Large carnivore distribution maps and population updates 2017 – 2022/23

Version 1.1 – with updated population estimates

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Large carnivore distribution maps and population updates 2017 – 2022/23

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Contents

1. Background

Large carnivores have made a remarkable comeback in Europe during the last half century, and recovery is still ongoing in large parts of the continent (Andrén 2018; Boitani 2018; Boitani et al. 2022; Chapron et al. 2014; Huber 2018; Ranc 2018; von Arx 2020). While this expansion can be celebrated as a huge conservation success, it also creates considerable challenges for coexistence in the multi-use landscapes of Europe (Linnell 2013).

Having a common understanding of the distribution, size and trends of large carnivore populations in Europe is one prerequisite for a knowledge-based dialogue in the often heated and highly politicized discussions about future scenarios of large carnivore conservation and management in Europe. Because of the scale at which large carnivores utilize the landscape it is essential to conduct periodic continental scale assessments of their status transcending sub-national and national borders. Assessments at this scale require harmonising diverse datasets that arise from different jurisdictions using different monitoring approaches.

This document provides the best available overview of brown bear (*Ursus arctos*), Eurasian lynx (*Lynx lynx*), wolf (*Canis lupus*), golden jackal (*Canis aureus*), and wolverine (*Gulo gulo*) distributions and population sizes at a continental scale. The data in this report is based on over 200 national experts who are co-authoring the report (Appendix 1) plus a huge number of additional regional and local collaborators and supporting agencies (Appendix 2).

References listed in overview tables are not part of part IV Literature but can be found in the compilation of the most recent publications on population and rage estimates in Appendix 6.

2. Methods

2.1. Distribution mapping methods

The mapping approach generally follows the methods described in (Chapron et al. 2014) and (Kaczensky et al. 2013). It updates the published Species Online Layers 2012-2016 for brown bear, Eurasian lynx, wolf, golden jackal, and wolverine (Kaczensky et al. 2021; Ranc et al. 2022) for the period 2017-2022/23.

Large carnivore presence was mapped at a 10 x 10 km (ETRS89-LAEA Europe) grid scale. This grid is widely used for Habitat Directive reporting to the European Union (EU) and can be downloaded at: http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2. The map encompasses the continental EU countries plus Switzerland and Norway, and the EU candidate / potential candidate countries in the Balkan region, in addition to Ukraine and Turkey. For the two latter countries, only parts were included; for Ukraine only the Carpathian region (for this report Ukraine was artificially cut off and the straight line in the east does not represent the national border), and the European part of Turkey (Fig. 1).

For the 2012-2016 mapping, several countries were not or not fully (not for all species) included (Hungary, Montenegro, Turkey), so that no comparisons can be made of the updated carnivore distributions with those from the last mapping for these countries.

Mapping large carnivores for this report had a two-fold goal:

- Visualizing areas of large carnivore presence
- Visualizing the variation in the underlying data quality

Fig. 1: Spatial extent of the large carnivore mapping area and the focal species: brown bear (Ursus arctos), Eurasian lynx (Lynx lynx), wolf (Canis lupus), golden jackal (Canis aureus), and wolverine (Gulo gulo). Note: Ukraine was cut to only include the Carpathian region and only the European part of Turkey was included for the mapping.

2.1.1. Presence status

We aimed to distinguish between two presence levels:

- **Permanent** = suggesting an established population which is reproducing, but also including cells with continuous presence in the absence of documented reproduction.
- **Sporadic** = suggesting only occasional presences of dispersers or lone individuals.
- Where this distinction was not possible, but presence was confirmed, we used **Undefined** = presence confirmed, but not known if it is permanent or sporadic.

"Permanent" is equivalent to the status of "Present regularly" (PRE) as used in Article 17 reporting to the Habitats Directive, while "Sporadic" corresponds to the status of "Occasional" (OCC) in the same system. It was not possible to systematically separate out the "Newly arrived" (ARR) category, although it may well apply to the many new jackal records throughout western and northern Europe. Finding a common harmonized definition that fits all monitoring circumstances is difficult and the distinction required expert assessment. Here are the most common scenarios that we have continued with from the previous 2012-2016 mapping cycles:

1) For **countries where the known annual species distribution was monitored annually**, the distinction between permanent and sporadic was primarily made based on how consistently the species was detected in a cell over the 5–7-year monitoring period:

- **Permanent** = presence confirmed in ≥ 3 years in the last 5 - 7 years OR reproduction confirmed at least once within the last 3 years
- **Sporadic (highly fluctuating presence)** (presence confirmed in <3 years in the last 5 years OR in <50% of the time)

2) For **countries where the probability of species presence is modelled** based on presence signs in combination with habitat parameters and distance rules, the distinction between permanent and sporadic can be made based on the modelled "probability of presence" value of a cell. As models used for different populations will vary in their approach, **the cut-off values for permanent, sporadic, and absent were defined by the national/population level species experts**.

3) For **countries where the total range is covered by rotating annual surveys of parts of the total area over a 5–7-year period** (i.e. different sections are surveyed in different years such that the whole area is surveyed at least once during the cycle), other criteria need to be used such as: comparison to presence in a cell (or adjacent cells) during the previous survey cycle, or confirmed reproduction, or the presence of females, to delineate permanent presence from sporadic presence. However, where monitoring is too fragmented and infrequent so that no reasonable distinction between permanent and sporadic can be made, the category "undefined" was used.

In general, telemetry data of long-distance dispersers out of the known range and once off documentation of individuals outside the known range were categorised as sporadic presence.

2.1.2. Large carnivore signs used to map presence

Large carnivore signs as a basis for mapping

We used the following presence categories, which were derived from the SCALP criteria for lynx in the Alps (Molinari-Jobin et al. 2012), but supplemented with two additional data quality information categories:

1. Confirmed presence signs

- **Category 1 (C1)**: "Hard facts", verified and unchallenged large carnivore presence signs (e.g. dead animals, DNA, verified camera trap images);
- **Category 2 (C2)**: "Confirmed signs", large carnivore presence signs controlled and confirmed by a large carnivore expert (e.g. trained member of the network), which requires documentation of large carnivore signs (e.g. tracks in the snow).
- We also had to include the category C1*, referring to C1 records which also include observations by trained or experienced personnel; it was not always possible to know if these observations also included non-documented records such as direct observations (which by the SCALP definitions do not quality as confirmed records). This is particularly true for the documentation of bear family groups or where monitoring was heavily based on hunters, foresters, and protected area wardens (e.g., Croatia, Slovakia, Ukraine).

2. Extrapolated confirmed presence signs

- **Category "buffered":** Confirmed presence signs with a buffer around them, ideally based on well documented/ published methods, and usually done to represent home ranges that are typically larger than 10 x 10 km in many parts of Europe (especially in the north).
- **Category "modelled": confirmed presence signs and modelling** based on habitat suitability and/or proximity criteria ideally based on well documented/published methods and explicit cut-off values.

For areas of poor monitoring coverage or infrequent monitoring, we also included:

3. Unconfirmed presence signs

- **Category 3 (C3)**: Unconfirmed reports of category 2 large carnivore presence signs and all presence signs such as sightings and calls which, if not additionally documented, cannot be verified.
- **Category "Soft":** Extrapolation of large carnivore presence based on interviews questionnaires, and media coverage from 2017-2022/23,
- **Category "Past presence":** Documented presence from the past (but no older than from 2010) and no indication that the situation has changed.

From signs to grid cell

Ideally, GPS locations of large carnivore signs were intersected with the 10 x 10 km ETRS89-LAEA Europe grid. However, for some countries, data was collected at the spatial scale of hunting grounds (e.g., bear observations by hunters in eastern and south-eastern Europe). In this case the hunting grounds with large carnivore presence were intersected with the 10 x 10 km grid. Large carnivore presence was assumed for all cells intersecting the hunting ground (normally using a minimum intersection area in the range of >10%).

2.1.3. Data quality of large carnivore presence cells

We aimed to present data quality information at the grid cell level, but for some datasets it was not feasible to do so, and data quality was provided at the scale of the entire, or parts of, the layer, and not the individual grid cells. For some datasets this resulted in a mix of cells based on confirmed and buffered, modelled or unconfirmed cells without spatially explicit information at the grid cell level (Fig. 2).

Consequently, the following final data quality categories were used:

- **Confirmed presence:** based on C1 & C2 signs, cases where C1 included unspecified "observations" were marked with a star (C1*)
- **Extrapolated presence:** cells which don't have LC signs but are intersected by buffers or have a high probability of large carnivore presence based on documented modelling approaches.
- **Unconfirmed presence:** cells with only C3 signs, or cells with only data from prior to 2017, where presence is still assumed to persist.

Where data was only available at the shape file level, we also used the following categories:

- **Confirmed and extrapolated presence:** mixed layer with buffered C1 & C2 signs and/or documented modelling approach, or when data was only available at the level of hunting grounds.
- **Confirmed and unconfirmed presence:** a mixed layer with C1-C3 signs; for these datasets it can be assumed that the majority are C1 and C2, but that documentation is not (readily) available - these data sources include hunter observations and some damage inspection data.

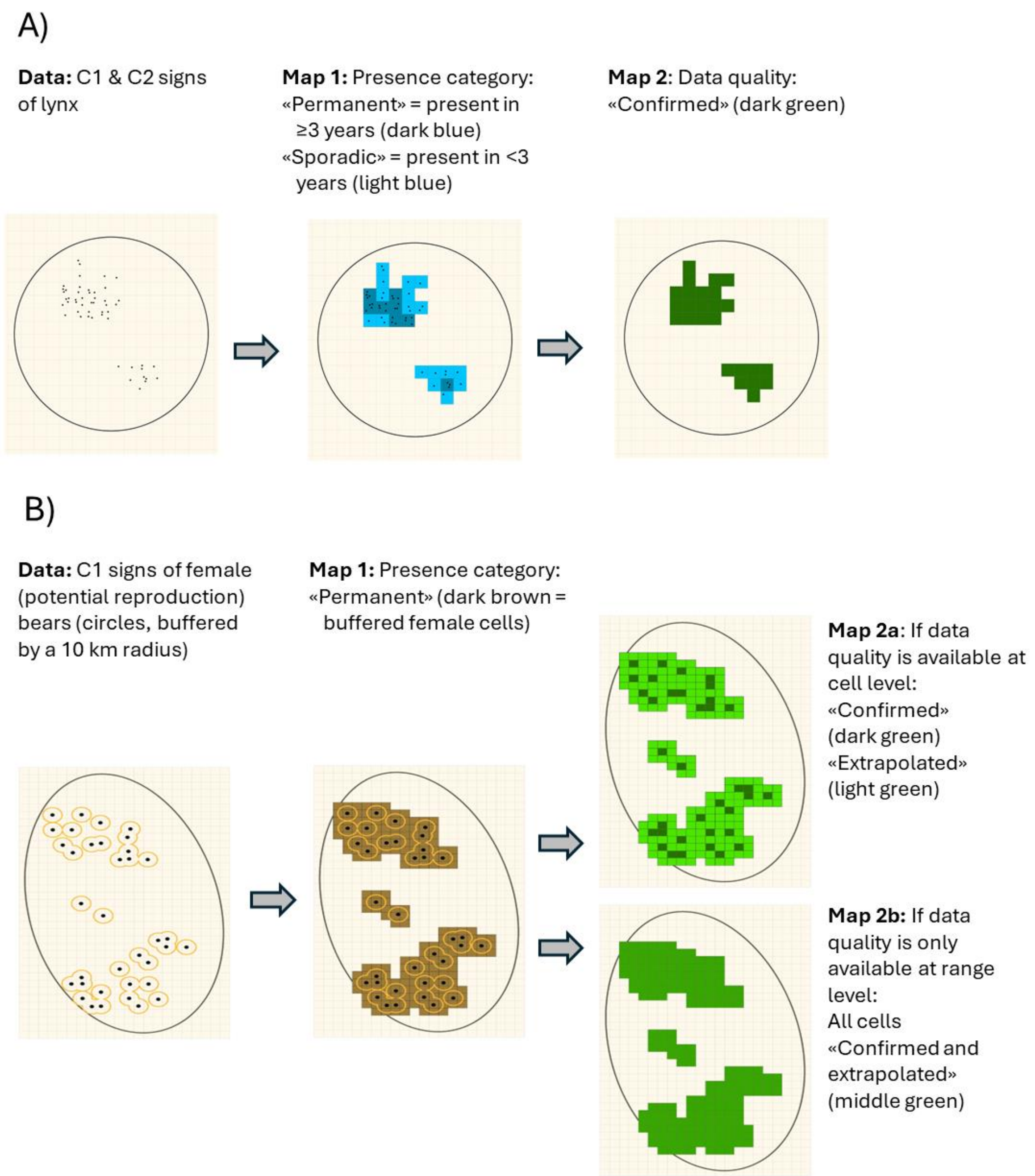

Fig. 2: Conceptual figure showing how presence and data quality were derived based on different datasets and the level at which information was available.

A) Dataset where presence over time was used to distinguish between permanent and sporadic presence in lynx

B) Dataset where presence signs were collected sequentially and where the presence of females (=potential for reproduction) with a 10 km buffer (orange ring) was used to distinguish between permanent and sporadic presence for brown bears in Scandinavia in the cumulative map. Data quality (confirmed signs versus extrapolated) was available at the cell level for map 2a and at the shape file level for map 2b.

2.1.4. Populations

Grid cells were assigned to populations based on the LCIE's population approach (Linnell et al. 2008). Population delineation follows a combination of ecosystem boundaries, topography, different management regimes, distributional discontinuities and administrative units, selected to create practical and functional management units. Population borders were partly drawn out of convenience, roughly following topographic regions, natural or artificial barriers such as large rivers, and in some cases national borders to facilitate reporting. Ecological conditions and monitoring methods tend to be similar within populations.

Populations are primarily based on where animals are detected, not where they have originated from (except for reintroduced populations). Hence even if the genetic origin of an individual was known (e.g., based on genetic analysis), the cell it shows up in will not represent the animal's origin, but rather the population of the location at which it was detected. Cells in-between existing populations and geographic regions and single cells outside of existing populations were given the Status "Unassigned" - even if their genetic origin was known. An exception to this concerns lynx which derive from many reintroductions. Here we have used the origins as an additional factor in population separation.

In the last cycle of large carnivore mapping for 2021-2016, we delineated 11 populations for lynx, 10 for bears, 9 for wolves, 4 for golden jackals, and 2 for wolverines (Kaczensky et al. 2021, Ranc et al. 2022; Fig. 3).

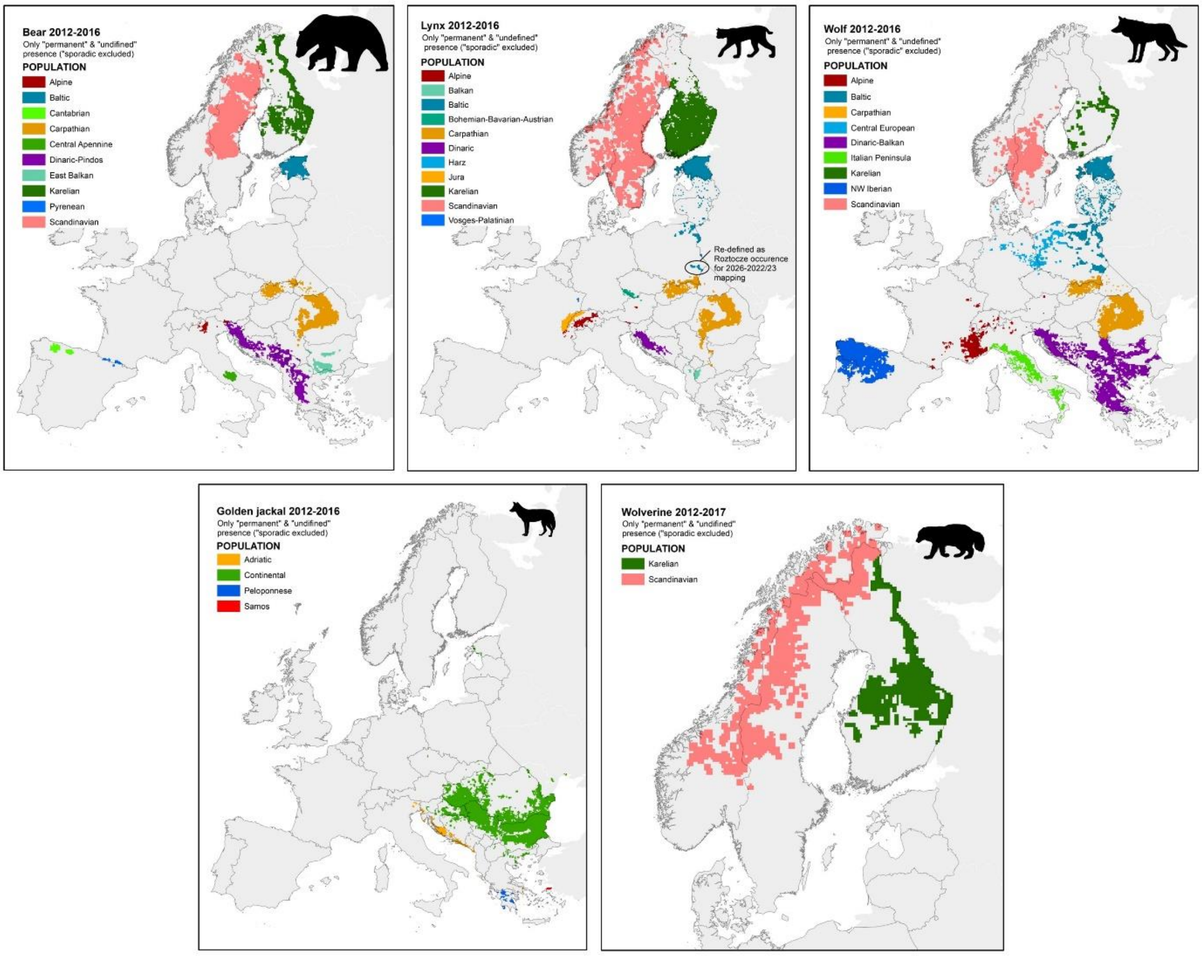

Fig. 3: Population delineations for large carnivores in Europe for the period 2012-2017.

We generally retained the same population delimitations but, made a few small adjustments to represent the changing situation on the ground (expansion and re-connection of populations) and new scientific information:

- **For wolves**, we changed the name of the "Central European Lowland" wolf population to "Central European" and the name of the "Northwest Iberian" wolf population to "Iberian", reflecting the spread of theses populations into mountain ranges and towards the east, respectively. For wolves in Germany, we used the shapefile of the perimeter of the Alpine Convention to delineate between "Central European" and "Alpine" wolf populations. For the Polish part, we used the delineation shown in ((Szewczyk et al. 2021) Fig. 1A). The "Alpine" population now also includes large adjacent areas in Italy and France (Fig. 10 & 11).
- **For lynx**, we separated the reintroduced population in northwest Poland from the Baltic population given its recent and different genetic origin and named it the "Pomeranian occurrence" in accordance with lynx population subdivision by the Cat Specialist Group (U. Breitenmoser pers. com. 2024). One other recent re-introduction project has resulted in another new occurrence: the "Black Forest – Swabian Jura occurrence" in southwestern Germany.
- **For wolverine**, we now drew a straight line from the Norwegian-Finnish-Russian border in the north to the southernmost point of the Finnish-Swedish border to delineate the Scandinavian from the Karelian population, which is convenient and in line with recent genetic results (Lansink et al. 2020; Lansink et al. 2022).
- **For Slovenia** – due to a request from national authorities - we used the national border of Slovenia in the north to delineate **bears** and **wolves** between the Alpine and Dinaric-Pindos / Dinaric-Balkan populations. Therefore, all wolves and bears on the territory of Slovenia are assigned to Dinaric population (where the majority likely originates from the Dinaric population). However, for delineating **lynx**, the geographic separation between the Alps and Dinaric Mountains (roughly marked by the highway A1) was used as the lynx in the Slovenian Alps still seem to be functionally separated from the Dinaric lynx (M. Krofel pers. comm. 2024).

