few days after the capture, but soon crossed the border with Croatia and since then mostly stayed in Gorski Kotar area.

His home range size measured 515 km^2 (MCP 100 %), which is larger than most other lynx home ranges in the Northern Dinaric Mountains. It is mostly located in Gorski Kotar in Croatia, partly within Risnjak National Park, with occasional visits to Slovenia, mainly around Osilnica and a single excursion (possibly extra-territorial) to Velika gora. Telemetry data revealed a likely encounter with young translocated lynx Boris, who left the area after this interaction. Bojan's collar stopped working on 3rd of March 2021 and his current status is unknown.

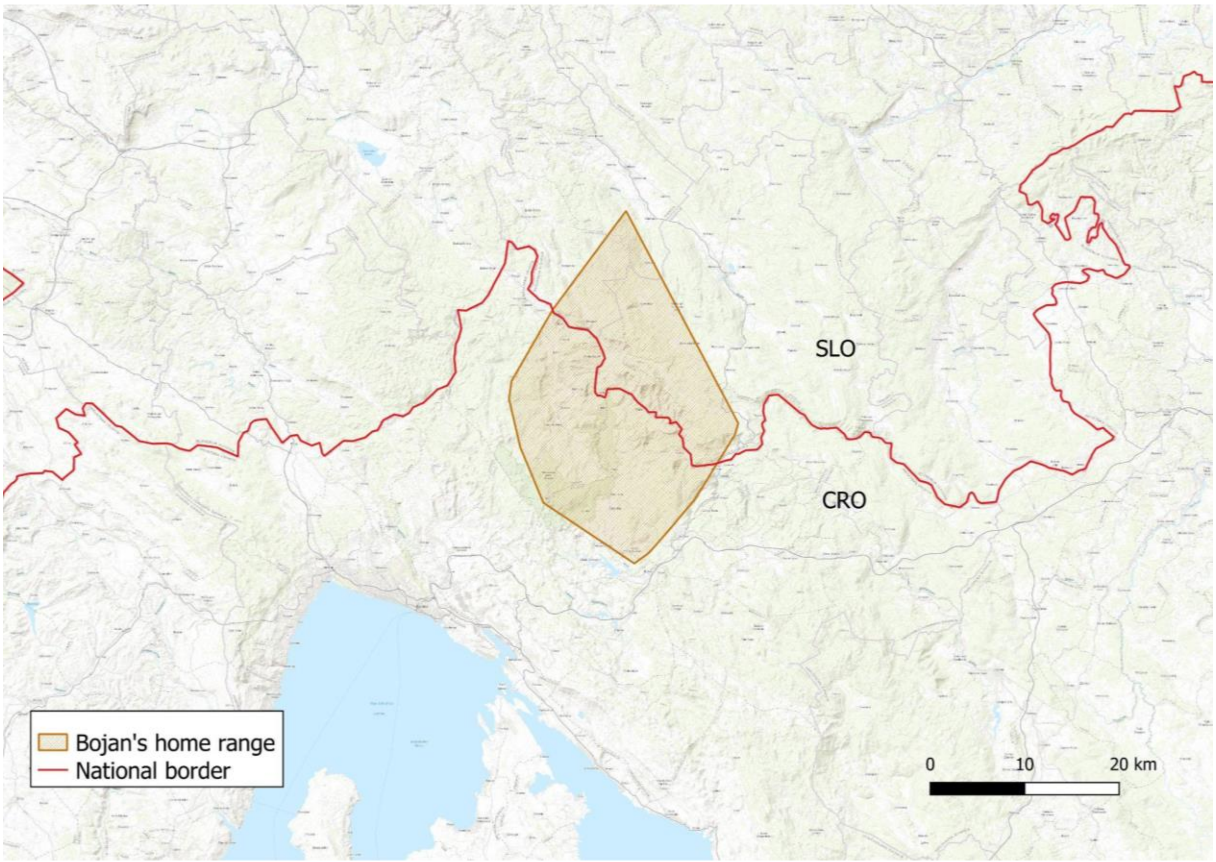

Figure 30. Map of Bojan's home range

Mala

Figure 31. Lynx Mala photographed with camera-trap on Mala gora, Slovenia.

Female lynx Mala is a descendant of the remnant lynx Teja and translocated lynx male Goru, born in mid-August 2019, which is a very late date for Eurasian lynx in Europe and was possibly a consequence of absence of male lynx in her mother's territory, before the arrival of a translocated male Goru in the beginning of June. Mala was first photographed at her mother's kill site on November 21, when she was estimated to weigh around 3-4 kg. On January 18, 2020 we captured Mala while trying to recapture her mother and collared her with an ultralight GPS collar. Mala stayed with her mother until the beginning of May when Teja gave birth to the next litter. Mala dispersed north to Suha krajina area but stayed close and occasionally visited her mother's territory. Mala was successful at hunting prey on her own and shortly after independence managed to kill her first roe deer. At the end of June 2020, the batteries in her collar started draining out so we triggered drop-off but unfortunately due to a collar failure it did not activate. Soon thereafter the signal was lost, but we continued to detect her on camera traps and she continues to appear in good physical condition (Figure 31). We continue with efforts to recapture her and replace the failed collar.