2.1.5. Border cells

- Many populations occur along and across national borders and cells are shared by neighbouring countries. Only a few populations reported in a coordinated way for a cross-border region (e.g., for bears in the Pyrenees, lynx in the Alps, and all species in Norway & Sweden). Where large carnivore presence was detected in the same cell by neighboring countries, the cell with the "better information status" wins, following the rule:
  - Permanent > Sporadic > Undefined
  - Confirmed presence > Confirmed and extrapolated presence > Confirmed and unconfirmed presence > Extrapolated presence > Unconfirmed presence

2.1.6. Time period

The majority of the large carnivore presence layers cover the time period 2017-2022/23. But because monitoring conditions and logistics vary between countries, regions, and species, we documented the specific monitoring periods. Periods referring to 2022/23 usually mean that the species range or population estimates are reported at the end of winter in early 2023. However, the use of 2022 for the calendar year versus 2022/23 for the biological/monitoring year was not consistently used and therefore 2022/23 can mean: only the first part of 2023 is included, all of 2023 is included, or all or parts of 2023 and the first part of 2024 is included. For all countries that provided data deviating from the 2017 start and 2022 or 2023 end date, we explicitly label the monitoring period on one map together with the range.

2.1.7. Change in range since the last mapping for 2012-2016

We visualised the gains and losses of cells with large carnivore presence of any presence category (undefined, permanent, sporadic pooled) between the two periods 2012-2016 and 2017-2022/23. We additionally compared the cell count between the two time periods by country and population.

The latter were critically reviewed to establish whether these gains or losses reflect true range changes or are just the result of altered monitoring methods or changes in monitoring effort. The latter information was obtained through an online questionnaire survey (Appendix 4), which asked about mapping details, assessment of the trend in distribution, changes in monitoring methods and effort, and the main monitoring method. We also took into account that certain countries were not included in the mapping exercise for 2012-2016.

2.1.8. Shape file information

Together with this report, we also provide the species distribution shape files (one file for each species) for 2017-2022/23. The shapefiles include the following metadata:

Metadata table	**Information provided**
FID	Unique identifier ID
CELLCODE	10x10 km ETRS89-LAEA (Lambert Azimuthal Equal Area) Europe grid ID
EOFORIGIN	East coordinate in ETRS89-LAEA projection (EPSG:3035)
NOFORIGIN	North coordinate in ETRS89-LAEA projection (EPSG:3035)
COUNTRY	Country (in some cases large transboundary region)
PERSON	Person(s) who compiled and sent the map
SPECIES	*Canis lupus*, *Canis aureus*, *Gulo gulo*, *Lynx lynx*, or *Ursus arctos*
POPULATION	Species-specific population as defined by LCIE
PRESENCE	Presence category: Undefined, Permanent, or Sporadic
DATAQUAL	Data quality categories: see section 2.1.3. above
DATASOURCE	Short reference of data source – for details see Appendix 6
YEAR	Time period the data layer covers
YRCOMPILED	Year the maps were compiled: 2024
COMPILERS	Kaczensky, Ranc, Hatlauf, Payne *et al.* 2024 for the Large Carnivore Initiative for Europe (LCIE)

2.1.9. Questionnaire survey

Information on mapping and distribution monitoring details were obtained via an online questionnaire consisting of 30 questions asking about mapping details, assessment of trend in species distribution, main range monitoring methods, and most recent supporting references or publications on status and distribution of the target species (Appendix 4).

2.2. Population estimation methods

We obtained population estimates from regional and national experts following the methods described previously (Boitani et al. 2022; Chapron et al. 2014; Kaczensky et al. 2013). In short, we used an online questionnaire (Appendix 5) distributed to members of the LCIE who then distributed it further to their contacts.

The questionnaire included 24 questions asking for population estimates of the target species at national and population segment level, the form of transboundary cooperation, trends, main monitoring methods, management plans, and population goals, as well as references to the most recent population estimates (see Appendix 6 for compilation) and management plans (see Appendix 7 for compilation).

We subsequently compiled an overview of main monitoring methods and population estimates at population level and compared numbers to those obtained by LCIE for 2012-2016 (see: https://www.lcie.org).

3. Results

3.1. Mapping results

Large carnivore distribution maps were compiled for all 24 mainland EU countries (the three island nations don't have large carnivore populations, namely Ireland, Malta, and Cyprus). Additional maps were compiled for another 10 European countries/regions, namely Switzerland, Norway, Bosnia and Herzegovina, Serbia, Kosovo*, Montenegro, Albania, and North Macedonian, plus the Carpathian region of Ukraine and the European part of Turkey because of the continuity of species distributions. The microstates of Andorra, Lichtenstein, San Marino, Monaco, and Vatican City are not explicitly listed due to their small size but are covered via monitoring of the neighbouring countries whose grid cells overlap the microstates.

In total this report provides distribution maps for 34 European countries/regions. This meant that we obtained maps for 3 more countries than for the period 2012-2026, namely Hungary, Montenegro, and the European part of Turkey. The latter needs to be kept in mind when comparing maps from 2012-2016 with those from 2017-2022/23.

Belarus was initially included and colleagues working in Belarus provided us with information on the large carnivore range. However, while presence data from camera traps was available at the 10 x 10 km grid for two study areas for lynx and wolf (Kudrenko et al. 2023; Palmero et al. 2023), the national monitoring is based on a 50 x 50 km of the Atlas of Mammals of Belarus. The data in the mammal atlas suggests widespread presence of wolf and lynx throughout the entire country, a more restricted, but still widespread presence of the brown bear, and some presence of the golden jackal. The huge difference in scale and the different grid projection did not allow for integrating this very coarse-grained data into our mapping framework in any comparable way. In addition, in November 2022 Poland build a 199 km impermeable border fences along the border with Kaliningrad and recently a 180 km impermeable border fence along the border with Belarus. Estonia, Latvia and Lithuania also have border fences towards Belarus and Russia. The sum of these fences making the exchange of large carnivores between Belarus and Russia, and the rest of Europe extremely challenging (Nowak et al. 2024). As a result, we excluded Belarus from our maps.

A note of caution:

The overview tables on mapping and distribution monitoring methods are based primarily on questionnaires with predefined categories that greatly simplifies the diversity of monitoring and mapping approaches. Even if the same general categories were used, other details differed but cannot be reflected here in all detail. In addition, different people interpreted categories differently. Examples of problems that arouse include:

- Main distribution mapping method – it was unclear if it meant the % of the range monitored with the method or the % of data used for the mapping; this was not carefully defined and likely resulted in people answering in different ways
- "% Known range monitored" – it was not clearly defined what is meant by active monitoring versus passive / opportunistic monitoring (e.g., is the information on culled/hunted bears active or passive / opportunistic monitoring? – it can be interpreted both ways).

* This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence

- There were some discrepancies between information provided in the questionnaire and the GIS data files, which could not always be fully resolved.

In summary, the tables show larger scale patterns, but may not be completely comparable for some countries/regions.

The maps represent the best available data on large carnivore distribution in Europe. However, detecting large carnivores is not only dependent on their presence, but also on the effort spent searching for their signs or collating and verifying reports. Thus, where monitoring is scarce or absent, presence can go undetected, especially if it is only sporadic. The smaller the large carnivore population and the more recent their appearance in a country, the more likely that they are detected and documented because of the increased effort that is used to follow rapidly emerging situations. Where populations are large and well established, on the other hand, there is often no capacity to document every large carnivore which happens to sporadically show up outside the permanent range.

The distinction between "permanent" and "sporadic" presence would be best done based on the presence or absence of confirmed reproduction. We tried to obtain data on reproduction for the 2012-2016 mapping, but it was not feasible at the continental scale – too many countries do not have the monitoring capacity to do so.

The current method to use re-occurrence of large carnivore signs in a 10 x 10 km cell over the monitoring period with or without information on reproduction is a compromise. It works quite well for countries with annual monitoring of the known range but does not allow us to distinguish between areas of an established population and areas of constant reoccurrence without reproduction. This is particularly true for bears which show strongly male biased long-distance dispersal where you can have areas with regular presence of male bears on the dispersal front far from areas with reproduction (Kojola et al. 2003; Swenson et al. 2001).

Consequently, "permanent" presence occurs in parts of the Alps (e.g. Switzerland and the eastern Alps) where no reproduction has yet been recorded. However, in respect to bear presence and perception by local people, bears are permanently present in these areas now.

Where monitoring data accumulates over the monitoring period through sequential surveys of different portions of the total range, re-occurrence cannot be used to distinguish between "permanent" and "sporadic". Where specific data on reproduction is available it is a good substitute, but where it is not available all cells were either given the status of "undefined" presence, or other criteria such as data quality or locality were used to distinguish between "permanent" and "sporadic". While this results in a somewhat subjective expert-based assessment of the presence category, we still believe there is a value in trying to separate between "permanent" and "sporadic" to understand species range dynamics.

In conclusion, changes in the large carnivore distribution range at the European scale between 2012-2016 and 2017-2022/23 must be interpreted with a focus on the "permanent" distribution but also need to consider changes in monitoring methods and effort, and trends in population size.

3.1.1. Brown bear

Overview of main distribution monitoring methods

The most important monitoring methods for determining bear distribution were dead animals (mainly from hunting/culling but also traffic kills), non-invasive genetics (hairs and scats), camera traps, damage statistics (livestock and beehives), observations of females with cubs, and interviews (Table 1). Methods under “other” are hunter observations at feeding stations (structured surveys conducted twice a year in Croatia) and direct observations by hunters (Slovakia).

Table 1: Main distribution monitoring methods for brown bears in Europe.

Country	Range monitoring method												
	Dead animals	Non-invasive genetics	Camera traps	GPS tracking	Active snow tracking	Howling surveys	Family groups	SCALP C2	Damage statistics	SCALP C3	Quest. & interviews	Past presence	Other*
Brown bear													
Albania	<10%	<10%	25-50%	<10%							10-25%	<10%	
Austria	<10%	50-75%	10-25%					<10%			>75%		<10%
Bosnia & Herzegovina	>75%	10-25%	50-75%					10-25%			<10%		
Bulgaria	<10%		25-50%	<10%				50-75%	50-75%	<10%			
Croatia	>75%	>75%	25-50%	10-25%			10-25%	>75%	50-75%		50-75%		>75%
Czech Republic		<10%	50-75%	<10%	10-25%			50-75%					
Estonia	<10%		25-50%				50-75%	<10%	<10%		>75%		
Finland	10-25%						50-75%	50-75%	10-25%		>75%		
France	>75%	>75%	>75%					>75%	>75%				
Germany		>75%	>75%					>75%					
Greece	10-25%	>75%	>75%	10-25%			25-50%	50-75%	>75%	10-25%	25-50%	10-25%	
Hungary		<10%	50-75%		10-25%		<10%	50-75%			>75%		
Italy - Alps	>75%	>75%	>75%	>75%			>75%	>75%	>75%	>75%			
Italy - Apennine	<10%	50-75%	25-50%	50-75%			50-75%	50-75%	50-75%			10-25%	
Kosovo*	no dedicated monitoring - by-catch from lynx camera trap monitoring												
Latvia	<10%	25-50%	25-50%				25-50%	>75%	>75%		>75%		
Lithuania			10-25%					50-75%		10-25%	>75%		
Montenegro		10-25%	10-25%	10-25%	25-50%			50-75%	<10%		<10%	25-50%	
North Macedonia	<10%	10-25%	25-50%		<10%		<10%	10-25%	<10%	<10%	<10%		
Poland	<10%								10-25%	<10%	50-100%		
Romania	<10%		<10%		>75%		<10%	<10%	50-75%	10-25%		>75%	
Serbia	<10%	<10%	50-75%	25-50%			<10%		<10%				
Slovakia	>75%	>75%	>75%	10-25%	>75%		>75%	>75%	>75%	>75%	>75%		>75%
Slovenija	>75%			<10%					<10%		>75%		
Spain	>75%	>75%	>75%	25-50%			25-50%	>75%	>75%				
Sweden	>75%	>75%							>75%				
Norway	>75%	>75%	>75%						>75%				
Switzerland	<10%	25-50%	25-50%					25-50%	<10%				
Ukraine	<10%	<10%	<10%	<10%	10-25%	<10%	<10%	<10%	<10%	25-50%	<10%		

More details on species monitoring methods can be found in the compilation of the most recent literature on population size and distribution estimates in Appendix 6.

Overview of main mapping methods

Distribution data was available for most countries up to 2022/23, with only Norway and Sweden having a one year shorter period (until 2021). Most of the bear presence is based on confirmed (C1 & C2) signs intersected directly with the 10 x 10 km grid.

Out of 29 countries/regions with bear presence, 6 use buffers around bear signs (Albania, Latvia, Montenegro, North Macedonia, Sweden, Norway) with 2 (Albania and North Macedonia) additionally using modelling for extrapolated presence. Three countries (Croatia, Slovakia, Ukraine) have some, or most, information collected at the level of hunting grounds, which were intersected with the 10 x 10 km grid.

For 6 countries (Croatia, Montenegro, Sweden, Norway and in part Slovakia and Ukraine) information on data quality was not or only partly available at the individual cell level (Table 2).

Table 2: Mapping details for brown bear in Europe.

Country / Region	FINAL_time	Spatial scale	% Known range monitored		Large carnivore signs used	Definition of gridcells based on	Scale of data quality information	Presence categorisation based on	Method change	Range trend estimate since 2012-2016	
			Active	Passiv						Trend	Assessment
Brown bear											
Albania	2017 – 2022/23	Only reference areas	15	20	C1 & C2	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Austria	2017 – 2022/23	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence only	No	Fluctuating	Real
Bosnia & Herzegovina	2017 – 2022/23	Entire known range	60	30	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real & method change
Bulgaria	2017 – 2022/23	Only reference areas	45 - 60	25-30	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Fluctuating	Real & method change
Croatia	2019 – 2023	Entire known range	100	100	C1* & C2	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid	Country level	Re-occurring presence and/or reproduction	No	Increasing	Real
Czech Republic	2017 – 2023	Entire known range	80	20	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Fluctuating	Real
Estonia	2018 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Finland	2017 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Reproduction only	Yes	Increasing	Real
France	2017 – 2022/23	Entire known range	90	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Germany	2017 – 2022/23	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence only	No	No obvious change	Real
Greece	2017 – 2022/23	Entire known range	70-80	20-30	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Hungary	2017 – 2022/23	Entire known range	50	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Italy - Alps	2017 – 2022/23	Entire known range	90	90	C1* & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Italy - Peninsula	2017 – 2022/23	Entire known range	60	90	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real & method change
Kosovo*	2016 - 2023/24	No information			C1 & C2-C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Data quality	Unknown		
Latvia	2017 – 2023	Entire known range	10	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Lithuania	2018 – 2023	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence	Yes	Increasing	Real
Montenegro	2018 – 2023	Entire known range	60	60	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Unknown	No	No obvious change	Real
North Macedonia	2017 – 2022/23	Entire known range	0	60	C1	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Geographic location	No	Unknown	More data needed
Poland	2017 – 2022	Entire known range	15	85	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	No obvious change	Method change
Romania	2017 – 2022/23	Entire known range	70	30	C1, C2 & C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Data quality	Yes	No obvious change	Method change
Serbia	2017 – 2022/23	Entire known range	75	25	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Slovakia	2017 – 2022/23	Entire known range	100	100	C1 & C2, C1*-C3	Hunting grounds with confirmed presence overlaid with the 10 x 10 grid & additional C1 & C2	Cell level & country	Re-occurring presence and/or reproduction	No	Increasing	Real
Slovenia	2017 – 2022/23	Entire known range	99	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	No obvious change	Likely expansion
Spain - Cantabrian Mnts	2018 – 2023	Entire known range	80	20	C1* & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence	No	Increasing	Real
Switzerland	2017 – 2023	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence only	No	No obvious change	Real
Ukraine - Carpathians	2017 – 2023	Carpathians	10	100	C1*-C3	Hunting grounds with confirmed presence overlaid with the 10 x 10 grid & additional C1 & C2	Cell level & country	Hunter density estimate	Yes	Fluctuating	Real
Sweden	2017 – 2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real
Norway	2017 – 2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real

A distinction between permanent and sporadic presence was primarily made based on re-occurrence and/or reproduction. However, 3 countries (Finland, Sweden, Norway) exclusively used reproduction, or the presence of female bears (=the potential for reproduction), to define the permanent range. A few used data quality (Kosovo*, Romania), geographic location (North Macedonia), or hunter density estimates (Ukraine); for Montenegro the criteria used were unknown.

The trend in bear distribution was estimated as increasing in 14 countries/regions, showing no obvious change for 9, fluctuating for 4, and unknown for 2. No country/region reported a decreasing range (Table 2).

Current brown bear distribution in Europe

Brown bear presence has been documented in 29 of the 34 countries/regions monitored. The species is totally absent from Belgium, Denmark, Luxembourg, the Netherlands, and Turkey. In Portugal, a brown bear was recorded for the first time in a border cell in 2019 (Fig. 4).

The total distribution area occupied by the brown bear in Europe currently covers ca. 1.2 million km^2, which is a 4.6% increase in distribution since 2016 (Table 3).