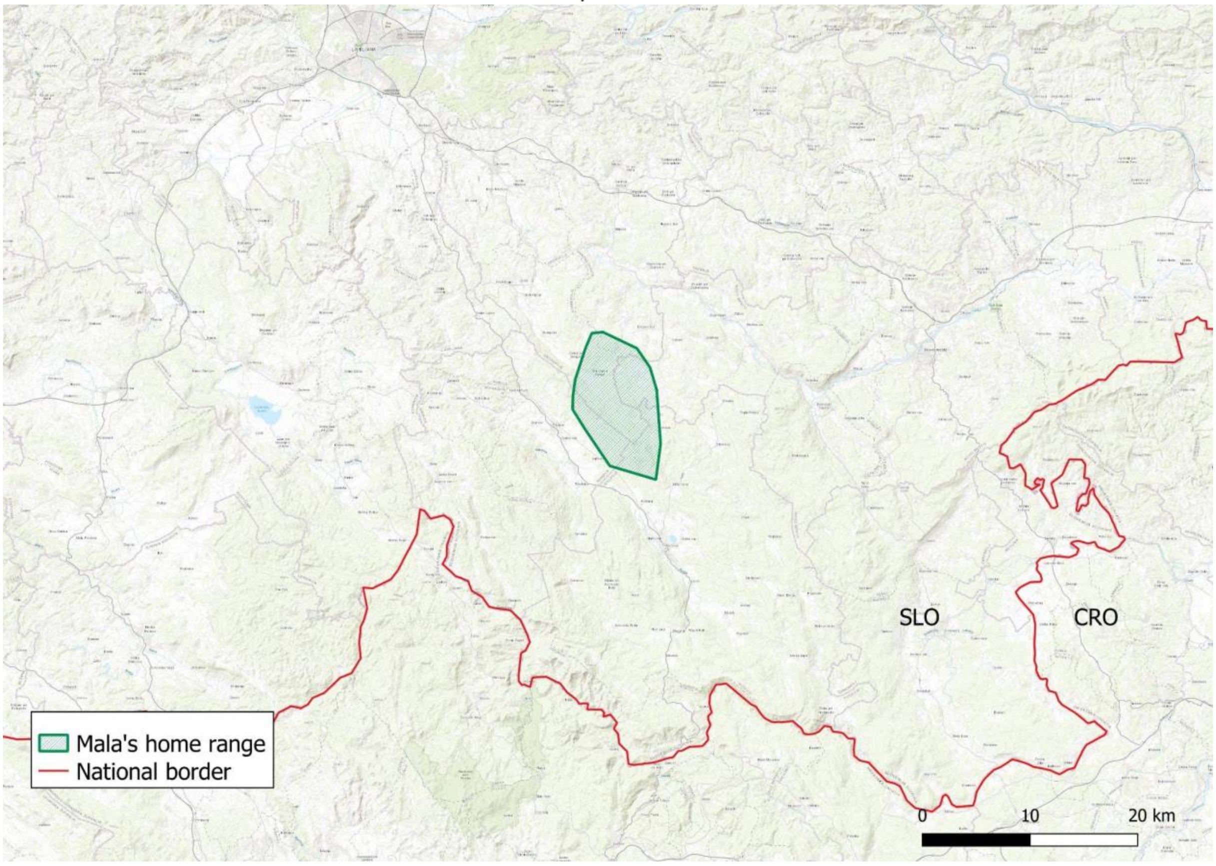

Figure 32. Map of Mala's home range (100% MCP) after independence.

Niko

On December 6th, 2020 we collared a young male lynx, one of lynx Teja's 2020 kittens. In mid-December 2020, he first moved about 15 km away to the eastern part of the Kočevski Rog. In February 2021 his collar stopped working. Luckily we found his prey on the last location that this collar sent, recaptured him and replaced his collar. His movement pattern initially indicated that he would settle in this area, but in early April 2021 he moved approximately 30 km south to the Vrbovsko area, where he remained until June 11, 2021. From here, he then moved on to the area southeast of Ogulin and remained there until mid-August 2021. In early September 2021, Niko returned to Slovenia, where he first went in the direction of Stojna but then changed direction and came back to the area of Kočevski Rog. He stayed in this area for about a month, then headed south again, and is now back in Croatia in the area between Kolpa and Vrbovsko, where he apparently established his territory (around 30 km^2 for now).

During the dispersal, he has so far covered at least 1,355 km. During that time, he crossed the Kolpa River three times and Rijeka-Zagreb highway six times. He probably swam the river, but he crossed the highway via a green bridge or over a tunnel, which shows how important green bridges are for connecting the lynx population.

We visited 16 potential kill sites in Slovenia and found 11 prey remains; 10 roe deer remains and on one occasion he was probably scavenging on a male red deer carcass (the cause of death is unknown).

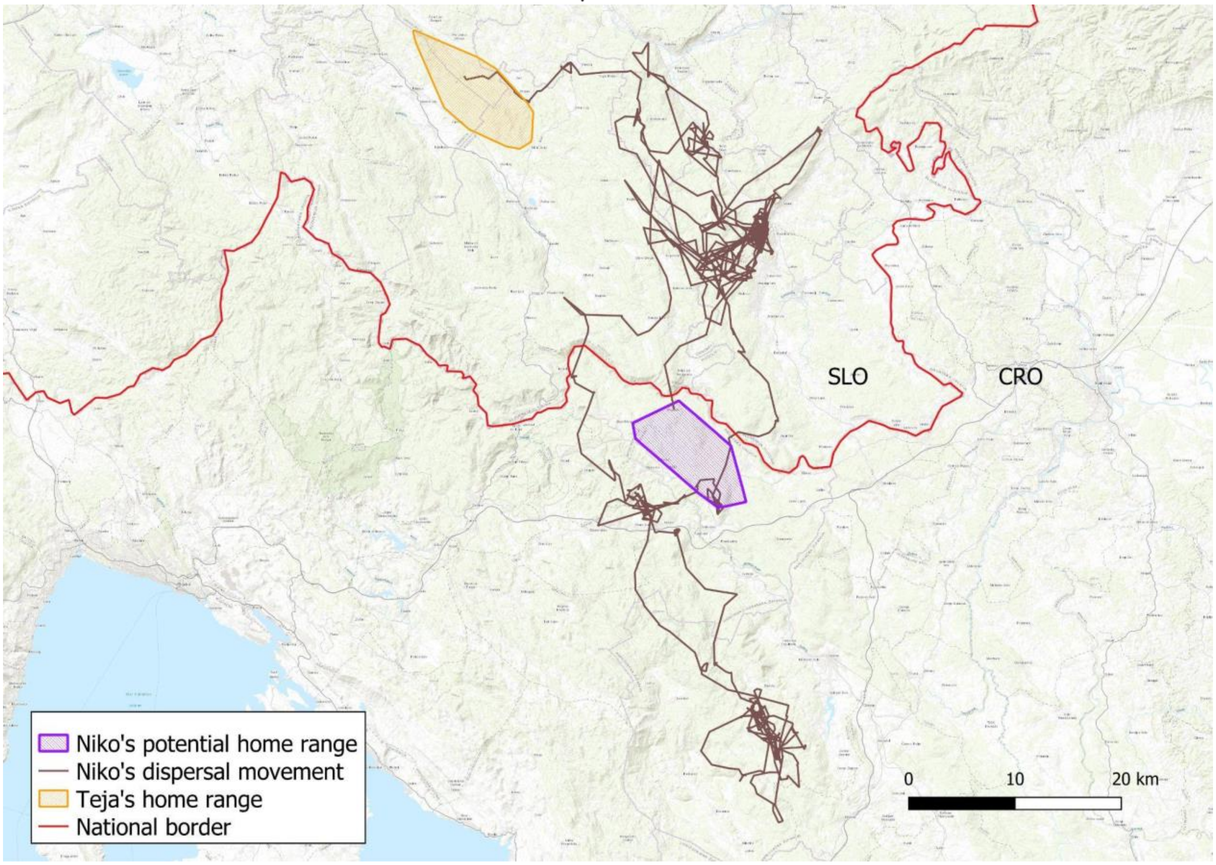

Figure 33. Map of Niko's dispersal movement from the home range of his mother, Teja (yellow) and his potential home range (purple) in Croatia.