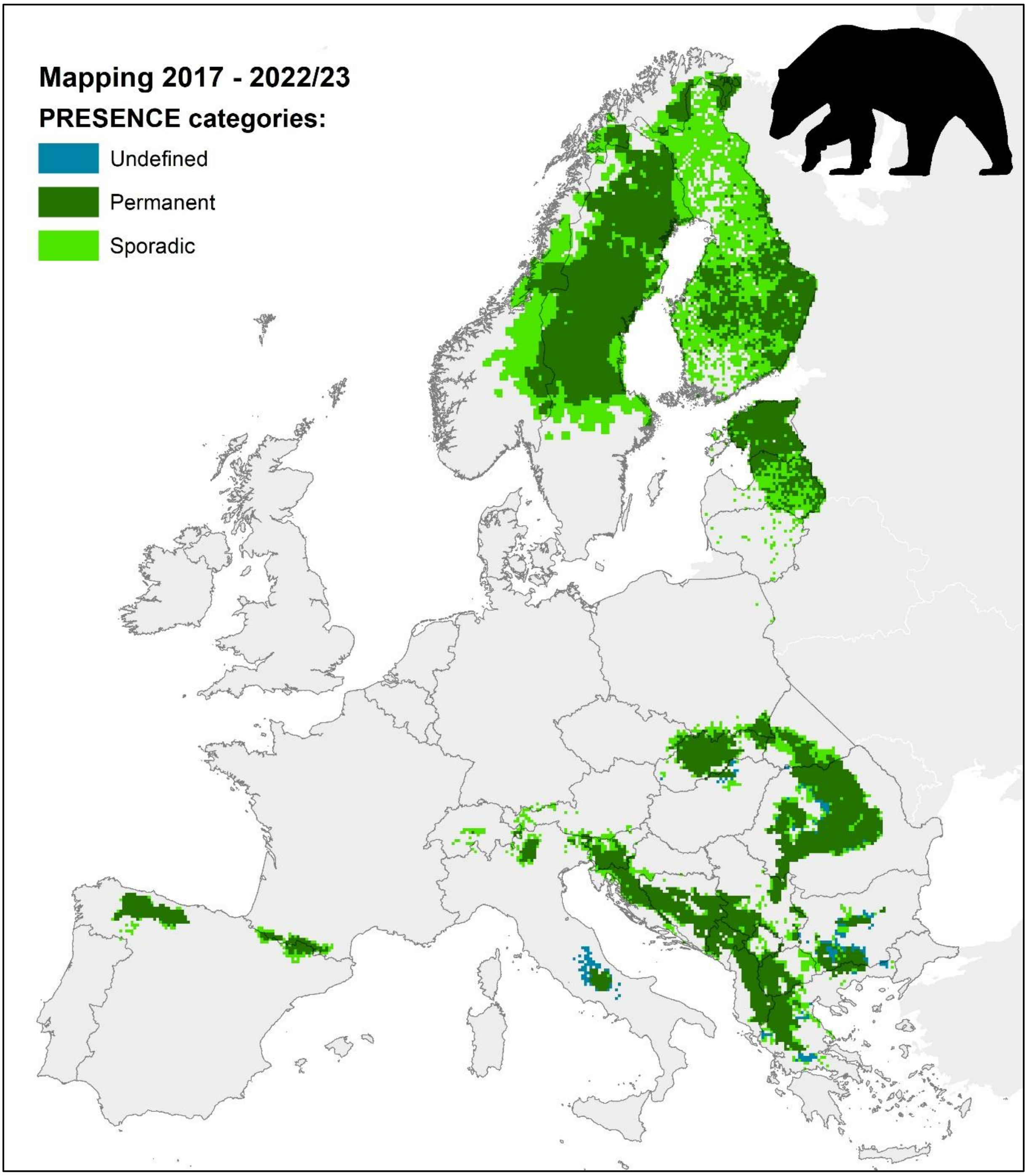

Fig. 4: Brown bear distribution in Europe for the period 2017-2022/23.

Most of the bear distribution in all populations is based on confirmed bear signs, often in combination with some form of extrapolation (buffers and/or modelling, see Table 2). The Dinaric-Pindos population still has the least robust data foundation. In parts of the Carpathian population monitoring is dependent on observations from hunting grounds or protected areas. These observations are often less formally documented or accessible and include direct observations and were given the mixed status of “Confirmed and unconfirmed” data quality. Where available, this data was confirmed with C1 & C2 data from dedicated monitoring projects, especially those using camera trapping or non-invasive genetic monitoring (Fig. 5).

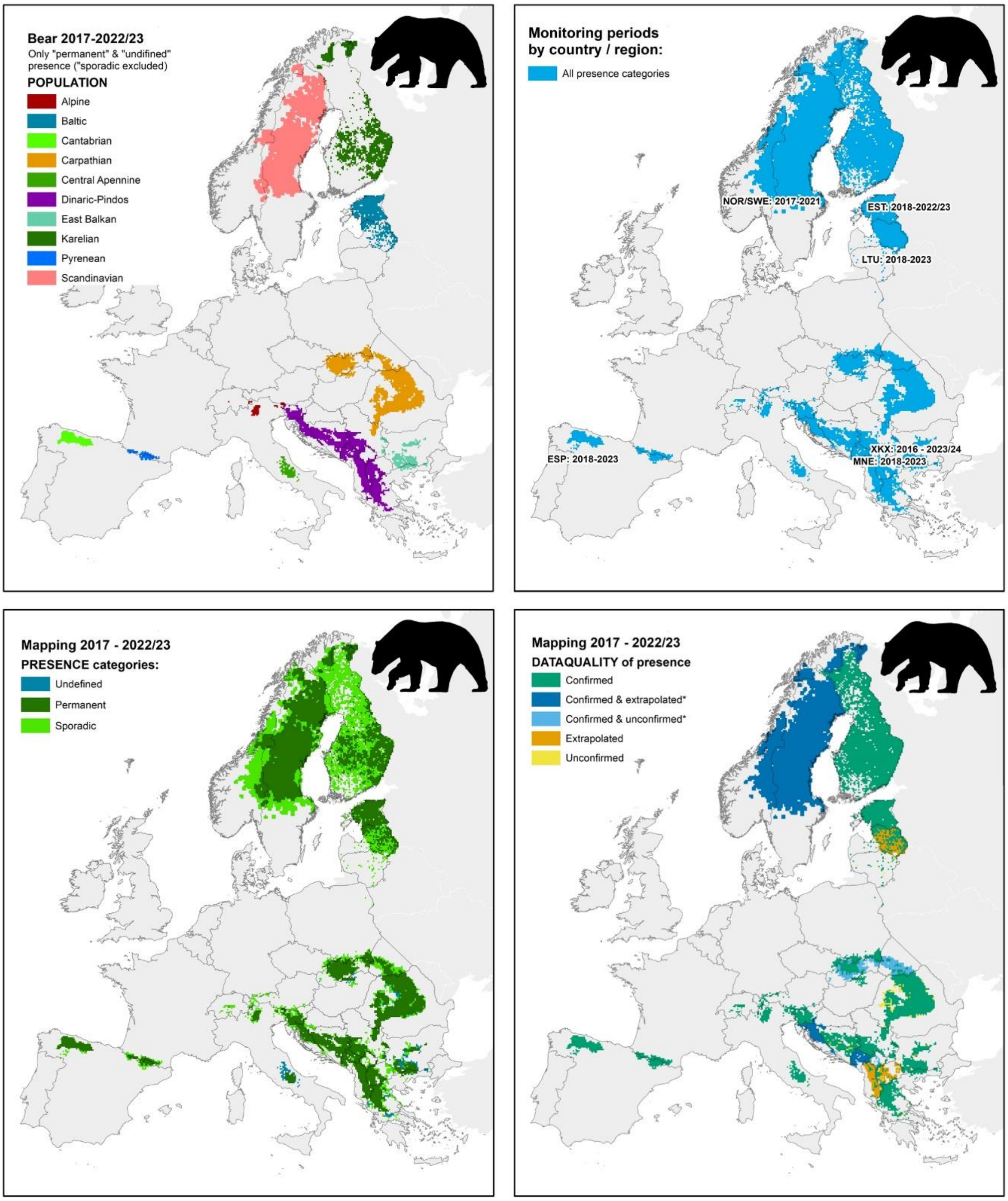

*Fig. 5: Brown bear populations, countries/regions with monitoring periods deviating from the 2017-2022/23 period, bear distribution, and underlaying data quality. *DATAQUAL: Mixed layer of confirmed and extrapolated or unconfirmed cells, where no separation at cell level was possible.*

Changes in brown bear distribution in Europe since 2012-2016

The brown bear distribution seems to have mainly gained. Looking at individual populations (Fig. 5 & 6, Table 3):

- The **Alpine population** lost some area, but mainly of the sporadic category. The population in Trentino has consolidated its permanent distribution but has a reduced sporadic distribution. There is less sporadic presence in the surrounding of Trentino and in Austria, but the sporadic distribution has spread into Germany. Italy self-reported an increasing distribution area of the bears in the Alps.
- The **Baltic population** has greatly gained in distribution, particularly in Latvia but also spreading into Lithuania. Both countries self-reported an increasing distribution area, whereas Estonia reported no obvious change.
- The distribution of the **Cantabrian population** has consolidated and expanded its the number of permanent cells, reaching a permanent connection between the Eastern and Western Cantabrian mountains and even sporadic presence towards Portugal. Spain self-reported an increasing distribution, and Portugal recorded its first bear visit in 2019.
- The **Carpathian population's** distribution has increased in all range countries. Gains in the north of the Carpathian arc are due to better monitoring data in Ukraine and first monitoring data from Hungary. A distinction between permanent and sporadic presence in Slovakia was possible due to better quality data. Range countries Romania and Poland self-reported no obvious change in the bear distribution, Ukraine a fluctuating trend, and Serbia, Slovakia and Hungary an increasing trend.
- The isolated **Central Apennine population's** distribution shows increased undefined presence primarily towards the north. Italy has self-reported an increasing distribution, but also a change in monitoring method.
- The **Dinaric-Pindos population's** distribution has increased and consolidated with improved permanent connectivity, although some gaps remain (e.g. between southern Croatia and Bosnia). Range countries Albania, Bosnia and Herzegovina, Croatia, Greece, and Serbia self-reported an increasing trend in the bear distribution, Bulgaria, Montenegro, and Slovenia no obvious change, and North Macedonia and Kosovo* an unknown trend in distribution.
- The **East Balkan population's** distribution has lost some area, and the current distribution suggests a new disconnection between the Stara Planina and Rodophi segments. Bulgaria self-reported a change in method and area losses may be due to changes in the way monitoring is conducted. Bulgaria self-reported a fluctuating range.
- The **Karelian population's** distribution seems to have lost some of the "permanent" bear area, especially along the Russian border, and some "sporadic" presence in the north. However, the country self-reported a change in method and an increasing distribution! Note that Finland does not buffer bear records in the way that Norway and Sweden do, creating an impression of a more limited permanent distribution when comparing to the neighbouring Scandinavian population.
- The **Pyrenean population** distribution area has increased and consolidated, and the connection between the west and eastern Pyrenees is now narrowly connected. The two range countries monitor the population's distribution jointly and self-reported an increasing range.
- The **Scandinavian population's** distribution has remained stable over the permanent distribution area and shown some losses and gains of sporadic presence along the fringes. Sweden and Norway jointly monitor the distribution and both self-reported no obvious change in the distribution.

Table 3: Changes in brown bear distribution in Europe since 2016, expressed as number of 10 x 10 km cells.

Population	N cells in 2016				N cells in 2022				Balance (%)			
	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total
Alpine	63	197		260	57	140		197	-10	-29	NA	**-24.2**
Baltic	407	60		467	596	315		911	46	425	NA	**95.1**
Cantabrian	88	53		141	160	27		187	82	-49	NA	**32.6**
Carpathian	947	137	183	1,267	1,286	327	43	1,656	NA	NA	NA	**30.7**
Central Apennine	80			80	44	1	56	101	NA	NA	NA	**26.3**
Dinaric-Pindos*	887	289	10	1,186	1,169	280	30	1,479	NA	NA	NA	**24.7**
East Balkan	218	186		404	180	97	70	347	-17	-48	NA	**-14.1**
Karelian	1,520	1,989		3,509	1,087	1,940		3,027	-28	-2	NA	**-13.7**
Pyrenean	36	29		65	78	59		137	117	103	NA	**110.8**
Scandinavian	2,489	1,584		4,073	2,539	1,395		3,934	2	-12	NA	**-3.4**
Total	**6,735**	**4,524**	**193**	**11,452**	**7,196**	**4,581**	**199**	**11,976**	**7**	**1**	**3**	**4.6**

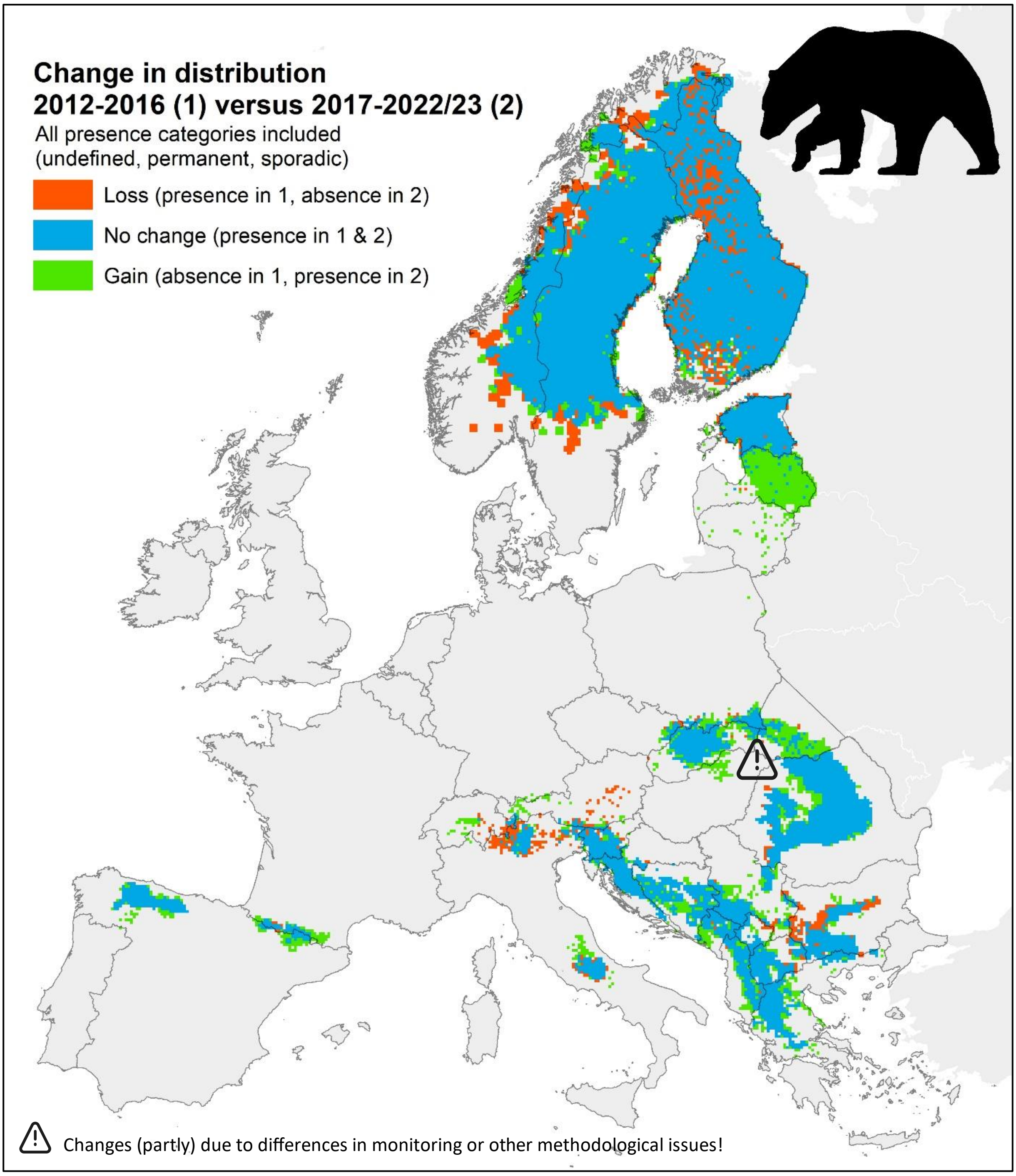

Fig. 6: Changes in brown bear distribution 2012-2016 versus 2017-2022/23.

3.1.2. Eurasian lynx

Overview of main distribution monitoring methods

The most important monitoring methods for determining lynx distribution are camera trapping, recording of SCALP C2 signs, questionnaires and interviews, family group observations, and active snow tracking. “Other” in Slovakia refers to opportunistic observations reported by hunters (Table 4).

Table 4: Main distribution monitoring methods for Eurasian lynx in Europe. BBA = Bohemian-Bavarian-Austrian population

Country	Range monitoring method												
	Dead animals	**Non-invasive genetics**	**Camera traps**	**GPS tracking**	**Active snow tracking**	**Howling surveys**	**Family groups**	**SCALP C2**	**Damage statistics**	**SCALP C3**	**Quest. & interviews**	**Past presence**	**Other***
Eurasian lynx													
Albania	<10%	<10%	>75%					<10%		10-25%	10-25%	<10%	
Austria - Alps	<10%		>75%								>75%		
Austria - BBA	<10%	<10%	>75%				25-50%				>75%		
Belgium	only single dispersers, by-catch of wolf monitoring												
Bosnia & Herzegovina		<10%	>75%	<10%	25-50%								
Bulgaria	only single dispersers, by-catch of wolf monitoring												
Croatia	>75%	<10%	>75%	10-25%	<10%		<10%	50-75%	>75%	<10%	>75%		
Czech Republic	<10%	<10%	>75%	<10%	25-50%			25-50%			>75%		
Estonia	<10%		10-25%		10-25%		25-50%	25-50%			>75%		
Finland	10-25%		10-25%		10-25%		>75%	>75%	10-25%		>75%		
France	>75%		>75%	<10%			>75%	>75%	>75%		>75%		
Germany			>75%	10-50%				>75%					
Germany - Alps	>75%							>75%		>75%	>75%		
Hungary	<10%	10-25%	50-75%		10-25%			>75%					
Italy		10-25%	>75%	10-25%			>75%	>75%					
Kosovo*	<10%		25-50%		10-25%			<10%	10-25%	50-75%	25-50%		
Latvia	>75%	<10%	<10%							10-25%			
Lithuania	<10%		25-50%					25-50%		<10%	>75%		
Montenegro	no information												
North Macedonia	<10%	<10%	50-75%	25-50%	<10%			<10%		<10%	<10%	<10%	
Poland	<10%	<10%	10-25%	10-25%	10-25%			10-25%	<10%		50-75%	<10%	
Romania			<10%		>75%			<10%		10-25%		>75%	
Serbia	<10%		25-75%	<10%							<10% & >75%		
Slovakia	>75%	<10%	>75%	10-25%	>75%		>75%	>75%	>75%	>75%	>75%		>75%
Slovenia	>75%	25-50%	>75%	50-75%	25-50%			>75%	>75%	>75%	50-75%	>75%	
Sweden & Norway	>75%		>75%		>75%		>75%		>75%				
Switzerland	>75%		>75%	<10%			>75%	>75%	25-50%	<10%			
Ukraine - Carpathians	<10%	<10%	<10%	<10%	10-25%	<10%	<10%	<10%	<10%	25-50%	<10%		
Ukraine - focal areas			>75%										

More details on species monitoring methods can be found in the compilation of the most recent literature on population and distribution estimates in Appendix 6.

Overview of main mapping methods

Distribution data was available for most countries up to 2022/23, with only Norway and Sweden presenting a one year shorter dataset (until 2021), and Kosovo* covering 10 years from 2014-2024. Most of the lynx presence is based on confirmed (C1 & C2) signs intersected directly with the 10 x 10 km grid.

Out of 30 countries/regions with lynx in our survey, 6 use buffers around lynx signs (Albania, Latvia, North Macedonia, Poland, Sweden, Norway) with 3 (Albania, North Macedonia, and Poland) additionally using modelling for extrapolated presence. Three countries (Croatia, Slovakia, Ukraine) have some, or most, information coming at the spatial scale of hunting grounds, which were intersected with the 10 x 10 km grid.

For 5 countries (Croatia, Sweden, Norway and in parts Slovakia and Ukraine) information on data quality was not available, or only partly available, at the individual cell level (Table 5).

Table 5: Mapping details for Eurasian lynx in Europe.

Country / Region	FINAL_time	Spatial scale	% Known range monitored: Active	% Known range monitored: Passiv	Large carnivore signs used	Definition of gridcells based on	Scale of data quality information	Presence categorisation based on	Method change	Range trend estimate since 2012-2016: Trend	Range trend estimate since 2012-2016: Assessment
Eurasian lynx											
Albania	2017 – 2022/23	Entire known range bu	100	20	C1 & C2	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real & method change
Austria - Alps	2017 – 2022/23	Entire known range	20	50	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Fluctuating	Real
Austria - BBA	2017 – 2022/23	Entire known range	75	unknowr	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Fluctuating	Real
Belgium	2020 – 2022/23	Only single dispersers present			C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No distinction was made	NA	First dispersers	Real
Bosnia & Herzegovina	2017 – 2022/23	Entire known range	75	15	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Fluctuating	Real
Bulgaria	2017 – 2022/23	Only single dispersers present			C1 & C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No distinction was made	No	Only single individuals	Real
Croatia	2018 – 2023	Entire known range	80	20	C1 & C2	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid	Country level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Czech Republic	2017 – 2022/23	Entire known range	80	20	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Estonia	2018 – 2022/23	Entire known range	100	100	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Finland	2017 – 2022/23	Entire known range	100	80	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Reproduction only	Yes	Fluctuating	Real
France	2017 – 2022/23	Entire known range	?	100	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Germany	2017 – 2022/23	Entire known range	20 - 100 (depending on federal state)		C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Germany - Alps	2017 – 2022/23	Entire known range	0	100	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Hungary	2017 – 2022/23	Entire known range	80	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Italy	2017 – 2022/23	Entire known range	75	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Kosovo*	2014 – 2024	Entire known range	60	40	C1, C2&C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Fluctuating	More data needed
Latvia	2017 – 2023	Entire known range	<5	100	C1	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Mortality	Yes	Increasing	Method change
Lithuania	2018 – 2023	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real & method change
Montenegro	2018 – 2023	No information	60	60	C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No information			
North Macedonia	2017 – 2022/23	Only reference areas	50	30	C1 & C2	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Poland	2017 – 2022/23	Entire known range	20	80	C1 & C2	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Romania	2017 – 2022/23	Entire known range	70	30	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Serbia	2017 – 2022/23	Entire known range	30	70	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Slovakia	2017 – 2022/23	Entire known range	100	100	C1, C1*-C3	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid & additional C1 & C2	Cell & country level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Slovenia	2019 – 2022/23	Entire known range	95	5	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Switzerland	2017 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Ukraine - Carpathians	2017 – 2023 (focus 2019)	Carpathians	10	100	C1*-C3	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid & additional C1 & C2	Cell & country level	Hunter density estimate	Yes	Fluctuating	Real
Ukraine - focal areas	2020-2023	Only reference areas	NA	25 - 50	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Data used for data quality only	NA	Unknown	More data needed
Sweden	2017 – 2021	Entire known range	100	100	C1* & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	Increasing	Real
Norway	2017 – 2021	Entire known range	100	100	C1* & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real

The distinction between permanent and sporadic presence was primarily made based on re-occurrence and/or reproduction. However, 3 countries (Finland, Sweden, Norway) used exclusively reproduction to define the permanent distribution, 2 with only a few dispersers made no distinction

(Belgium, Bulgaria), 1 used mortality events (Latvia), 1 used hunter derived density estimates (Ukraine), and 1 did not provide any information (Montenegro).

The trend in Eurasian lynx distribution was estimated to be increasing in 11 countries/regions, showing no obvious change in 9, and fluctuating in 6. Two countries had only single dispersers and in one the trend was unknown. No country/region reported a decreasing trend in distribution area (Table 5).

Current Eurasian lynx distribution in Europe

The lynx is currently found in 25 of the 34 countries/regions surveyed. The species is absent or only found in border cells in Denmark, Greece, Kosovo*, Luxembourg, Montenegro, Portugal, Spain, The Netherlands, and Turkey. The possible presence in Greece in the 2012-2016 lynx map could not be confirmed and was excluded from the distribution area gain/loss calculation table (Fig. 7, Table 6).

The total distribution area encompassed by the Eurasian lynx in Europe currently covers ca. 1.47 million km^2, which is a 21.2% increase in distribution since 2016 (Table 6).

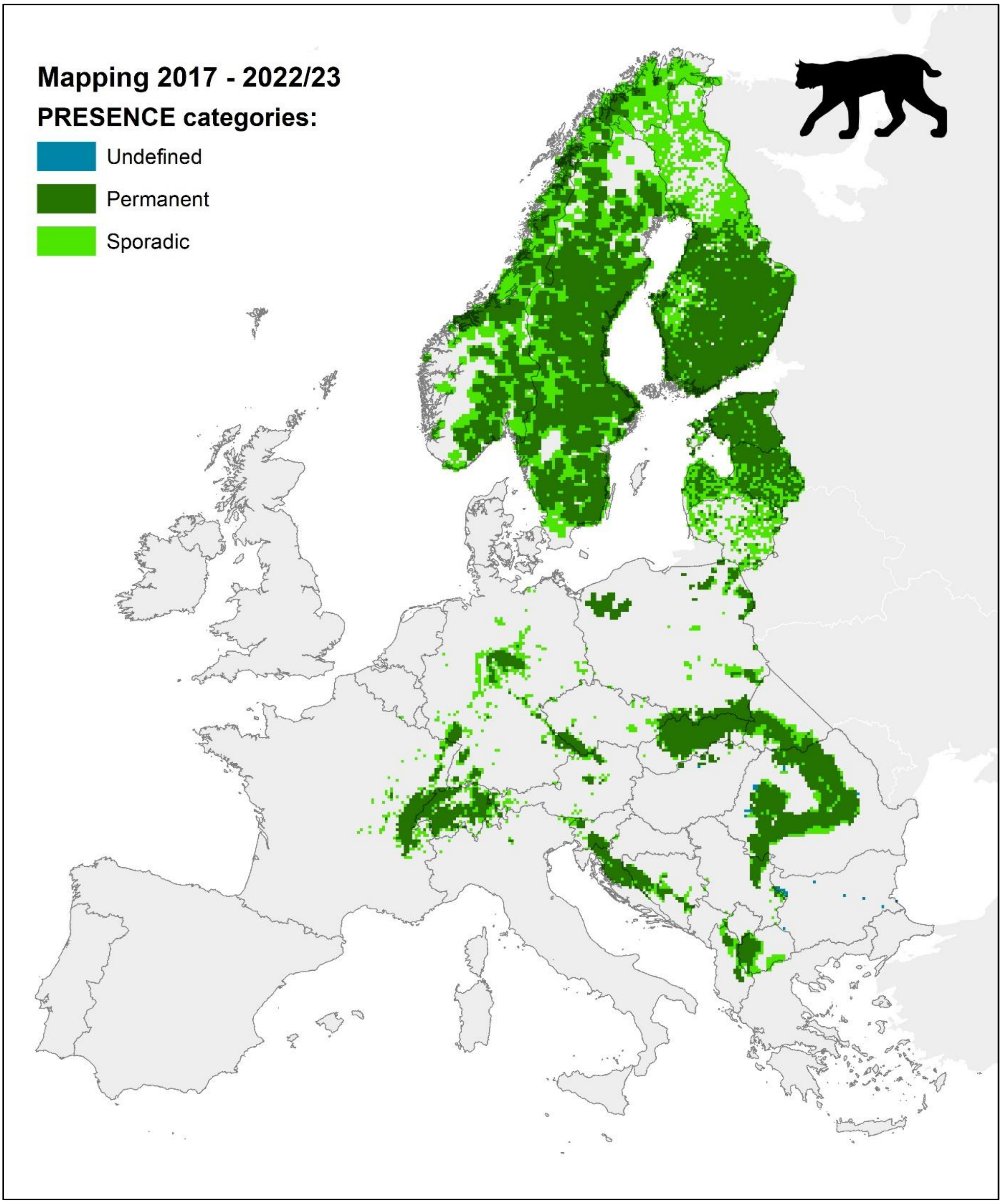

Fig. 7: Eurasian lynx distribution in Europe for the period 2017-2022/23.

Most of the lynx distribution area in all populations is based on confirmed lynx signs, often in combination with some form of extrapolation (buffers and/or modelling, see Table 5). The small Balkan population still has the least robust data foundation. In parts of the Carpathian population monitoring is dependent on observations from hunting grounds or protected areas (in Ukraine and Slovakia). These observations are often less formally documented or accessible and include direct observations and thus were given the mixed status of “Confirmed and unconfirmed” data quality. Where available, this data was confirmed with C1 & C2 data from dedicated monitoring projects, especially those using camera trapping or non-invasive genetic monitoring. In Latvia buffered C1 records, which were exclusively used in the past, are now supplemented with C3 records from observations recorded by volunteers via wildlife citizen science apps, so that the distribution is now filled in with sporadic presence based on unconfirmed records (Fig. 8).

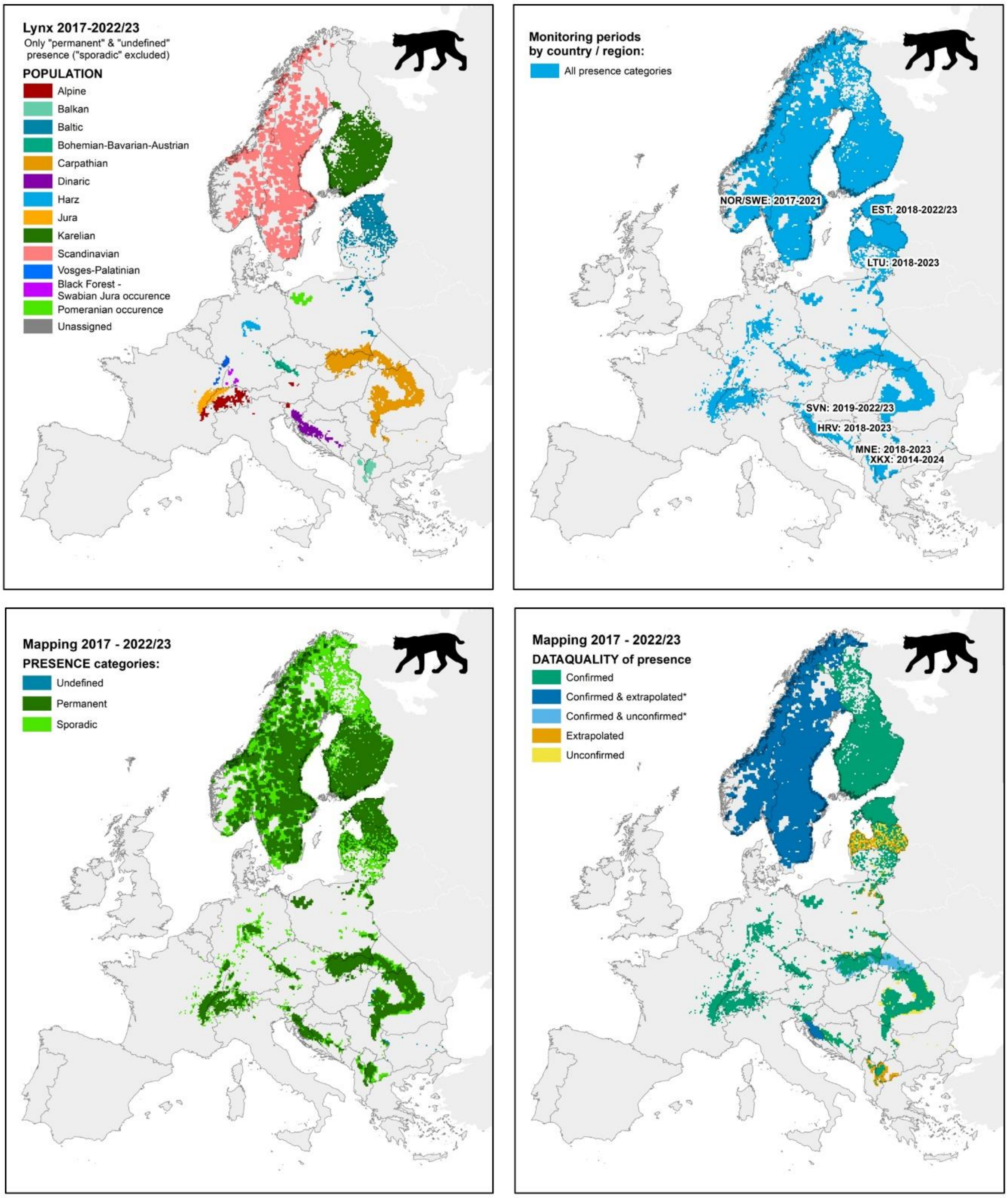

*Fig. 8: Eurasian lynx populations, countries/regions with monitoring periods deviating from the 2017-2022/23 period, lynx distribution, and underlaying data quality. *DATAQUAL: Mixed layer of confirmed and extrapolated or unconfirmed cells, where no separation at cell level was possible.*

Change in lynx distribution 2012-2016 versus 2017-2022/23

The Eurasian lynx distribution seems to have mainly gained area due to natural expansion, active reinforcement (translocation) of reintroduced populations, and new reintroduction projects. For countries having several population segments, self-reported trend estimates were not necessarily available for each segment, but rather for the overall national population. Looking at individual populations (Fig. 8 & 9, Table 6):

- The **Alpine population's** distribution has expanded in both the eastern and western Alps and is now connected via permanent cells to the Jura population and via sporadic cells to the new Black Forest – Swabian Alp occurrence. In the eastern Alps the area of permanent distribution of the Alpine lynx population remains still largely separated from the Dinaric population, although sporadic cells are documented. The distribution map for the Alpine population is regularly updated within the SCALP initiative (Molinari-Jobin et al. 2021). The range countries largely self-reported increasing trends for the distribution, but a fluctuating trend was reported for the Austrian Alps and no obvious change for the German Alps.
- The isolated **Balkan population's** distribution appears to have increased, but large parts of this expansion are based on model extrapolations. Permanent presence has been primarily documented in North Macedonia and a small part in Albania. The loss in Greece is due to the failure to confirm possible presence mapped in 2012-2016 (the distribution change is shown in the change map but was not included in the area calculation table). Albania self-reports an increasing distribution trend which is due to both a change in method and a real change, but North Macedonia reported no obvious change.
- The **Baltic population's** distribution has increased. The large increase in Latvia is due to a change in method for recording sporadic presence and a real change for permanent presence. The distribution is also increasing in Lithuania but has not changed much in eastern Poland, apart from an increase in sporadic occurrence cells in the isolated Roztocze region.
- The **Bohemian-Bavarian-Austrian population's** distribution has expanded to both the northwest and to the southwest and seems about to connect with the Harz population range. However, the distribution area is self-reported as fluctuating in Austria and showing no real change in the Czech Republic. For Germany no assessment was available for this population segment separately.
- The **Carpathian population's** distribution seems stable. Gains in the north of the Carpathian arc are due to better monitoring data in Ukraine and the inclusion of the first monitoring data from Hungary. The range countries largely self-report no obvious change in the distribution (Romania, Slovakia, Serbia) or a fluctuating range (Ukraine). For Poland no assessment was available for this population segment separately.
- The **Dinaric population's** distribution has changed very little and remains separated from the Alpine population and Balkan population. Slovenia and Croatia self-reported an increasing distribution (there has been extensive population reinforcement in recent years (Fležar et al. 2024)), and Bosnia and Herzegovina a fluctuating distribution.
- The distribution of the **Harz population** has increased and is starting to connect with the Bohemian-Austrian-German and the Vosges-Palatinian populations. The overall distribution of lynx in Germany was self-reported as increasing.
- The **Jura population's** distribution has increased and is now connected via permanent cells to the Alpine population. Connections to the Vosges-Palatinian and the Black Forest – Swabian Jura also seem to be developing. In addition, there is more sporadic presence westwards. The distribution of the lynx in Switzerland and France was self-reported as increasing.

- The **Karelian population's** distribution has remained stable, but shows more sporadic presence in the north, which is likely due to a change in monitoring methods. The distribution is self-reported as fluctuating by Finland.
- The **Scandinavian population's** distribution has remained stable, but the area of permanent distribution has consolidated in Sweden. Sweden self-reported an increase in the distribution while Norway reported no obvious change.
- The **Vosges-Palatinian population's** distribution has increased due to a reintroduction program in the Palatine Forest in Germany (Port et al. 2024) and likely due to expansion of the Jura population distribution.
- A new reintroduction project reintroduced 61 captive born lynx in NW Poland between 2019-2021 (Skorupski et al. 2022). Multiple lynx in this new **Pomeranian occurrence** have been followed by GPS tracking and have roamed over quite a large area and long-distance dispersal has occurred towards the southwest into a new area in Brandenburg and Saxony in Germany.
- Dispersing lynx have reached the Black Forest and the Swabian Jura in the past. This has resulted in an increase and permanent presence in the **Black Forest – Swabian Jura** occurrence area; however no female lynx have been documented so far. Steps to strengthen this occurrence have started [in December 2023 with the first release of a female lynx].

Table 6: Changes in the distribution of Eurasian lynx in Europe since 2016, expressed as number of 10 x 10 km cells.

Population	2016				2022				Balance (%)			
	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total
Alpine	147	151		298	239	143		382	62.6	-5.3		28.2
Balkan*	48	111	2	161	105	90		195	118.8	-18.9	NA	21.1
Baltic	716	252		968	992	674		1,666	38.5	167.5		72.1
Bohemian-Bavarian-Austrian	59	53		112	89	45		134	50.8	-15.1		19.6
Carpathian	1,204	158		1,362	1,415	249	24	1,688	17.5	57.6		23.9
Dinaric	217	43		260	210	59		269	-3.2	37.2		3.5
Harz	39	90		129	79	158		237	102.6	75.6		83.7
Jura	139	34		173	169	53		222	21.6	55.9		28.3
Karelian	2,269	323		2,592	1,887	1,053		2,940	-16.8	226.0		13.4
Scandinavian	4,523	1,295		5,818	4,043	2,492		6,535	-10.6	92.4		12.3
Vosges-Palatinian	5	72		77	49	51		100	880.0	-29.2		29.9
Pomeranian occurrence		3		3	91			91	NA	NA	NA	NA
Black Forest-Swabian Jura		37		37	30	26		56		-29.7		51.4
Unassigned	3	19		32	5	45	2	52	66.7	136.8		62.5
Total	**9,369**	**2,641**	**2**	**12,022**	**9,403**	**5,138**	**26**	**14,567**	0.4	94.5	NA	**21.2**

*The cells defined as "possible presence" in the maps for 2016-2012 for the portion of the Balkan lynx distribution in Greece could not be confirmed and we now assume an absence of lynx in Greece for both mapping periods and these 111 cells of potential presence were excluded from the balance calculation in this table.