Martina

Figure 34. Lynx Martina at lynx enclosure in Risnjak National Park

Martina was an orphan lynx that was captured on 11.11.2019 near Ogulin by the wolf and lynx intervention team from Croatia as she was approaching the vicinity of villages. At the time of the capture she was around 6 months old and weighed 6 kg. She was taken to Risnjak National park enclosure that is built for orphan lynx where she was fed until the end of February 2020, when she was released. Prior to the release she had broken her upper canines in the enclosure, but the Croatian team fromFaculty of veterinary medicine in Zagreb had the canines successfully reconstructed. She was equipped with a telemetry collar. After the release, she started moving north for two weeks and stopped at one location near Lividraga in Risnjak National Park, but soon after, she crossed the border and went towards Ilirska Bistrica. She was frequently approaching the vicinity of the villages, where she was feeding on slaughter remains and reported chasing domestic cats. She has been also frequently visiting fox dens, where she was killing and feeding on fox pups. To help improve her condition, a roe deer carcass was put near her location. The action was successful as she was feeding with the carcass. However, she was still moving around the villages. On 2.6.2021 her collar stopped working and two months later, her remains (only bones were left) and her collar were found in the agricultural landscape near Pivka.

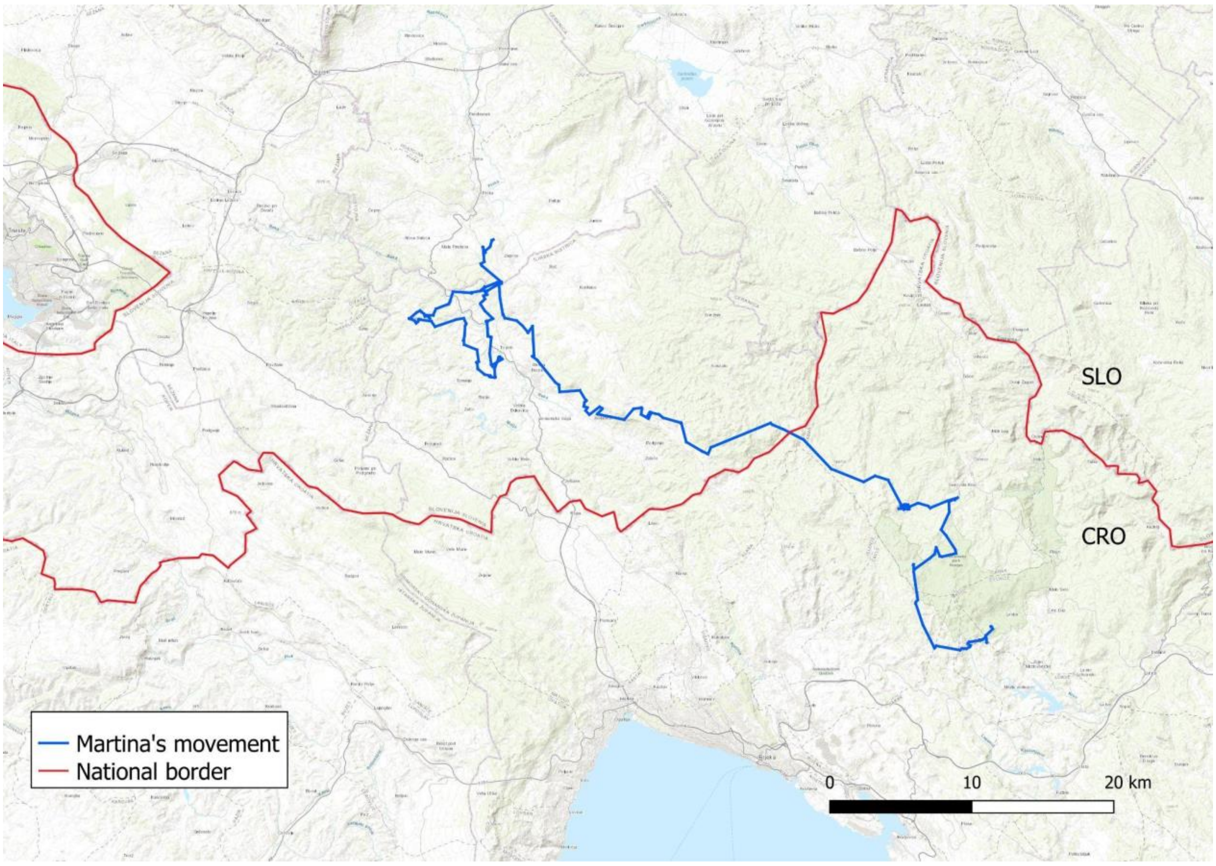

Figure 35. Lynx Martina's movement

2.6.3 Monitoring lynx predation on ungulates

Thanks to lynx behaviour of returning to their ungulate kills for several days (Krofel et al. 2013), telemetry data obtained from GPS tracking can be a useful tool for studying lynx predation and thus enable us to find the kill sites in the field. Collection of data at the kill sites can provide us with insight about lynx diet, which can be later implemented into ungulate management plans and evaluation of the lynx ecological impact. Besides, installing camera traps on fresh kills provides us with an opportunity to obtain footage and assess lynx' physical condition and impact of kleptoparasitism (loss of prey to scavengers).

Between May 2020 and April 2021 we found 103 lynx kill sites in Slovenia and Croatia in total. The main prey species found at the kill sites was European roe deer (*Capreolus capreolus*) with 83 % of all detected kills. We also detected red deer (*Cervus elaphus*) (11%), red fox (*Vulpes vulpes*) (2%), dormice (*Glis glis*) (2%), chamois (*Rupicapra rupicapra*) (1%) and wildcat (*Felis silvestris*) (1%) at the lynx kill sites. There was one case of lynx scavenging on a male red deer carcass. Scavenger species that were recorded at the lynx kill sites were red fox, brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), Eurasian badger (*Meles meles*), golden jackal (*Canis aureus*), beech marten (*Martes foina*), wild boar (*Sus scrofa*), golden eagle (*Aquila chrysaetos*), common buzzard (*Buteo buteo*), common raven (*Corvus corax*), Eurasian jay (*Garrulus glandarius*) and coal tit (*Parus ater*). In Table 8 we present sex and age structure of roe deer killed by the collared translocated and remnant lynx. Lynx mostly killed adults and somewhat more females than males. In general, these results suggest similar predation patterns to those observed in previous research on resident lynx from the Dinaric population (Krofel et al. 2014), as well as in the previous monitoring year (Krofel et al. 2021).

Table 8. Age and sex structure of roe deer killed by collared lynx.

	roe deer	**sex**			**Total (%)**
		male (%)	**female (%)**	**unknown (%)**	
age	adult	17(19.8)	25 (29.1)	6 (7)	43 (55,8)
	juvenile	5 (5.8)	8 (9.3)	5 (5.8)	14 (18)
	unknown	0 (0)	2 (2.3)	18 (20.9)	3 (23,3)
	Total (%)	22 (25.6)	35 (40.7)	29 (33.7)	86 (100)

With the telemetry data and GPS cluster analysis (see Krofel et al. 2013 for details), we could also calculate the kill rates for each of the collared translocated lynx, except for Doru, Alojzije, Pino and Emil, where this was not possible due to too low GPS fix rate for this purpose or collar malfunction. The average interval between consecutive kills was 6.4 days for the translocated lynx. The highest kill rate was observed for lynx Catalin, with an average interval between the kills of 6.0 days. The lowest kill rate was observed in lynx Goru, with an average kill made every 6.7 days. Compared to the previous research on remnant Dinaric lynx (average kill interval of 7.2 days; Krofel 2012) this kill rate appears higher. We assume that this could be connected with higher densities of wild ungulates in some of the areas occupied by monitored lynx, as well as potentially naïve prey in areas recently re-colonized by the translocated lynx (e.g. Rakitna, Menišija, Mala gora), similar to observations reported from elsewhere (Duľa & Krofel 2020). Additional reason for the observed difference could be due to the male-biased sample of lynx monitored during the first period of this project compared to the previous study in this area.

2.7 Lynx mortality

In total, there were 4 mortality events detected in Slovenia (n=2) and Croatia (n=2) in the lynx monitoring year 2020-2021.

Female Martina (found as an orphan in Croatia and rehabilitated, see subchapter 2.5.2) was found dead in an open agriculture landscape near Pivka, Slovenia in August 2020. Only the collar and some bones were found at the site, therefore no autopsy could be performed.

Another female lynx died in Slovenia on 23.3.2021, a day after she was captured in a box-trap, sedated, collared and released. This female was known from systematic camera trapping and other photo records since 2016 while genetic analysis later showed that she was at least 10 years old (her genetic sample was found in Snežnik area in 2011). She was a territorial female in the area of Glažuta and Kočevska Reka, and had been recorded with two cubs in lynx year 2020-2021. The Faculty of veterinary medicine University of Ljubljana performed a necropsy on the carcass. The female lynx most likely died from a permanent (patent) foramen ovale between the atria of the heart. Patent foramen ovale is a congenital heart defect that often leads to stroke, which in this case was probably due to the shock of capture. Moreover, histopathological examination revealed severe degeneration and fibrosis of the myocardium and liver, severe anemia in the lungs, and small groups of glial cells in the brain. Chronic inflammation and a single small renal stone were found in the kidneys, while numerous large hemorrhages were found in the small intestine and small hemorrhages in the uterine wall. The necropsy results are essential information for unravelling the detrimental effects of inbreeding depression. Although impossible to assess the individual lynx health status from visual data available (e.g. camera trapping records) prior the capture or foresee its response to capture, we must be aware that several malfunctionalities or defects exist in the inbred population. This unfortunate example further supports the urgency of the reinforcement activities to save the Dinaric SE Alpine lynx population from collapse.

In Croatia, a young male aged approximately 6 months was found in an abandoned and uncovered well, near Donji Lapac, Lika - Senj county, on November 5th 2020. The carcass was collected, transported to Zagreb and examined at the Faculty of Veterinary Medicine of Zagreb. Drowning was confirmed as a cause of death. On April 20th 2021 another young male was found dead, the carcass was already decayed so a certain cause of death could not be established at Faculty of Veterinary Medicine University of Zagreb. Bullet wounds or casings were not detected, but the ears were cut with knife or scissors pointing that a human was in contact with the carcass, so poaching is not excluded. Animal was found by a hunter in northern Dalmatia, south of Sinj and this is the most southeastern verified (C1 category) evidence of lynx presence in Croatia.