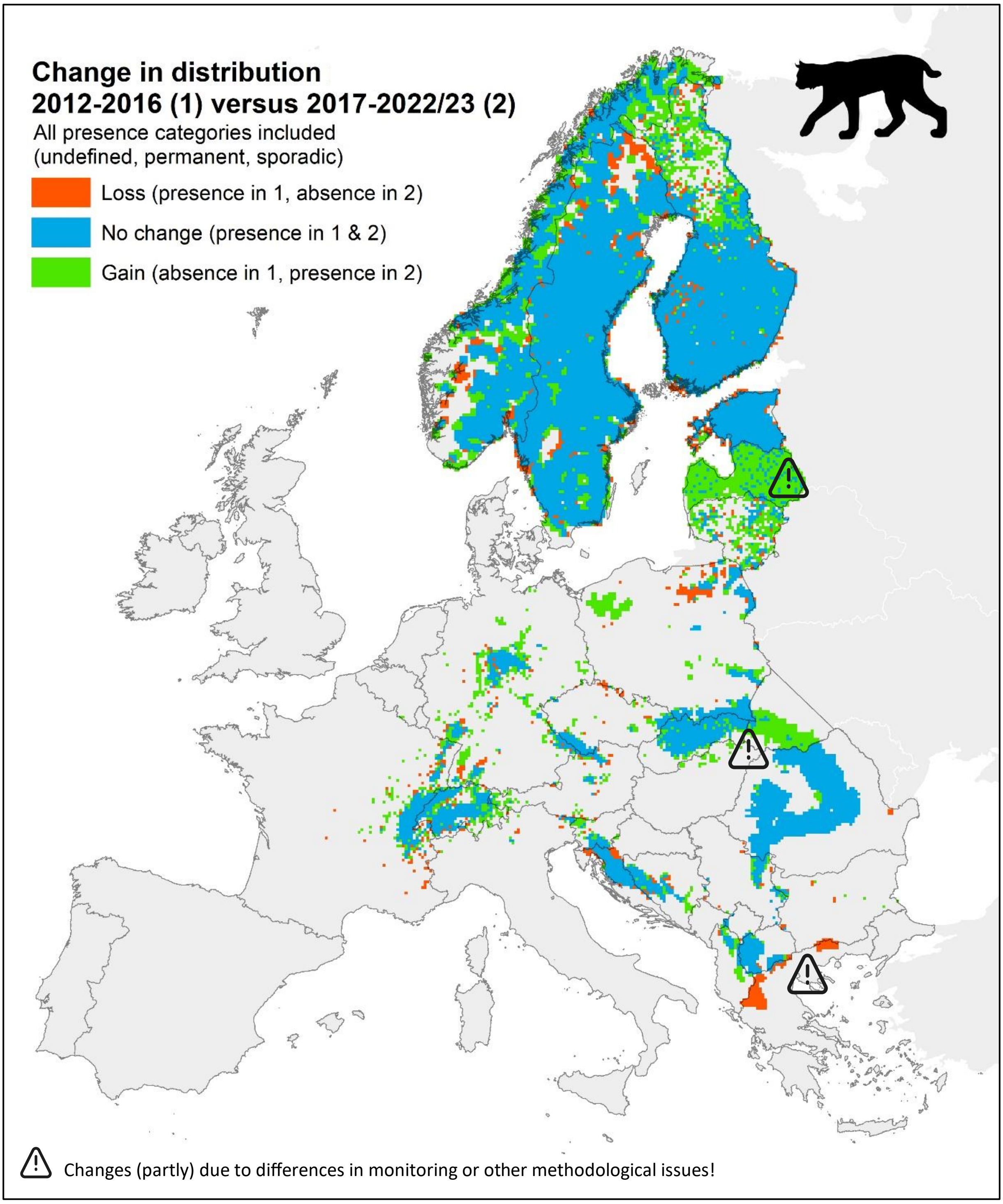

Fig. 9: Changes in Eurasian lynx distribution 2012-2016 versus 2017-2022/23.

3.1.3. Wolf

Overview of main distribution monitoring methods

The most important monitoring methods for determining wolf distribution are dead animals, non-invasive genetic monitoring (scats, urine), camera trapping, active snow tracking, and recording of other SCALP C2 signs. "Other" in Slovakia refers to opportunistic observations reported by hunters (Table 7).

Table 7: Main distribution *monitoring method for the wolf.*

Country	Range monitoring method												
	Dead animals	Non-invasive genetics	Camera traps	GPS tracking	Active snow tracking	Howling surveys	Family groups	SCALP C2	Damage statistics	SCALP C3	Quest. & interviews	Past presence	Other*
Wolf													
Albania	<10%		25-50%			<10%				<10%	<10%	<10%	
Austria	<10%	>75%	<10%	<10%			<10%				>75%		
Belgium	<10%	>75%	>75%					10-25%	50-75%				
Bosnia & Herzegovina	50-75%		25-50%		<10%	<10%		50-75%			<10%		
Bulgaria	>75%		50-75%	<10%	<10%	<10%	<10%	50-75%		<10%			
Croatia	>75%	50-75%	25-50%	10-25%	<10%	<10%	<10%	>75%	>75%	<10%			
Czech Republic	<10%	50-75%	50-75%	10-25%	50-75%	<10%		25-50%	<10%		>75%		<10%
Denmark	<10%	25-50%	25-50%	<10%	<10%		10-25%	<10%	<10%		>75%		
Estonia	<10%		10-25%	<10%		<10%	10-25%	10-25%			>75%		
Finland	10-25%	>75%	10-25%	10-25%	10-25%		>75%	>75%					
France	<10%	25-50%	25-50%		10-25%	<10%		25-50%					
Germany	>75%	>75%	>75%	<10%	10-25%			>75%			>75%		
Greece	<10%		10-25%	<10%		10-25%	<10%	<10%	>75%		<10%		
Hungary	10-25%	10-25%	50-75%		10-25%	<10%	10-25%	>75%	<10%				
Italy - Alps	>75%	>75%	>75%		>75%			>75%					
Italy - Peninsula	>75%	>75%	>75%		>75%			>75%					
Kosovo*	no dedicated monitoring - by-catch from lynx camera trap monitoring												
Latvia			<10%		10-25%				10-25%	10-25%			
Lithuania	25-50%		10-25%					10-25%		<10%	>75%		
Luxembourg	only single dispersers, detected through analysis of livestock kills and photos/videos from the public												
Montenegro	no information												
North Macedonia	<10%	<10%	25-50%		<10%	<10%	<10%	<10%	<10%	<10%	10-25%	<10%	
Poland	10-25%	10-25%	10-25%	<10%	10-25%	<10%	10-25%	10-25%	25-50%		50-75%	<10%	
Portugal	<10%	>75%	>75%			>75%	>75%	>75%	>75%			>75%	
Romania			<10%		>75%			<10%	<10%	<10%		>75%	
Serbia	25-50%		25-50%	<10%					<10%				
Slovakia	>75%	10-25%	>75%	25-50%	>75%	<10%	>75%	>75%	>75%	>75%	>75%		>75%
Slovenia	<10%	50-75%							10-25%		>75%		10-25%
Spain	>75%	<10%	>75%	10-25%	<10%	>75%			>75%				
Sweden & Norway	>75%	>75%	>75%		>75%				>75%				
Switzerland	>75%	>75%	50-75%	<10%		25-50%	>75%	>75%	>75%				
The Netherlands	<10%	>75%	25-50%		<10%	<10%		25-50%	>75%	<10%	<10% & >75%		
Turkey - European part												>75%	<10%
Ukraine - Carpathians	<10%	<10%	<10%	<10%	10-25%	<10%	<10%	<10%	<10%	25-50%	<10%		

Overview of main mapping methods

Distribution data were available for most countries up to 2022/23. However, France reported only until 2019/20, Italy for the peninsula area reported for one intensive monitoring period in 2020-2021 (Gervasi et al. 2024), Norway and Sweden reporting from 2017-2021, and Turkey presented new data based on media reports with video and/or photo documentation only for the last 2 years, but was otherwise based on older data (Ambarli et al. 2016).

Out of 35 countries/regions with wolf presence, 7 use buffers around wolf signs (Albania, Bulgaria, Latvia, North Macedonia, Poland, Sweden, Norway) with 3 (Albania, Italy – Peninsula, North Macedonia, and Poland) additionally using modelling for extrapolated presence. Three countries (Croatia, Slovakia, Ukraine) used some or most wolf signs obtained at the level of hunting grounds, which were intersected with the 10 x 10 km grid.

For 5 countries (Croatia, Sweden, Norway and in part Slovakia and Ukraine) information on data quality was not, or only partly, available at the individual cell level.

A distinction between permanent and sporadic presence was primarily made based on re-occurrence and/or reproduction. However, 2 countries (Sweden, Norway) exclusively used reproduction, and 1 country (Latvia) exclusively used mortality (locations of dead animal) to define the area of permanent distribution. Three countries/regions made no distinction between permanent and sporadic (Greece, Italy – Peninsula, and Turkey). Kosovo* used data quality, Romania a combination of data quality and quantity, Montenegro used geographic location, Ukraine used hunter density estimates <1/100km^2, and North Macedonia did not specify.

The distribution area of wolves was estimated to have increased in 20 countries/regions, showed no obvious change in 6, fluctuated in 2, decreased in 2 (Bosnia and Herzegovina, Portugal), and consisted of only single individuals in 1, and was unknown or unreported from 5 (Table 8).

Table 8: Mapping details for the wolf in Europe.

Country / Region	FINAL_time	Spatial scale	% Known range monitored		Large carnivore signs used	Definition of gridcells based on	Scale of data quality information	Presence categorisation based on	Method change	Range trend estimate since 2012-2016	
			Active	Passiv						Trend	Assessment
Wolf											
Albania	2017 – 2022/23	Only reference areas	15	20	C1	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	No obvious change	Real
Austria	2017 – 2022/23	Entire known range	10	90	C1 (C2)	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Belgium	2017 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Bosnia & Herzegovina	2017 – 2022/23	Entire known range bu	85	10	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Decreasing	Real & method change
Bulgaria	2017 – 2022/23	Entire known range	variable	100	C1*-C3	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Fluctuating	Real
Croatia	2017 – 2022/23	Entire known range	80	20	C1 & C2	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid	Country level	Re-occurring presence and/or reproduction	No	Increasing	Real
Czech Republic	2017 – 2022/23	Only reference areas	75	5	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Denmark	2017 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Estonia	2018 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Finland	2017 – 2023/24	Entire known range	100	80	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
France	2017 – 2019/20	Entire known range	42	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Germany	2017 – 2022/23	Entire known range	20 - 100 (depending on federal state)		C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Greece	2019 – 2023	Entire range with C2/C	25	25	C1 & C2, some C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No distinction was made	No	Increasing	Real & method change
Hungary	2017 – 2022/23	Entire known range	75	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Italy - Alps	2020 - 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Italy - Peninsula	2020 – 2021	Entire known range	100 (randomly sampled)		C1 & C2	Confirmed presence signs and modelling overlaid with the 10 x 10 grid	Cell level	No distinction was made*	Yes	Increasing	Real & method change
Kosovo*	2016 - 2023/24	no information			C1 & C2-C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Data quality	no information		
Latvia	2017 – 2023	Entire known range	100	0	C1	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Mortality	yes	Increasing	Real & method change
Lithuania	2018 – 2023	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence	No	Increasing	Real & method change
Luxembourg	2017 – 2023	Only single dispersers present			C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Only first individuals	
Montenegro	2022 – 2023	No information	60	60	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Geographic location	no information		
North Macedonia	2017 – 2022/23	Monitoring is opportur	0	25	C1 & C2	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Not specified	No	Unknown	More data needed
Poland	2017 – 2022/23	Entire known range	20	80	C1 & C3	Buffered confirmed presence signs & modelling overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Portugal	2017 – 2022/23	Entire known range	100	0	C1 & C2	Confirmed presence signs or UTM grid overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Decreasing	Real
Romania	2017 – 2022/23	Entire known range	70	30	C1, C2 & C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Data quality & Number of signs	Yes	No obvious change	Method change
Serbia	2017 – 2022/23	Entire known range	60	40	C1	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Real
Slovakia	2017 – 2022/23	Entire known range	100	100	C1, C1*-C3	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid & additional C1 & C2	Cell & country level	Re-occurring presence and/or reproduction	No	Increasing	Real
Slovenia	2017 – 2022/23	Entire known range	70	30	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Yes	Increasing	Real
Spain	2017 – 2022/23	Entire known range	90	10	C1* & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	No obvious change	Expansion of non-breeders
Switzerland	2017 – 2022/23	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	Slight	Increasing	Real
The Netherlands	2017 – 2022/23	Entire known range	80	20	C1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	Re-occurring presence and/or reproduction	No	Increasing	Real
Turkey - European part	<2016 & 2023/2024	European part	unkown	unknowr	(C1), C3	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No distinction was made	NA	Unknown	
Ukraine - Carpathians	2017 – 2023 (2019)	Carpathians	10	100	C1*-C3	Hunting grounds with confirmed presence signs overlaid with the 10 x 10 grid & additional C1 & C2	Cell & country level	Hunter density estimate (>1/km2) for permanent	Yes	Fluctuating	Real
Sweden	2017 – 2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	Increasing	Real
Norway	2017 – 2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real

Current wolf distribution in Europe 2017-2022/23

The wolf is currently found in all 34 of the 34 countries/regions monitored (Fig. 10). The total distribution encompassed by the wolf in Europe currently covers ca. 2.2 million km^2, which is a 40% increase since 2016 (Fig. 10, Table 9).

Although there is no doubt that wolf distribution has greatly increased, some of this increase can be clearly attributed to a change in methods, particularly for the Italian peninsula (gain: 63,200 km^2), Latvia (gain: 49,000 km^2), and access to new data from Ukraine (gain: 27,500 km^2). The gain by these 3 countries alone accounts for 22% of the range change (Table 9).

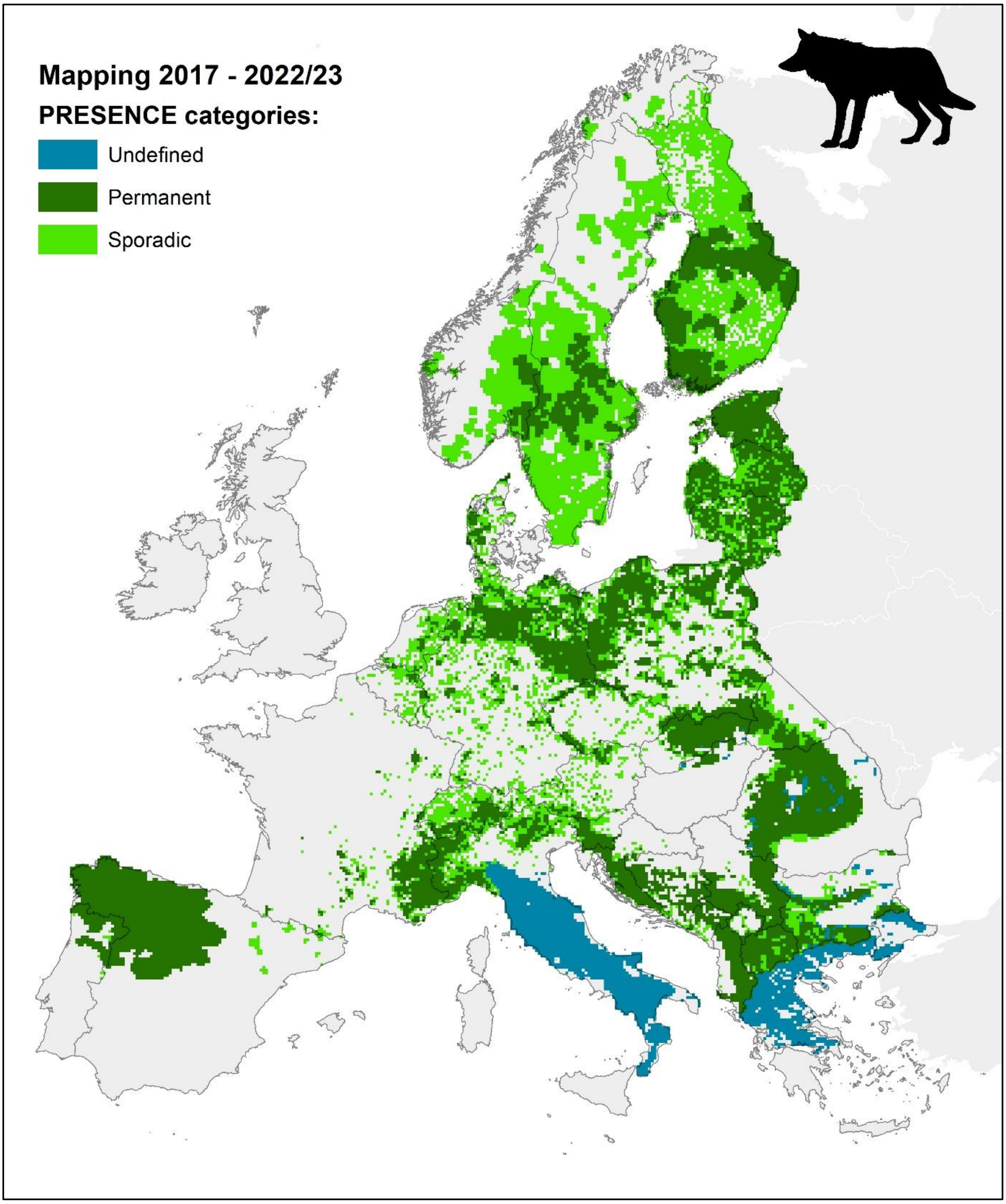

Fig. 10: Wolf distribution in Europe for the period 2017-2022/23.

Most of the wolf distribution area in all populations is based on confirmed wolf signs, often in combination with some form of extrapolation (buffers and/or modelling, see Table 2). Only in some parts of the Dinaric-Balkan region is the wolf distribution largely based on extrapolated or unconfirmed records (Albania, North Macedonia, and Turkey). In parts of the Carpathian population monitoring is dependent on observations from hunting grounds or protected areas in Ukraine and Slovakia. These observations are often less formally documented or less accessible, and include direct observations, and were given the mixed status of “Confirmed and unconfirmed” data quality. Where available, this data was confirmed with C1 & C2 data from dedicated monitoring projects, especially those using camera trapping or non-invasive genetic monitoring (Fig. 11).

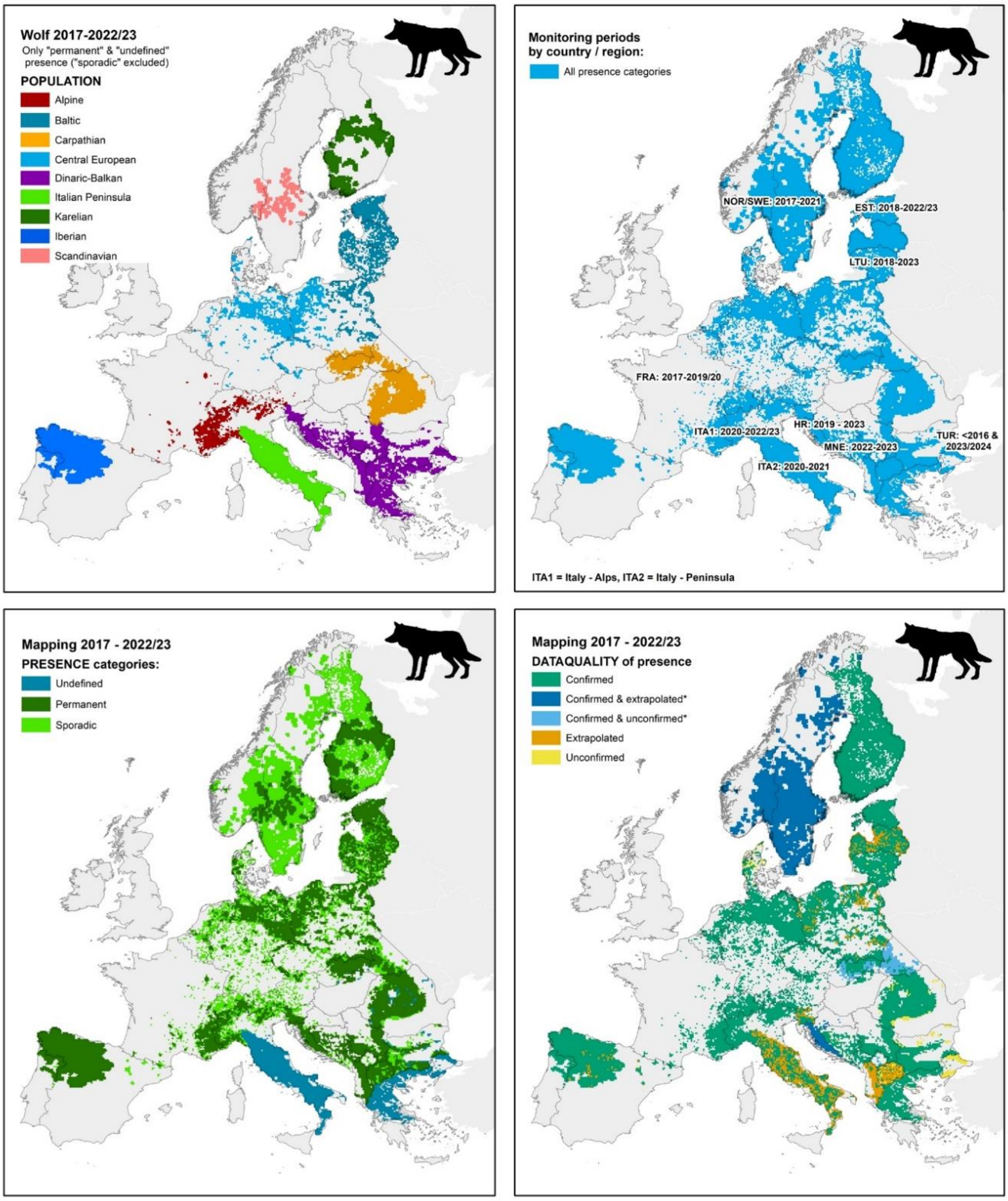

*Fig. 11: Wolf populations, countries/regions with monitoring periods deviating from the 2017-2022/23 period, wolf distribution, and underlaying data quality. *DATAQUAL: Mixed layer of confirmed and extrapolated or unconfirmed cells, where no separation at cell level was possible.*

Change in wolf distribution 2012-2016 versus 2017-2022/23

The distribution area of wolves increased due to natural expansion. For countries having several population segments, self-reported trend estimates were not necessarily available for each segment but rather the national population. Looking at individual populations (Fig. 11 & 12, Table 9):

- The **Alpine population's** distribution has increased, and the area of permanent presence is consolidating especially in Italy, France, and Switzerland. The population's distribution is in the process of connecting with the Central European to the north and the Dinaric-Balkan population to the east, and wolves of Alpine origin have maintained a presence in the Pyrenees and soon may be able to connect to the Iberian wolf population. Monitoring is increasingly happening at the population level (Marucco et al. 2023). The main range countries all self-reported an increasing population range.
- The **Baltic population's** distribution is increasing, although the apparent increase in the sporadic presence in Latvia is largely due to methodical changes (the 2012-2016 mapping did not include buffers and unconfirmed data). Latvia and Lithuania self-report an increase in the wolf distribution, Estonia reported no obvious change, and Poland reported an increasing population distribution at the overall national level.
- The **Carpathian population's** distribution has remained stable, except for the north where the area of permanent presence has increased widely in Slovakia (but this may also have to do with access to better data for the current mapping), increased somewhat in Poland, and is also reaching into Hungary. The apparent gains in Hungary and Ukraine are due to better monitoring data in Ukraine and the first inclusion of monitoring data from Hungary. The 3 northern countries all self-report an increasing trend in wolf distribution area. Romania self-reported no obvious change.
- The **Central European population's** permanent distribution has greatly expanded and consolidated in northwest Poland and northeast Germany and now stretches into the Netherlands, Belgium, and Denmark, and along the border with the Czech Republic. Monitoring methods are increasingly harmonised between the range countries (Reinhardt et al. 2015) as is online reporting for Germany and the Benelux countries. Sporadic occurrence is starting to connect to the Alpine, Dinaric-Balkan, and Carpathian populations. All range countries self-reported an increasing population range.
- The **Dinaric-Balkan population's** distribution has remained largely stable but shows some more losses than gains. Better connectivity is suggested in Montenegro, but this is an artefact as no data was available from this country for 2012-2016. The largest distribution loss is visible in northern Croatia and northeast Bulgaria. For Bulgaria this may be due to a change in methods and monitoring effort. Bulgaria self-reported a fluctuating trend, Albania and Serbia reported no obvious trend, Bosnia-Herzegovina a decreasing trend and Kosovo*, Montenegro, and North Macedonia have no information and need more data. Only Croatia and Slovenia self-reported an increasing trend in the wolf distribution area.
- The **Italian Peninsula population's** distribution was mapped for the first time in its entirety in a standardised and representative way combining field inspections and modelling (Gervasi et al. 2024).Consequently, the maps from 2012-2016 and now are not directly comparable. The wolf distribution area on the Italian peninsula is now fully connected with the Alpine wolf population. The distribution in the Italian Peninsula is self-reported to have increased due to the combination of a change in method and a real trend.
- The **Karelian population's** distribution has increased both in permanent and sporadic cells. Finland self-reported an increasing area of distribution.

- The **Iberian population's** distribution has remained stable in Spain but lost some area in Portugal. In line with this, Portugal self-reported a decreasing distribution and Spain no obvious change, but an expansion of non-breeders.
- The **Scandinavian population's** permanent distribution has decreased but may have also been overestimated for the period 2012-2017 (G. Chapron pers. comm. 2023). An enforced zoning policy does not allow for expansion of the permanent wolf distribution in Norway and not surprisingly Norway self-reported no obvious change. Sweden, on the other hand, self-reported an increasing wolf distribution which is likely due to the expansion of the area of sporadic presence, especially in the south.

Table 9: Changes in the wolf distribution in Europe since 2016, expressed as number of 10 x 10 km cells.

Population	N cells in 2016				N cells in 2022				Balance (%)			
	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total
Alpine	536	517		1,053	853	896		1,749	59.1	73.3		66.1
Baltic	1,271	324		1,595	1,770	770		2,540	39.3	137.7		59.2
Carpathian	1,229	122	202	1,553	1,670	286	70	2,026	35.9	134.4	-65.3	30.5
Central European	487	520		1,007	1,669	1,703		3,372	242.7	227.5		234.9
Dinaric-Balkan	2,277	702	18	2,997	1,678	353	817	2,848	-26.3	-49.7	4438.9	-5.0
Iberian	1,199	140	169	1,508	1,578	61		1,639	31.6	-56.4	-100.0	8.7
Italian Peninsula	531	203		734	6	12	1,348	1,366	-98.9	-94.1		86.1
Karelian	510	1,378		1,888	1,176	1,717		2,893	130.6	24.6		53.2
Scandinavian	1,518	2,030		3,548	635	3,136		3,771	-58.2	54.5		6.3
Unassigned		7		7					NA	NA		NA
Total	**9,558**	**5,943**	**389**	**15,890**	**11,035**	**8,934**	**2,235**	**22,204**	**15.5**	**50.3**	**474.6**	**39.7**

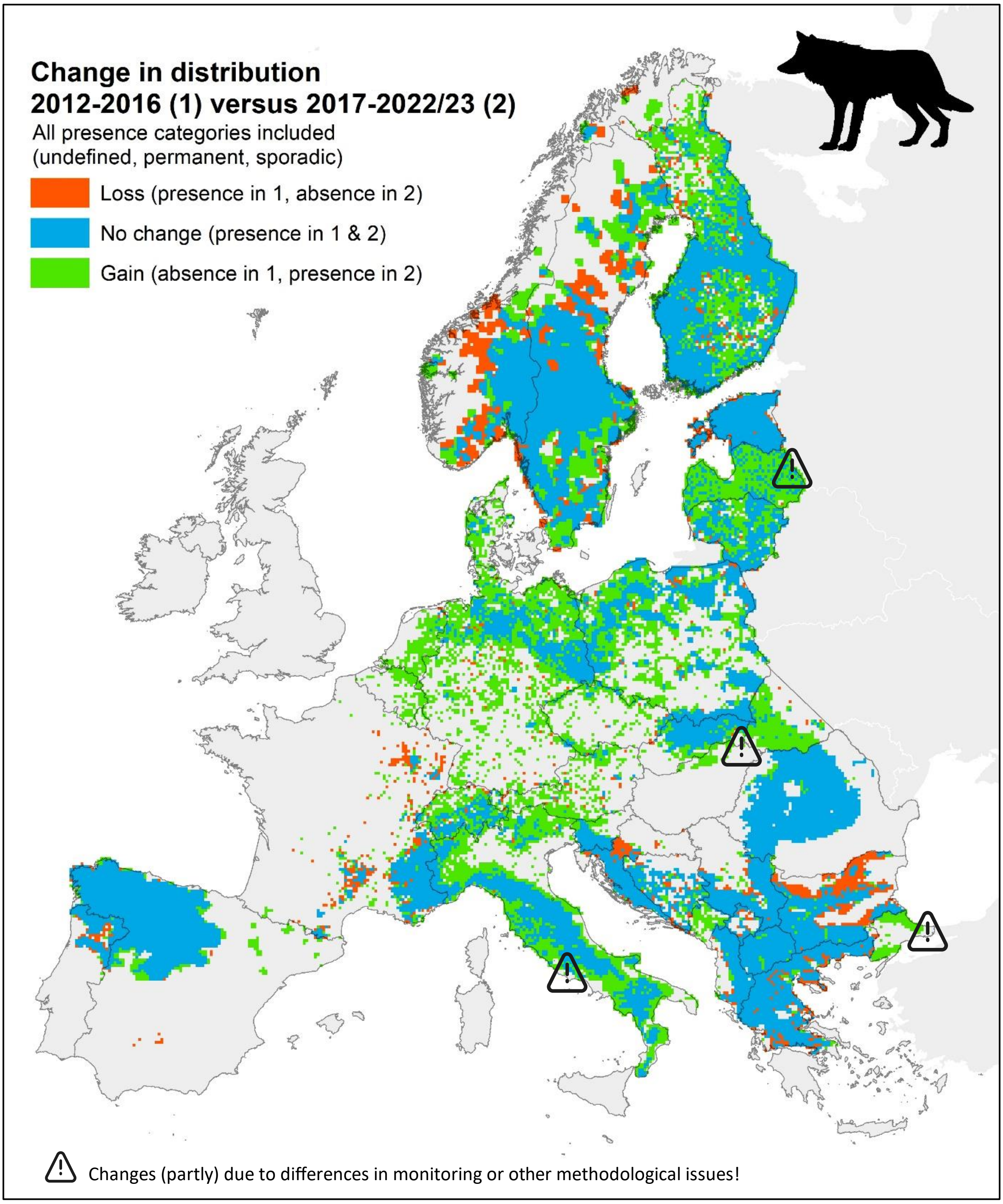

Fig. 12: Changes in wolf distribution 2012-2016 versus 2017-2022/23.

3.1.4. Wolverine

Overview of main distribution monitoring methods

The most important monitoring methods for determining the distribution of wolverines are dead animals, non-invasive genetics (scats), camera traps, active snow tracking, natal-den (family group) detection, damage statistics in Norway and Sweden, and confirmed wolverine signs and family group detection in Finland (Table 10).

Table 10: Main distribution monitoring method for the wolverine.

Country	Range monitoring method												
	Dead animals	Non-invasive genetics	Camera traps	GPS tracking	Active snow tracking	Howling surveys	Family groups	SCALP C2	Damage statistics	SCALP C3	Quest. & interviews	Past presence	Other*
Wolverine													
Finland		<10%					25-50%	>75%					
Sweden & Norway	>75%	>75%	>75%		>75%		>75%		>75%				

Overview of main mapping methods

Norway and Sweden use identical distribution monitoring and mapping methods, with buffers around confirmed wolverine signs of reproduction to define the area of permanent presence. In Finland, unbuffered confirmed signs of wolverines are used to define the range. Information on reproduction is not systematically collected, so that the distinction between permanent and sporadic presence, which was done in the 2012-2016 mapping, is no longer possible for Finland (Table 11).

Table 11: Mapping details for wolverine in Europe.

Country / Region	FINAL_time	Spatial scale	% Known range monitored		Large carnivore signs used	Definition of gridcells based on	Scale of data quality information	Presence categorisation based on	Method change	Range trend estimate since 2012-2016	
			Active	Passiv						Trend	Assessment
Wolverine											
	2022/23	Entire known range	100	80	C 1 & C2	Confirmed presence signs overlaid with the 10 x 10 grid	Cell level	No distinction was made	No	Increasing	Real
Sweden	2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real
	2021	Entire known range	100	100	C1 & C2	Buffered confirmed presence signs overlaid with the 10 x 10 grid	Country level	Reproduction only	No	No obvious change	Real

Current wolverine distribution in Europe 2017-2022/23

The wolverine is only found in the 3 northernmost countries, Norway, Sweden, and Finland. The total distribution area of wolverines in Europe currently covers 745,00 km², which is a 4% increase in range since 2016 (Fig. 13, Table 12).

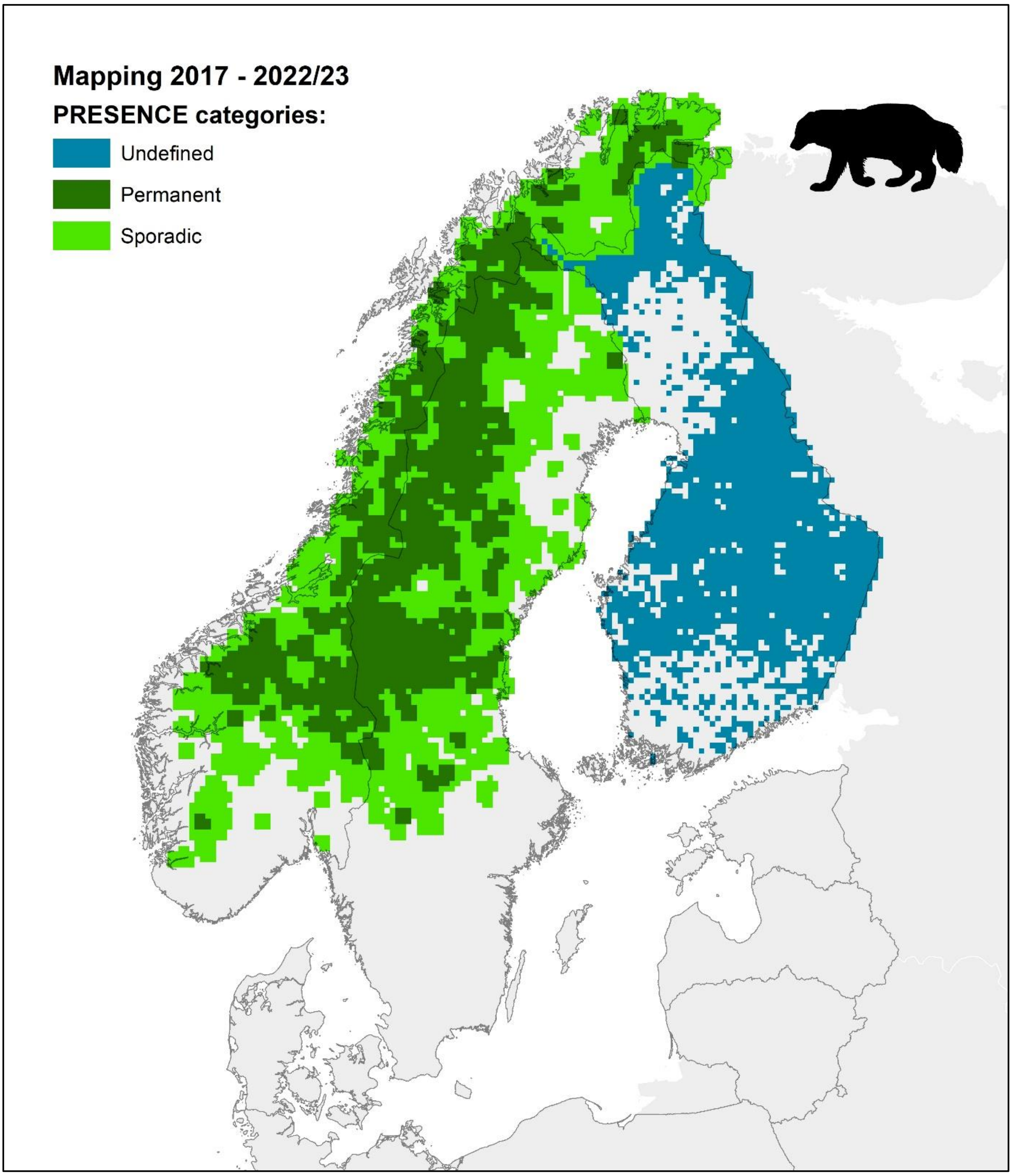

Fig. 13: Wolverine distribution in Europe for the period 2017-2022/23.

The distribution of the wolverine is entirely based on confirmed presence signs in Finland and on confirmed and buffered presence signs in Norway and Sweden. For Finland the distinction between permanent and sporadic distribution is no longer possible as the monitoring of den sites is greatly reduced and therefore no longer effectively represents the permanent range (Fig. 14).