3. REGIONAL SYNTHESES

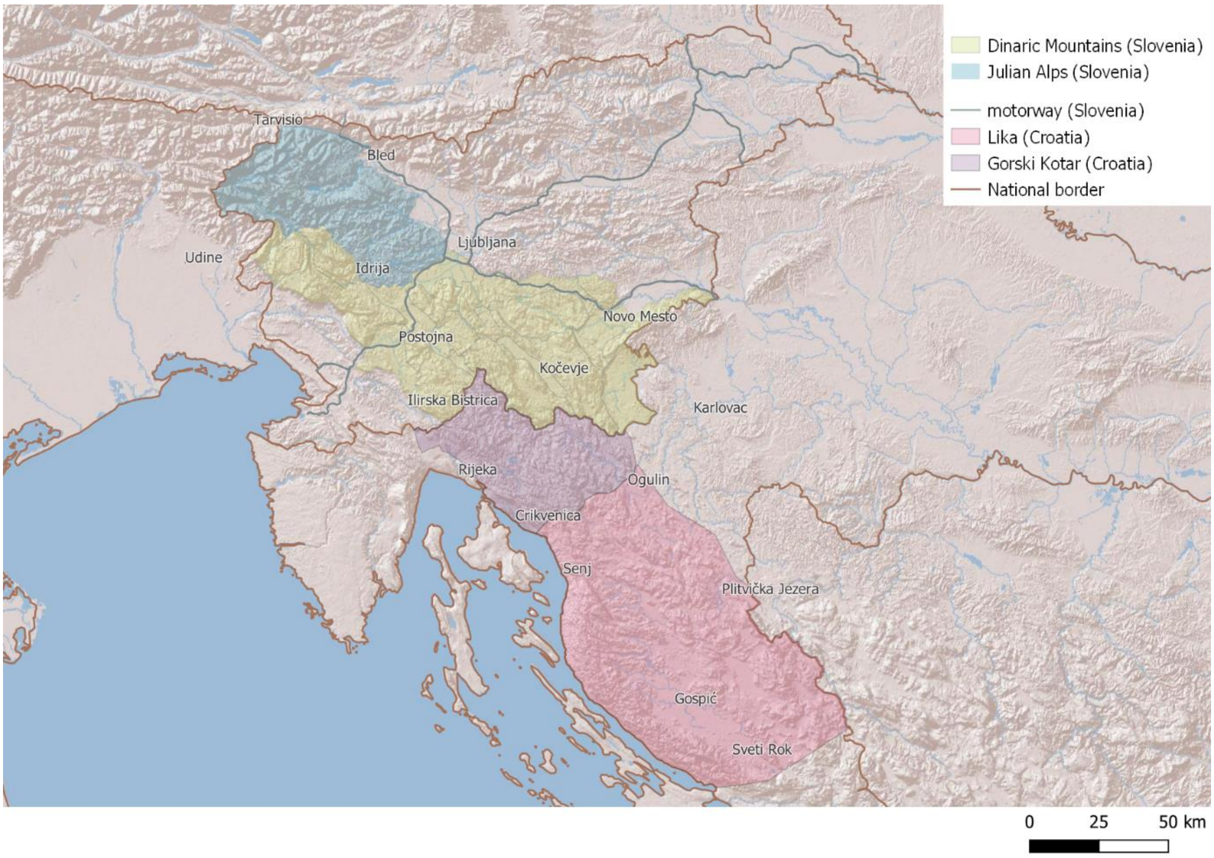

Figure 36. The division of Dinaric-SE Alpine project area in distinctive regions for which we present the syntheses in chapters 3.1 – 3.5. The NE Alpine – Italy region is omitted due to lack of reliable data on lynx presence there.

3.1 Slovenian Dinaric Mountains

In the Slovenian part of the Dinaric Mountains east of the Ljubljana-Koper highway (i.e. Notranjska and Kočevska) most of the region is currently occupied by lynx, including several territories occupied by both male and female lynx. A minimum of 24 different adult lynx were detected in this region in 2020-2021 lynx-monitoring year, including two translocated males with established territories (Goru and Catalin). In this monitoring year we again recorded a higher number of successful lynx reproductions (5), including another successful mating between the translocated male and remnant female. In comparison to the previous lynx monitoring year (Krofel et al. 2021), both minimum number of adults and number of reproductions suggest positive population development.

Lynx pairs sharing a territory were confirmed in Kočevski Rog/Poljanska gora, Mala gora (with reproduction), Goteniška gora/Velika gora/Kolpa (with two reproductions), Racna gora (with reproduction), Snežnik plateau (with reproduction), Menišija/Logatec plateau/Rakitna and Mokrc. Areas with potential single lynx, although some of them might only be transient dispersers, detected this year include Pivka valley (collared dispersing female which later died), Velika gora and northern part of Goteniška gora (after death of a territorial female in this area only a male apprea to be present, which was detected both with camera trapping and genetics), northern part of Kočevski Rog (one male confirmed genetically), Dolenjska and Poljanska gora (single records of lynx of unknown sex).

A notable absence of lynx is noted in Javorniki, where lynx were regularly present in the past (including translocated male Doru, which apparently disappeared), but none was detected this year, despite intensive camera-trapping and snow-tracking in the area. At the moment it is not clear what could be the reason for this absence (poaching is suspected but no evidence is available). Despite the disappearance of lynx from Javorniki, the situation in Slovenian Dinaric Mountains west of the Ljubljana-Koper highway generally improved in comparison to the previous year, primarily due to confirmed presence of a lynx pair on Mokrc and improved situation in Kočevski rog. According to available data, the main non-occupied areas in the area, where potential new lynx could establish territories include Javorniki, area around Bloke, Stojna, Vremščica and northern part of Suha Krajina. However, it must be noted that some of these areas are not systematically monitored, therefore the presence of lynx cannot be excluded.