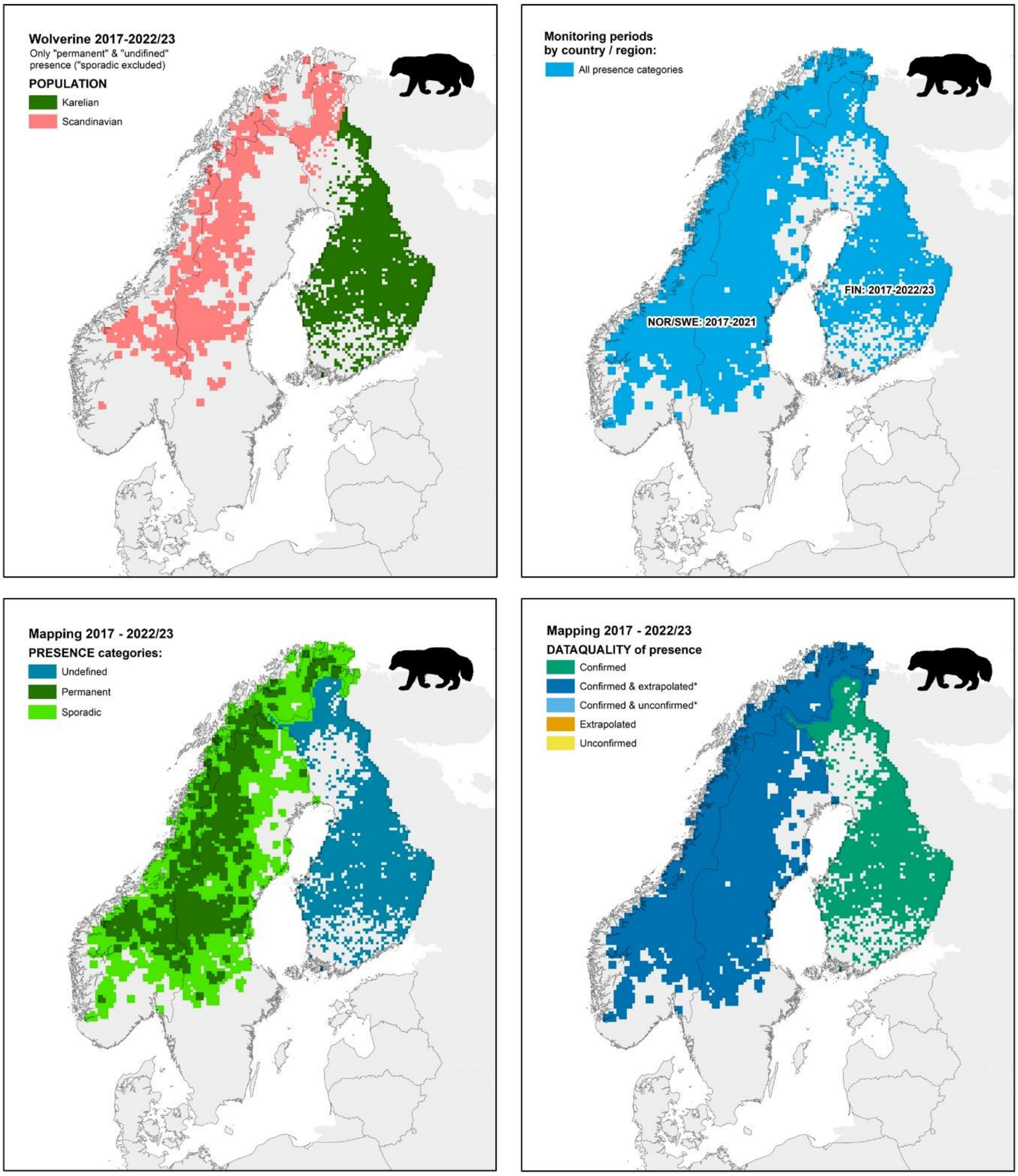

*Fig. 14: Wolverine populations, countries/regions with monitoring periods deviating from the 2017-2022/23 period, wolverine distribution, and underlaying data quality. *DATAQUAL: Mixed layer of confirmed and extrapolated or unconfirmed cells, where no separation at cell level was possible.*

Change in wolverine distribution 2012-2016 versus 2017-2022/23

Wolverine distribution seems to have mainly remained stable. Looking at individual populations (Fig. 14 & 15, Table 12):

- The **Scandinavian population's** distribution has remained largely stable with slightly more losses than gains along the fringes. The area has been self-reported as showing no obvious change by both Norway and Sweden.
- The **Karelian population's** distribution also seems to be expanding in the south and north-west. The area has been self-reported as increasing by Finland.

Table 12: Changes in wolverine distribution in Europe since 2016, expressed as number of 10 x 10 km cells.

Population	N cells in 2016				N cells in 2022				Balance (%)			
	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total
Karelian	1,073	784		1,857			2,343	2,343	NA	NA	NA	26.2
Scandinavian	2,350	2,957		5,307	2,200	2,907		5,107	-6.4	-1.7		-3.8
Total	**3,423**	**3,741**		**7,164**	**2,200**	**2,907**	**2,343**	**7,450**	**-35.7**	**-22.3**		**4.0**

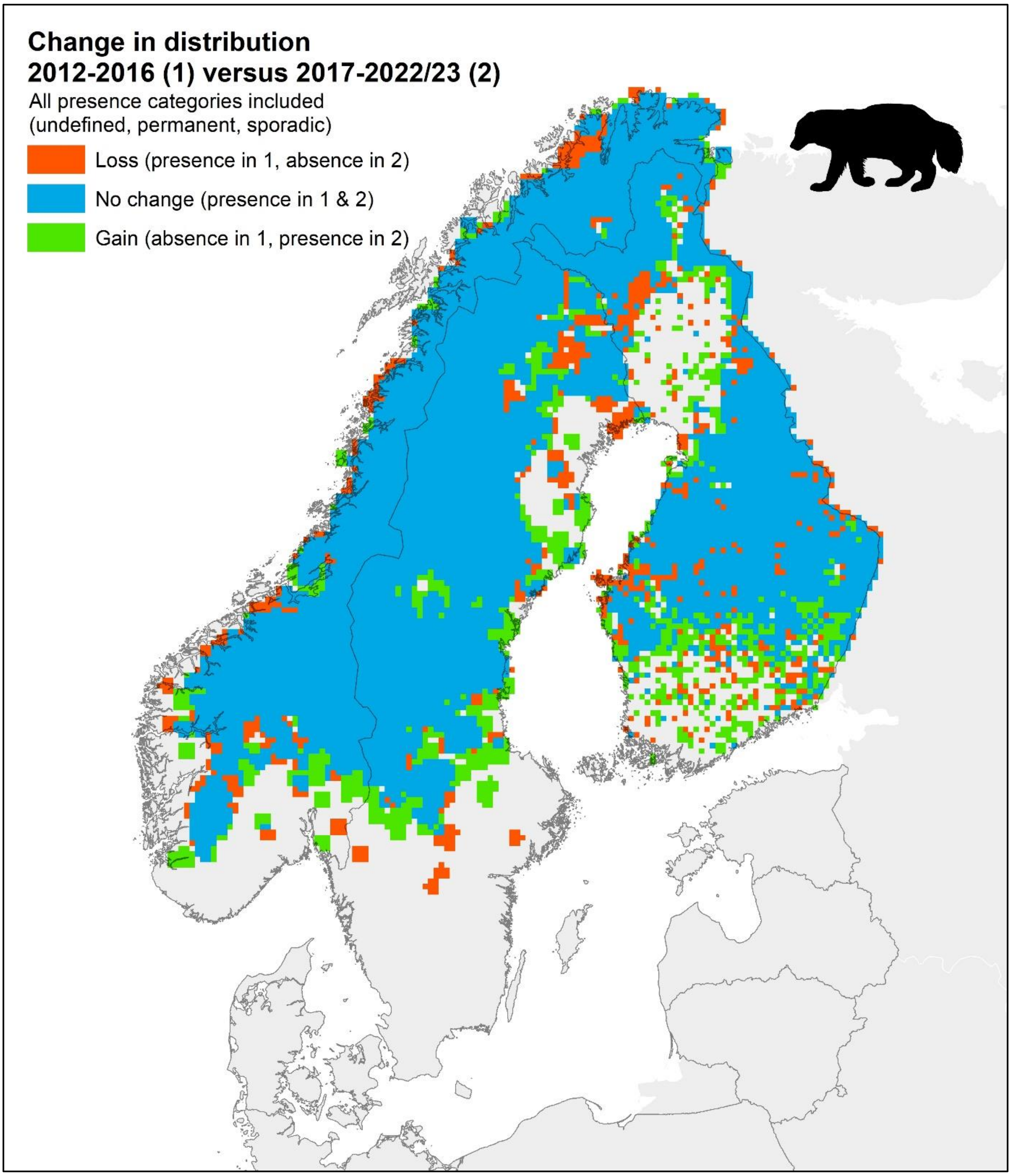

Fig. 15: Changes in wolverine distribution 2012-2016 versus 2017-2022/23

3.1.5. Golden jackal

Overview of main distribution monitoring methods

Overall, golden jackals are rarely subject to regular, intensive and active monitoring at regional or national scales. In the core of the species range, monitoring is primarily based on recorded dead animals, mainly from hunting bags. Howling surveys, camera traps, citizen-science based data and C3 records are especially prevalent in countries at the expansion front. Methods under "other" (Table 13) are ground- and aerial-based observations using thermal imaging in Greece.

Table 13: Main distribution monitoring method for the golden jackal.

Country	Range monitoring method											
	Dead animals	Non-invasive genetics	Camera traps	GPS tracking	Active snow tracking	Howling surveys	Family groups	SCALP C2	Damage statistics	SCALP C3	Quest. & interviews	Past presence	Other*
Golden jackal												
Albania	<10%		10-15%			10-25%		10-25%				<10%	
Austria	10-25%	10-25%	25-50%		<10%	<10%			10%				
Bosnia & Herzegovina	>75%		10-25%			>75%					<10%		
Bulgaria	>75%		25-50%					<10%				10-25%	
Croatia	>75%												
Czech Republic	primarily opportunistic												
Denmark	10-25%	25-50%	25-50%										
Estonia	25-50%		10-25%			10-25%							
Finland	No dedicated monitoring; entirely opportunistic												
France	No dedicated monitoring; entirely opportunistic												
Germany		<10%	>75%				<10%	<10%					
Greece	<10%		<10%			<10%							>75%
Hungary	>75%												
Italy	<10%		25-50%		<10%	25-50%					<10%		
Kosovo					<10%								
Latvia	No dedicated monitoring; entirely opportunistic												
Lithuania	No dedicated monitoring; entirely opportunistic												
Montenegro												>75%	
North Macedonia	10-25%		10-25%			25-50%					10-25%	<10%	
Norway	No dedicated monitoring; entirely opportunistic												
Poland	Little dedicated monitoring; largely opportunistic												
Romania										>75%			
Serbia	50-75%				<10%	<10%							
Slovakia	>75%	<10%	>75%	>75%	<10%	10-20%	>75%	>75%		>75%			
Slovenia	>75%												
Spain	No dedicated monitoring; entirely opportunistic												
Switzerland	No dedicated monitoring; entirely opportunistic												
The Netherlands	No dedicated monitoring; entirely opportunistic												
Turkey												>75%	

Overview of main mapping methods

For most countries, distributional data for golden jackals was available between 2017 and 2022/23, and in some rare cases (e.g., Kosovo* and Spain) until 2024. Some countries either used fragmented but recent data (Romania) or older records (Montenegro, North Macedonia and Turkey; Fig. 16). Most of the presence data is based on confirmed (C1) records, but in some countries also C2 and C3 are reported. In Romania, jackal presence data came in the form of unconfirmed jackal population estimates (C3) at hunting ground level.

Most commonly, signs of presence were intersected directly with the 10 x 10 km grid and are reported or later intersected with cell level. In nine countries (Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, Hungary, Lithuania, Romania, Slovakia, Slovenia), however, presence signs were aggregated at the hunting ground level, which were then intersected with the 10x10 km grid. In these countries, the cells overlapping with hunting grounds where jackals were detected were assigned presence (the threshold of overlap was unknown in most cases; 5% was used for Croatia and Romania and 10% for Slovakia and Ukraine). The distribution of jackals may have therefore been overestimated in these countries due to the spatial resolution of the input data. Three countries (Albania, Latvia and North Macedonia) relied on buffers around jackal signs, and extrapolated presence and modelling was used in Albania.

The distinction between permanent and sporadic presence was primarily made based on the re-occurrence of golden jackal signs in the core distribution, or confirmed reproduction on the expansion front, where potential dispersers were assigned sporadic presence. Some countries on the expansion front (Austria, Denmark, Latvia and Poland) largely classified jackal presence as undefined; however, given the observed pattern of jackal expansion, it is likely that most recorded signs are associated with dispersing individuals i.e., “sporadic presence”. In some countries within the core of the distribution (Greece, Montenegro, Romania, Serbia, Slovenia and Turkey), the data was either too fragmented or too infrequent for making a reasonable distinction between permanent and sporadic presence; the cells were therefore classified as "undefined" (Table 14).

Table 14: Mapping details for the golden jackal in Europe.

Country / Region	FINAL_time	Spatial scale	% Known range monitored		Large carnivore signs used	Definition of gridcells based on	Scale of data quality information	Presence categorisation based on	Method change	Range trend estimate since 2012-2016	
			Active	Passive						Trend	Assessment
Golden jackal											
Albania	2017-2023	Entire known range	15	10	C1, C2 & C3	Presence is based on buffered confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level and buffer of 2km	Re-occuring presence, and new records as	Yes (more howling surveys)	Increasing	Real & Method change
Austria	2017-2023	Entire known range	5	95	C1 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	confirmed presence	No	Increasing	Real
Bosnia & Herzegovina	2017-2023	Entire known range	65	35	C1 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	Increasing	Real
Bulgaria	2017-2023	Entire known range	0	100	C1, C2 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	No obvious change	
Croatia	2017-2023	Entire known range	0	95	C1	Presence based on larger areas (hunting grounds) with confirmed presence signs (hunted individuals) which were overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	Increasing	Real
Czech Republic	2017-2022	Entire known range	<10	100	C1 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence, confirmed	Yes	Increasing	Real
Denmark	2016-2023	Entire known range	0	100		Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	Increasing	Real
Estonia	2017-2023	Entire known range	100	100	C1 & C2	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	Increasing	Real
Finland	2017-2023	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Confirmed reproduction	No	Increasing	Real
France	2017-2023	Entire known range	0	100	C1	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Confirmed reproduction	No	Increasing	Real
Germany	2017-2023	Entire known range	<1	99	C1 (Hatlauf & Böcker, 2022)	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Confirmed reproduction	Yes	Increasing	Real
Greece	2017-2024	Entire known range	60	60	C1 & C2	Confirmed presence signs overlaid with the 10x10 grid	Cell level	NA	Yes	Increasing	Real & Method change
Hungary	2017-2022	Entire known range	0	100	C1	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence	No	Increasing	Real
Italy	2016-2023	Entire known range	<10	100	C1, C2 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Re-occuring presence, confirmed	Yes	Increasing	Real
Kosovo	2017-2024	Only in certain reference areas	20	NA	C1	Presence based on confirmed presence signs and modeling based on habitat suitability and/or proximity criteria which were overlaid with the 10x10 grid	Cell level	NA	Yes	Unknown	Unknown
Latvia	2018-2023	Entire known range	0	100	C1	Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level	NA	Yes	Likely increasing	Likely real
Lithuania	2018-2024	Entire known range	0	100	C1	Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level	NA	No	Likely increasing	Likely real
Montenegro	2012-2016	NA	NA	NA	NA	NA	NA	NA	NA	Unknown	Unknown
North Macedonia	2014-2023	Selected areas	30	40	C1, C2 & C3	Presence based on confirmed presence signs and modeling based on habitat suitability and/or proximity criteria which were overlaid with the 10x10 grid	Cell level	NA	Yes	Increasing	Real
Norway	2017-2023	Entire known range	0	100	C1	Confirmed presence signs overlaid with the 10x10 grid	Cell level	NA	No	Likely increasing	Likely real
Poland	2017-2023	Entire known range	0	100	C1 & C2	Confirmed presence signs overlaid with the 10x10 grid	Cell level	NA	No	Likely increasing	Likely real
Romania	2022-2023	Entire known range	0	100	C3	Presence based on larger areas (hunting grounds) with unconfirmed presence signs (estimated number of individuals by hunters) which were overlaid with the 10x10 grid	Cell level	NA	Yes	Increasing	Real & Method change
Serbia	2017-2023	Entire known range	60	40	C1	Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level	Re-occuring presence, confirmed	No	Increasing	Real
Slovakia	2017-2022	Entire known range	0	100	C1, C2 & C3	Presence is based on larger areas (e.g. hunting grounds) with confirmed presence signs (e.g. hunted individuals) which were overlaid with the 10 x 10 grid	Cell level	Re-occuring presence, confirmed reproduction	No (some)	Increasing	Real
Slovenia	2017-2023	Entire known range	0	100	C1	Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level		No	Increasing	Real
Spain	2017-2024	Entire known range	0	100	C1	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Confirmed reproduction	No	Increasing	Real
Switzerland	2017-2023	Entire known range	0	100	C1, C2 & C3	Confirmed presence signs overlaid with the 10x10 grid	Cell level	Confirmed reproduction	No	Increasing	Real
The Netherlands	2017-2023	Entire known range	0	100	C1	Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid	Cell level	Re-occuring presence, confirmed	Yes	Increasing	Real
Turkey	2004-2013	Entire known range	0	100	C1 & C2	Presence in part of the range is based on unconfirmed presence signs, or assumed presence based on interviews, questionnaires, and media reports, or documented past presence (this past presence cannot be older than from 2010)	Cell level	No distinction	No	No obvious change	Method change

Current golden jackal distribution in Europe

The golden jackal is currently found in 29 of the 34 European countries/regions covered by this report. The species is thought to be absent only in Belgium, Luxembourg, Portugal, and Sweden. The total range encompassed by the species in Europe currently covers approximately 765,000 km^2, which is a 46% increase of its distribution since 2016 (Fig. 16, Table 15).