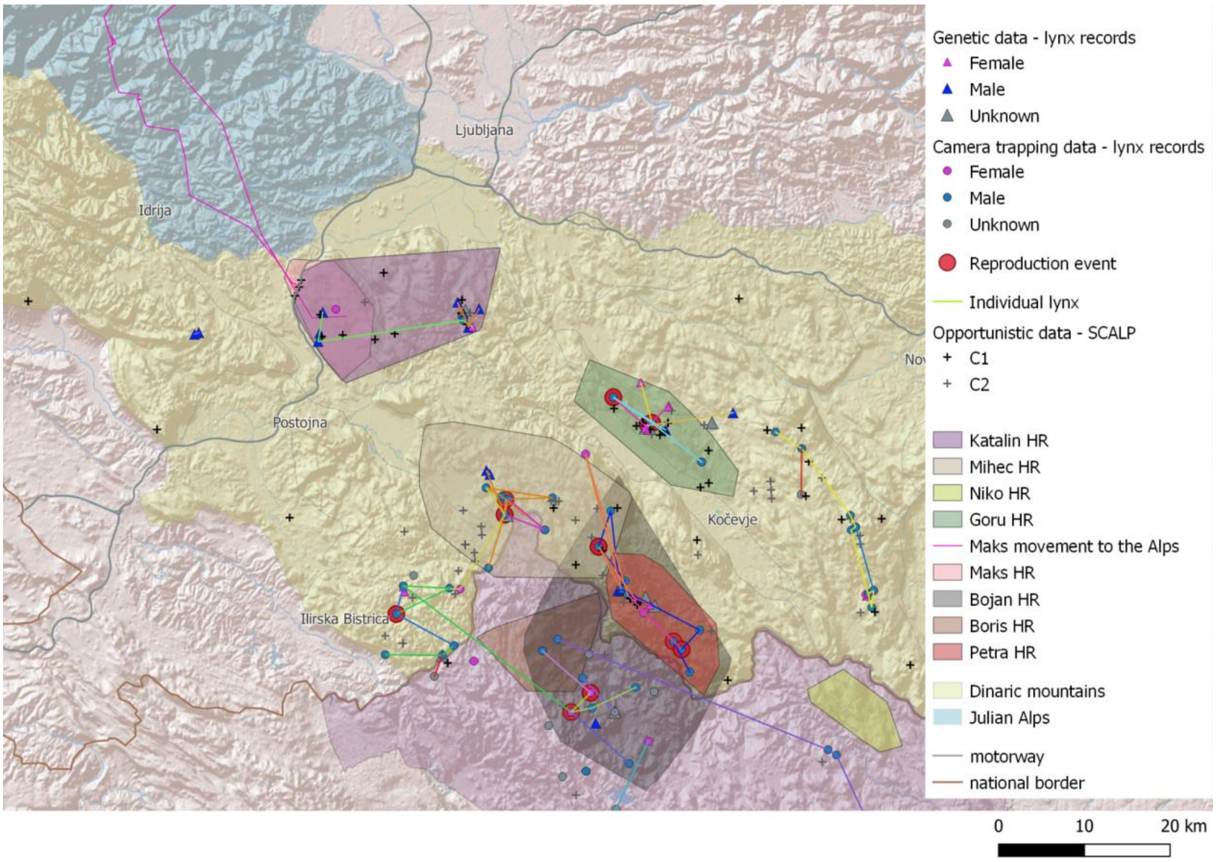

Figure 37. Overview of all confirmed records of Eurasian lynx collected during the 2020-2021 monitoring year in Kočevska and Notranjska regions in Dinaric Mountains of Slovenia. Shown are records from the systematic camera-trapping and non-invasive genetic monitoring (with information about the sex of detected lynx, when available), home-ranges (HR; 100% MCP) of translocated lynx tracked with GPS telemetry and confirmed opportunistically-collected records (C1 and C2 category). Straight lines connect genetic samples and camera-trap records confirmed to belong to the same individual, each line colour representing a different individual.

In the Slovenian part of the Dinaric Mountains west of the Ljubljana-Koper highway we could confirm lynx presence in 2020/2021 lynx monitoring year on Hrušica, Nanos and Trnovski gozd, although we still do not have any confirmed record of reproduction or females present in this region. On Hrušica the presence of one remnant male was confirmed genetically, however, this is apparently a new male, while the two males that were recorded here in the previous years were no longer detected. From Nanos and Trnovski gozd we obtained only two confirmed opportunistic C1 records, which did not allow identification of the individual or sex. In addition, a collared lynx translocated to Snežnik (male Maks) crossed the region twice during his return trip to Julian Alps. After the end of this lynx monitoring year, this male appeared to have started to establish his territory in Hrušica and Trnovski gozd, but then his signal was lost. Further intensification of monitoring efforts is recommended for this region, also because this represents the potential connection between the Alps and core area in Dinaric Mountains east of the Ljubljana-Koper highway.

3.2 Julian Alps, Slovenia

No confirmed records of any remnant lynx were obtained from this region in 2020/2021, thus all the records of lynx presence were connected with the translocated lynx. At the end of 2020, collared lynx translocated to Snežnik (male Maks) made an excursion and crossed this area, but later returned to Dinaric Mountains. At the very end of this lynx monitoring year (in late April 2021) five lynx were released in this region on Jelovica and Pokljuka with probably two females reproducing later in 2021. This necessitates that systematic monitoring is expanded in this region in the following years to be able to follow the development of this new stepping-stone subpopulation.

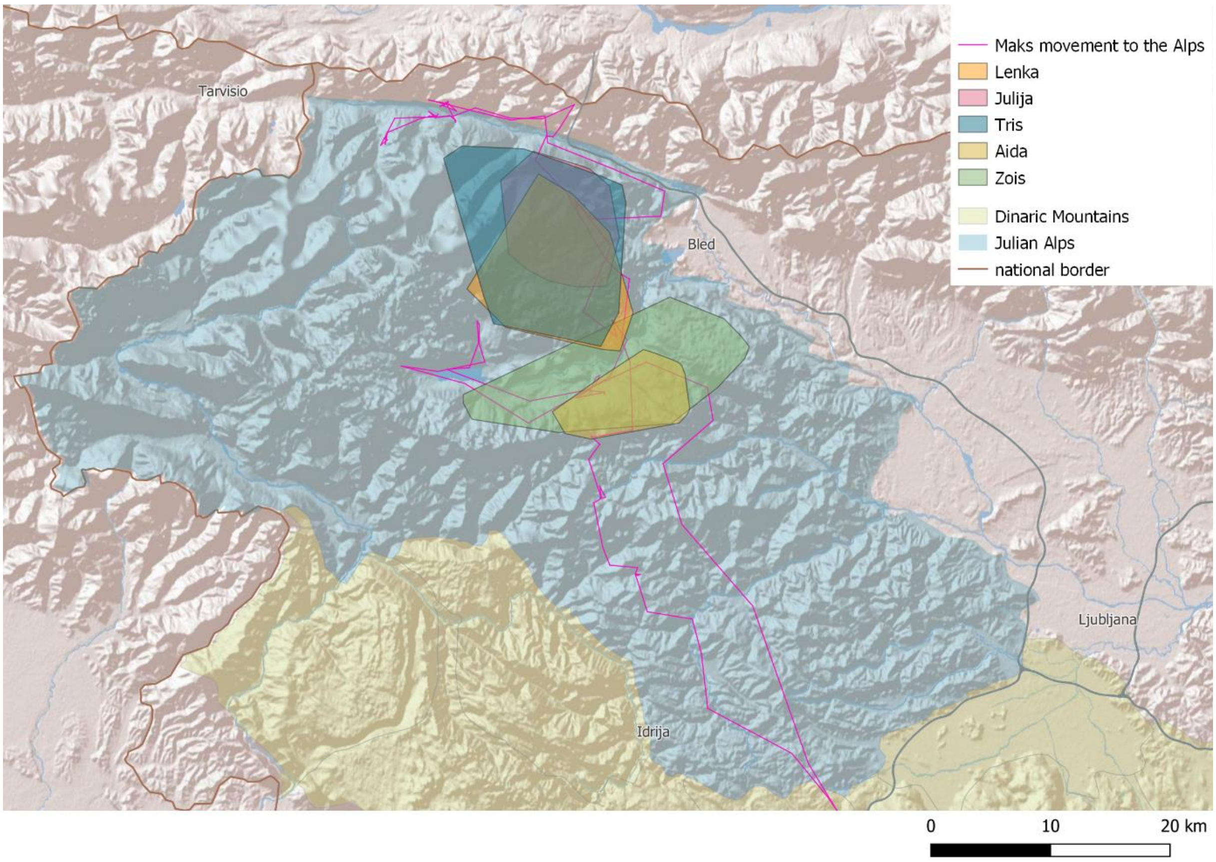

Figure 38. Overview of all confirmed records of Eurasian lynx collected during the 2020-2021 monitoring year in Julian Alps, Slovenia. No other records apart from telemetry data from translocated lynx were available.

3.3 Gorski Kotar, Croatia

In Gorski Kotar we identified 29 adult lynx, 26 with photos from both sides of the body, 2 from only right side and one (from different area) from the left side only, among which were 12 females, 13 males and 4 animals of unknown sex. This suggests a similar situation compared to the previous year. No lynx were recorded in the northern part (except data from GPS telemetry), where several detections were noted in the previous year, but at the moment it is hard to conclude whether this is reflecting actual decrease in lynx presence in this part. On the other hand, we collected more records in the central and southern part of Gorski Kotar this year. Lynx Boris is mostly present on Kapela Mountain, an area which is still suspected to be covered with land mines, which limits our ability to monitor this area.

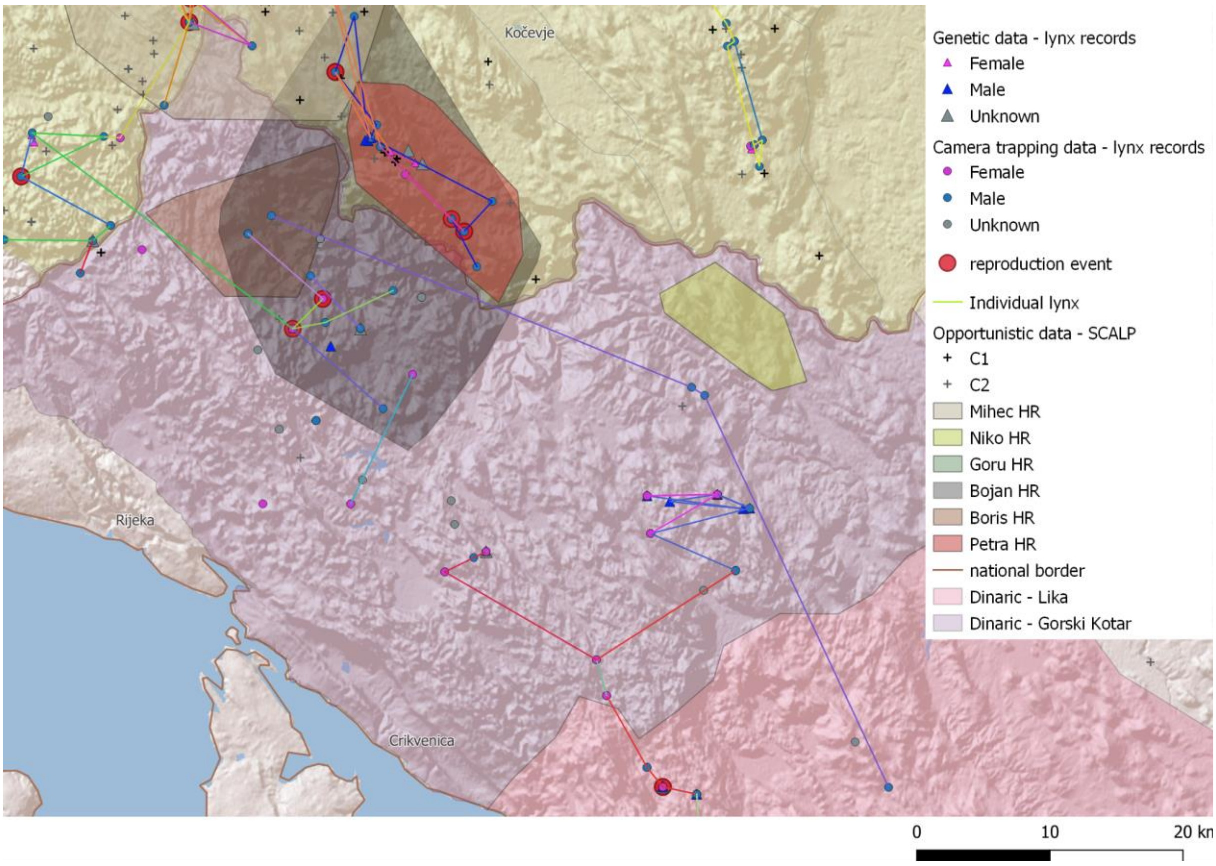

Figure 39. Overview of all confirmed records of Eurasian lynx collected during the 2020-2021 monitoring year in Gorski Kotar, Croatia. Shown are records from the systematic camera-trapping and non-invasive genetic monitoring (with information about the sex of detected lynx, when available), movements of translocated lynx tracked with GPS telemetry and confirmed opportunistically-collected records (C1 and C2 category). Straight lines connect genetic samples and camera-trap records of the same individual.

3.4 Lika and northern Dalmatia, Croatia

A total of 45 adult animals were identified in the wider Lika and northern Dalmatia region (including animals in Karlovac and Zadar county), 33 from both sides of the body, 8 only from the right, 4 only from the left. Among them were 10 females, 10 males, 18 animals of unknown sex. 26 of the animals are known from the previous season, while 12 are recorded since the 2018 - 19 season. Compared to the previous year (58 adults recorded; Krofel et al. 2021) number of recorded animals has reduced, although there was improvement in the number of animals identified on both sides of the body. This reduction is probably connected with decrease in monitoring effort, since the total number of active cameras was somewhat lower in the last year and, more importantly, we could not include data from other sources (National park Plitvice lake and environmental impact assessment study by Geonatura company), which were provided in the previous year. This year we detected lynx, including reproduction, in central Lika, where no signs of lynx presence were recorded previously. Positive development is also the likely reproduction of the translocated male Alojzije. An isolated case of a male lynx mortality record (not shown on the map on Fig. 32, see chapter 2.6 for details) south of Sinj is an important indication of possible occasional occurrence of lynx in this area.

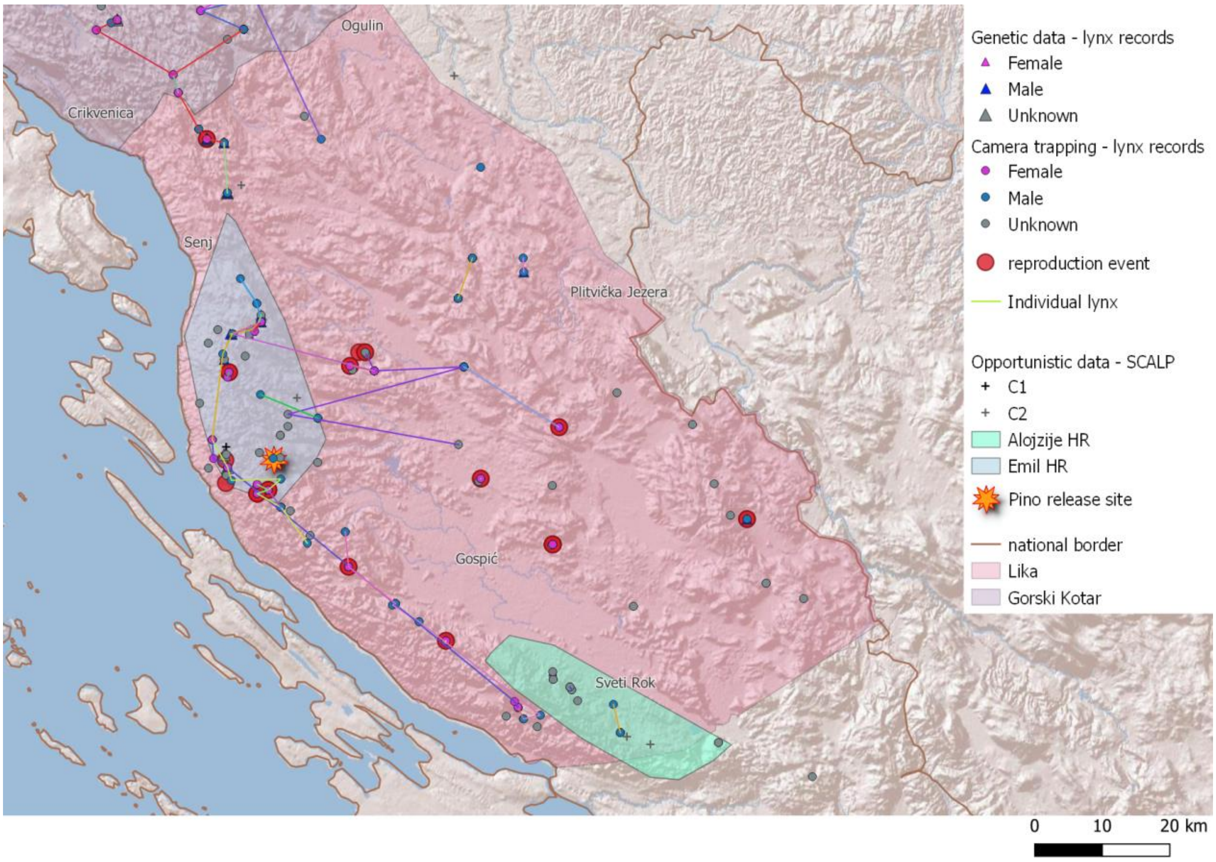

Figure 40. Overview of all confirmed records of Eurasian lynx collected during the 2020-2021 monitoring year in Lika, Croatia. Shown are records from the systematic camera-trapping and non-invasive genetic monitoring (with information about the sex of detected lynx, when available), home range (HR) of translocated lynx tracked with GPS telemetry and confirmed opportunistically-collected records (C1 and C2 category). No telemetry data was received from one of the released lynx, therefore only his release site is indicated.

4. CONCLUSIONS WITH RECOMMENDATIONS FOR FURTHER RELEASES

According to available data, in 2020-2021 the status of Dinaric-SE Alpine lynx population generally appears similar to the previous year, with an increase in recorded adults and reproductions in Slovenia and apparently similar situation in Croatia. Due to this year's lower monitoring effort in Croatia (data from National park Plitvice was included in the last year's report, but not this year), it is possible that numbers in this country are underestimated compared to previous year and further monitoring will be required to better understand trends.

Several territories across the Dinaric Mountains of Slovenia and Croatia are occupied by lynx of both sex and at least four of the males translocated from Carpathian population in 2019 and 2020 have become successfully integrated in the population with several confirmed or suspected reproductions. The number of lynx in the western part of Dinaric Mountains in Slovenia (i.e. west of Ljubljana-Koper highway) remains small and no confirmed records of presence of remnant lynx in the Alpine region of Slovenia or north-eastern Italy were collected. However, the situation in the Alpine region is expected to considerably improve in the next years, following the translocation of five Carpathian lynx to the Slovenian Julian Alps at the end of 2020/2021 lynx monitoring year.

Similar to the previous year, camera trapping provided the most informative insight into demographic status of the population, especially in Slovenia where camera-trap density was high and monitoring activities intensively coordinated. This could only be achieved by close cooperation with hunters, which should be further nourished in order to yield good results. In addition to camera-trapping, also genetic and opportunistic data importantly complemented the picture. Genetic monitoring is crucial for assessing genetic status and influence of ongoing translocations. But due to difficulties of collecting enough samples over the entire area, genetic monitoring could so far only be used as supplementary data to camera trapping for understanding the demographic status and population parameters. However, genetic samples gave us important insight into the level of effective inbreeding, which is the most important threat to this population and which could not be monitored with other methods. While inbreeding is still high, we can already see important improvements due to population reinforcement efforts and large increase in expected heterozygosity indicates the potential for rapid decrease of inbreeding if the translocated animals continue to successfully reproduce.

In this report we also included the first preliminary population density estimate for Dinaric lynx population for monitoring year 2019/2020 using spatial capture-recapture model. The density in the core area of the population in Slovenia and Croatia was estimated to 0.74 lynx/100 km^2 (confidence interval: 0.56-0.98 lynx/100 km^2), which is comparable to some other reintroduced populations in Central Europe (e.g. 0.58 lynx/100 km^2; Gimenez et al. 2019) but still lower compared to source population in Romania (1.83 lynx/100 km^2; Iosif et al. 2020). Lynx densities primarily depend on prey availability and proportion of occupied territories. Since some of the territories in Dinaric Mountains are still not occupied, there is potential for further increase in the lynx numbers in this region. This first estimate also presents a baseline to which future similar estimates can be compared, as one of the measures of the success of the reinforcement process.

In 2022, additional releases are planned in the Dinaric Mountains, according to the reinforcement plan (Wilson et al. 2019), mostly to compensate for the lynx that disappeared before becoming integrated into the population. In Slovenia and Croatia, several areas appear unoccupied with resident lynx or only single territorial animal is present and could represent suitable areas for colonization by the new lynx. In Slovenia, these include Javorniki, Bloke, Stojna, Vremščica, Velika gora and northern part of Goteniška gora, and parts of Kočevski rog/Poljanska gora and Suha Krajina in Slovenia. Based on available information, the most appropriate location for potential releases in Slovenia 2022 is the enclosure in Loški Potok, especially if a female will be available for a soft release, since female is currently lacking in the area and several young males from litters born in 2021 will be looking for empty territories in this region. Male can be released also from the Snežnik enclosure. In Croatia, we recommend next releases to take place in Lika, especially in the northern Velebit area or areas adjacent to National park Plitvice lakes. Males or females can be released in these areas. Areas in Gorski kotar, central and south Velebit are less suitable, because several translocated animals have already established their territories there.

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