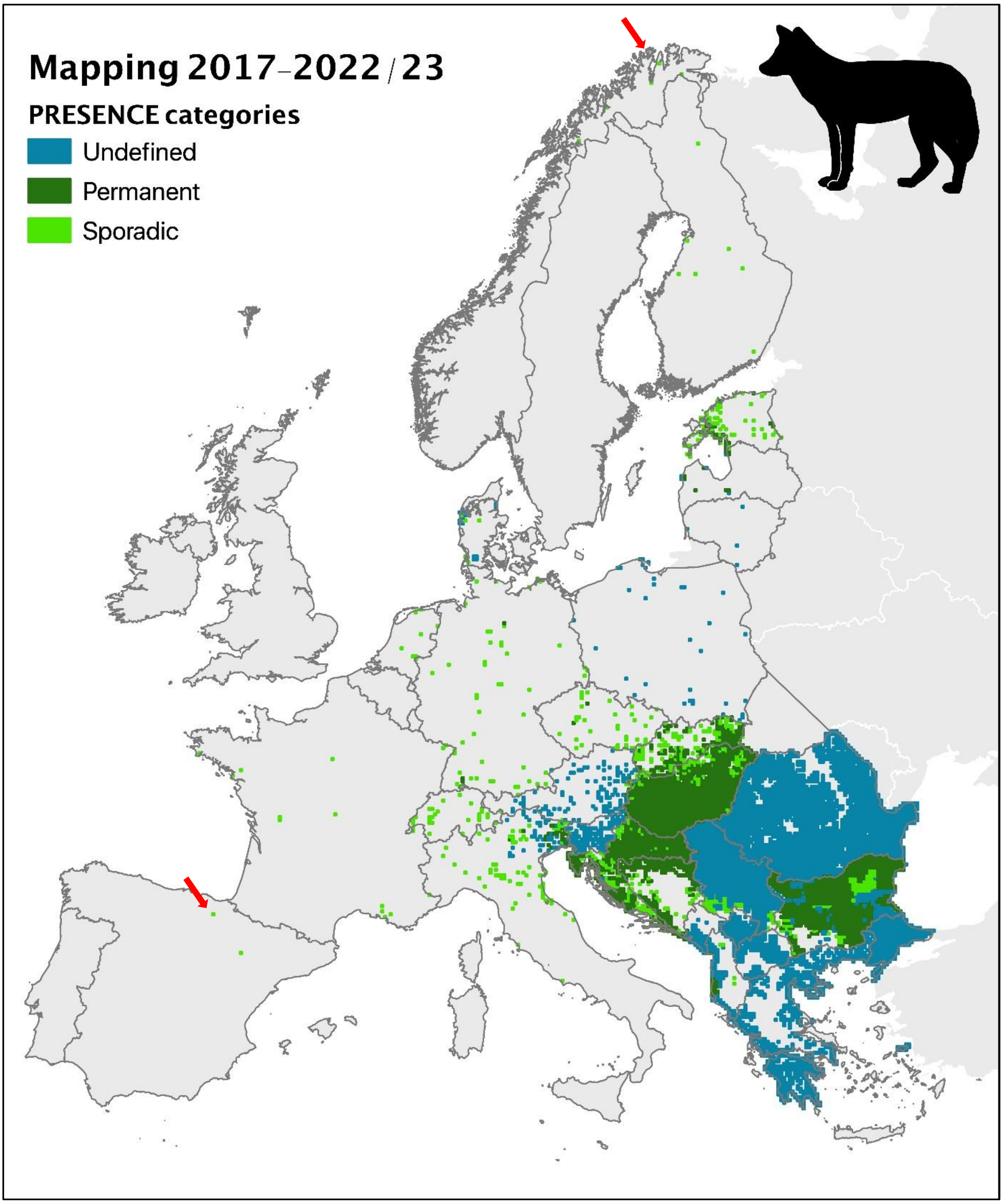

Fig. 16: Golden jackal distribution in Europe for the period 2017-2022/23. Note: Isolated cells away from the main population are slightly enlarged for better visibility and arrows point to Europe's northernmost and easternmost occurrence records.

Golden jackals are primarily distributed within a single interconnected Continental population. The (previous) 2012-2016 assessment distinguished between Continental and Adriatic populations (Ranc et al. 2022). Due to the large contact zone observed in the Dinaric and Balkan population range, we now treat these previously separated populations jointly as the Continental population. In contrast, two populations in Greece, on the island of Samos and on the Peloponnese peninsula, remain largely isolated (Fig. 17).

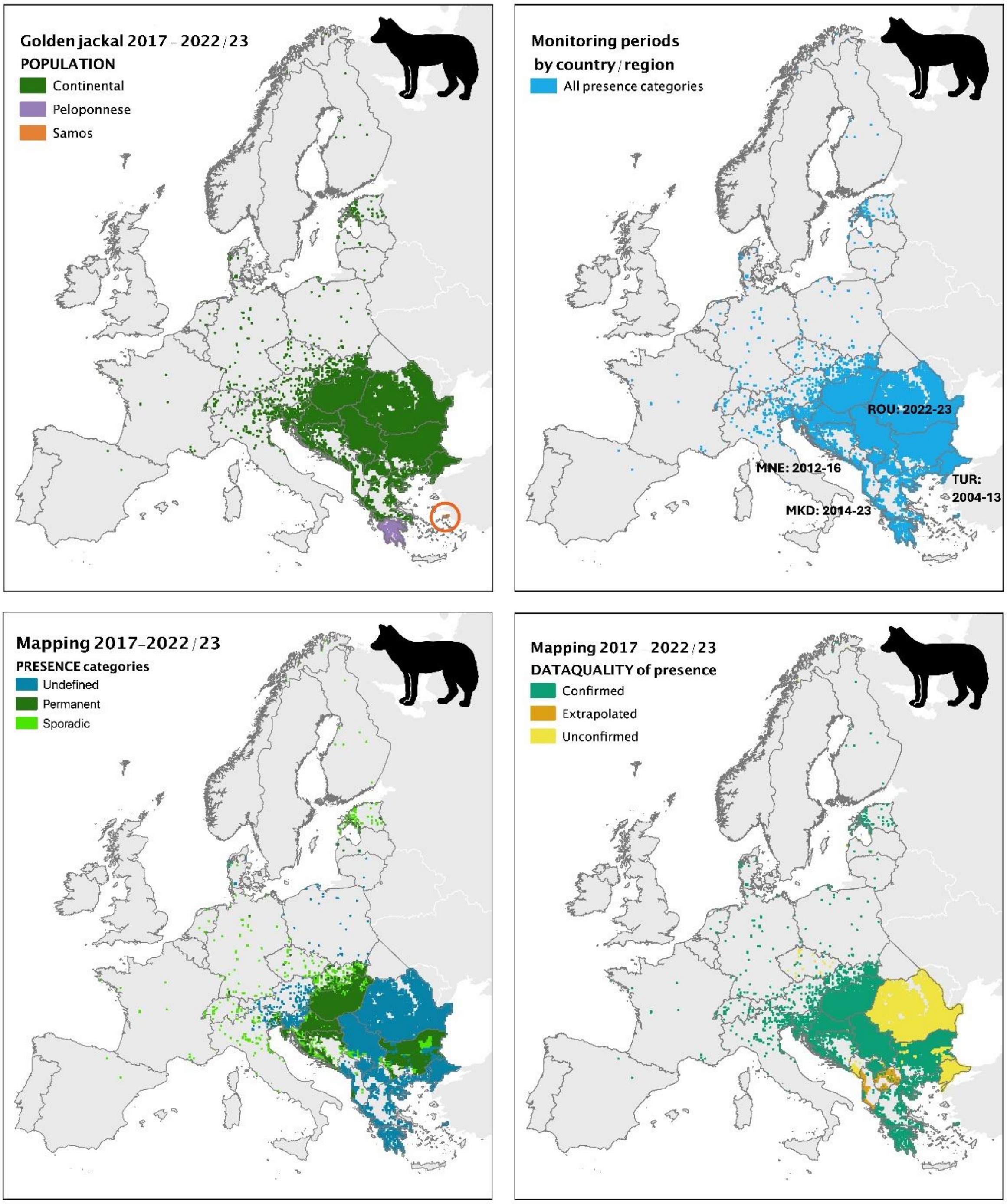

Fig. 17: Golden jackal populations, countries/regions with monitoring periods deviating from the 2017-2022/23 period, golden jackal distribution, and underlaying data quality

The present estimation of distribution does not cover Belarus, Moldova and Ukraine. Dispersing jackals are known to occur in Belarus while established populations seem to be present in both Moldova and Ukraine.

Change in golden jackal distribution 2012-2016 versus 2017-2022/23

The trend in golden jackal distribution area was estimated to be increasing in 21 countries. Two countries reported no obvious change. Due to infrequent or fragmented monitoring, the trend in jackal presence is unknown in six additional countries. No country/region reported a decreasing area of distribution (Table 15).

To quantitatively compare these changes, we reclassified the (previous) 2012-2016 distribution such that “expert-based absences” were considered as “absences”, “expert-based presences” as “undefined presence”, and assigned “Adriatic”, “vagrants” and “NA” to the “Continental” population. Overall, the golden jackal range seems to have significantly increased, although changes in monitoring methods, effort, or mapping have likely also had some regional influence (Fig. 18; Tab.15).

- The **Continental population’s** distribution is characterized by a significant expansion in the Dinaric mountains (Croatia and Slovenia), in Central Europe (especially Hungary and Serbia) and in the small nucleus in the Baltic States (Estonia and spreading into Latvia). Important (absolute) increases are noted in Greece and Romania, but these may be partly the result of a change in monitoring and mapping methods. Turkey was not covered in the previous assessment (2012-2016) other than the border areas, so gains are largely the result of a dedicated mapping for 2017-2022/23. No new data for Montenegro were available since the previous assessment so that changes in local jackal distribution are not possible to identify quantitatively. Long-distance dispersers are being noticed throughout western and northern Europe, with several countries (Finland, France, Norway and Spain) recording their first jackal presence during the 2017-2022/23 period (Hatlauf et al. 2021). In western and central Europe, particularly in Austria and the Czech Republic, there are both local losses and gains (but overall, largely gains), which likely reflect the ongoing jackal expansion process with a dynamic settlement/disappearance of dispersers.
- The distribution of the populations on the **Peloponnese** and **Samos Island** (both in Greece) appears relatively stable, although changes in monitoring makes the trend in the Peloponnese relatively unclear.

Table 15: Quantitative changes (km^2) in golden jackal distribution 2012-2016 versus 2017-2022/23, expressed as number of 10 x 10 km cells.

Population	km^2 in 2016				km^2 in 2022				Balance (%)			
	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total	Permanent	Sporadic	Undefined	Total
Continental	319,918	93,212	52,130	**465,260**	250,431	71,326	424,377	**746,134**	-22	-23	714	60
Samos	480	0	0	**480**	0	0	480	**480**	NA	NA	NA	0
Peloponnese	5,100	495	15,777	**21,372**	0	0	18,363	**18,363**	NA	NA	NA	-14
Total	**325,498**	**93,707**	**67,907**	**487,112**	**250,431**	**71,326**	**443,220**	**764,977**	**-22**	**-23**	**714**	**46**

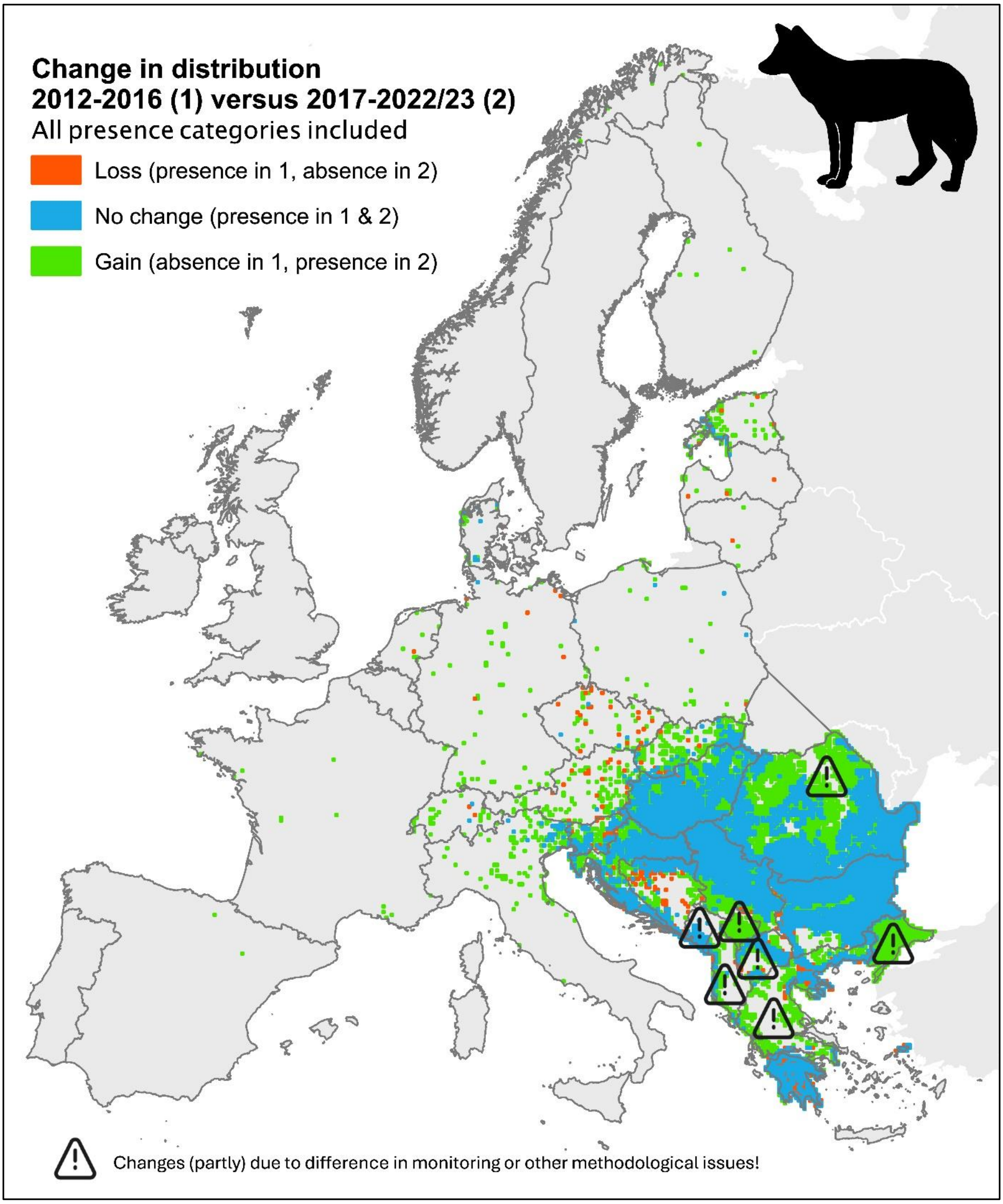

Fig. 18: Changes in golden jackal distribution 2012-2016 versus 2017-2022/23.

3.2. Population estimates

Although the data presented in this section represent the best available figures for each species and each country there is a wide diversity of methods in use, and a massive variation in the accuracy and precision of the numbers produced. For several countries and species no recent (France, Spain), or no reliable, population estimates were available (Kosovo*, Ukraine, Turkey) at all. Some are only based on expert assessments or informed guesses, whereas others result from more robust methodology.

Many populations are shared among several countries and individuals or social groups which have transboundary ranges and may be counted in more than one country. While monitoring and population estimates are harmonised among countries sharing borders for some species and populations, for many transboundary populations there is no correction for the number of individuals or social groups with transboundary ranges. While the number may be relatively small where populations just share short borders, the proportion of transboundary individuals can be very large, where populations are primarily found along international borders.

However, even when the same method is used, it can be used in many different ways. Camera trapping and the use of non-invasive DNA from scats / hairs are widely regarded as the gold standard methods for many species. But they can be used in different ways, either to add up the known individuals or produce statistical estimates of density with confidence intervals based on capture-recapture analyses. The area covered by surveys may vary, with different approaches to extrapolate to the rest of the distribution area. Different statistical approaches may produce different estimates. Different field methods also target different population metrics. Some survey all individuals, whereas others only survey certain parts of the populations, such as adults, or just document the presence of reproduction. Various conversion factors exist to allow conversion between the number of wolf packs and the number of wolves, for example. Unfortunately, there is as yet little standardisation of these conversion factors even within the different parts of the same population.

Surveys can also be conducted at different times of the year which can reflect very different population sizes, especially in areas where hunting is conducted. Methods also change and adapt over time, which makes comparisons with older data harder. A final challenge concerns the availability of data as we had several cases where data is known to be available, but is not accessible, or not sufficiently well documented to include.

There are encouraging signs of more sophisticated methods being used in more areas, although some regions, such as southeastern Europe with their large populations, suffer from a major underinvestment in monitoring activity. There are also areas where neighbouring countries make great efforts to standardise their field methods and analysis, such as the Alps, Scandinavia, or the Pyrenees. Such efforts need to be expanded so that methods within populations are harmonised.

Overall, it is important to treat all figures with a certain degree of caution, look for the bigger picture and refer to the overview tables on methods and data quality and go back to the original literature (many of which is listed in Appendix 6). Despite this caution we believe that they do reflect the general size and trend of large carnivore populations in Europe relatively well. We have gone to great lengths to make them as comparable as possible, and to make the underlying variation in methodology as transparent as possible. But the diversity is huge (also see Appendix 3 for a few random examples).

The question asked for compiling the main monitoring methods was rather complex as it was asking for “What is the main monitoring method to obtain population estimates and how much of the species range is approximately monitored with this method (% area)?” Hence selecting a method category, was meant to identify it as the main monitoring method and the % was meant to provide information what % of the population was monitored with this method. However, the question was not always interpreted this was and some categories/terms were not entirely clear. Hence the overview has to be interpreted with some caution and for more details the original literature in Appendix 6 should be consulted.

3.2.1. Brown bear

Brown bear population estimates in Europe are by now widely based on non-invasive genetic monitoring either determining the minimum number of individuals or calculating densities using capture-recapture methods, although observations/detection of females with cubs-of-the-year (coys), and harvest data, are still used in some countries (Table 16).

For details on country specific large carnivore population estimate methods and/or monitoring methods please see references in Appendix 6.

Main methods to estimate brown bear populations in Europe

Table 16: Main monitoring methods for bears in Europe. Min = minimum number, Repro = reproduction, CMR = capture-mark-recapture, Pres = presence, YoY = Young of the Year, Obs = observation; (Scats Repro and Howling surveys not relevant for bears)

Country/Region	Camera traps			Snow tracking				Non-invasive genetics		Scats	Howling surveys		YoY obs	Hunter data		Expert estimate	Other
	Min	Repro	CMR	Min	Repro	Natal dens	Track index	Min	CMR	Repro	Repro	Pres		Obs index	Harvest data		
	Brown bear																
Albania		25-50%						10-25%		10-25%							>75%
Austria								>75%									
Bosnia & Herzegovina	50-75%	10-25%						10-25%							25-50%	<10%	
Bulgaria															0	0	25-75%
Croatia	10-25%	10-25%	<10%	<10%	<10%		<10%	>75%	>75%				50-75%	50-75%	>75%	25-50%	
Czech Republic	>75%	>75%		10-25%			50-75%	<10%									
Estonia		>75%											>75%				
Finland	<10%	10-25%	<10%	<10%	<10%	<10%	<10%	<10%	<10%				>75%	<10%	25-50%		
France								>75%	>75%								
Germany	>75%							>75%									
Greece	>75%	50-75%						>75%	25-50%				25-50%				
Hungary	25-50%	<10%	<10%	10-25%	<10%	<10%	<10%	10-25%	<10%				<10%	<10%		50-75%	10-25%
Italy - Alps								>75%	>75%								
Italy - Apennine								10-25%									
Kosovo*	no population estimates available																
Latvia	>75%	>75%						>75%					>75%				>75%
Lithuania																	
Montenegro																	
North Macedonia								10-25%								50-75%	
Norway								>75%	>75%								
Poland									>75%								
Romania				>75%				<10%					10-25%				
Serbia	50-75%	<10%						<10%					<10%				<10%
Slovakia	>75%	>75%	<10%	>75%	>75%	<10%	<10%	>75%	>75%	<10%			>75%	<10%	<10%	<10%	
Slovenia	<10%	<10%	<10%	<10%	<10%	<10%	<10%		>75%	<10%			<10%	<10%	>75%	<10%	
Spain									>75%				10-25%				
Sweden								>75%	>75%					>75%	>75%		
Switzerland	10-25%			10-25%				10-25%								10-25%	
Ukraine - Carpathians	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.																

Most recent population estimates and changes in population estimates for brown bears in Europe

The bear population in 2023 is estimated at around 20,500 individuals. The increase since 2016 (see https://www.lcie.org/Large-carnivores/Brown-bear) is largely due to an increase in the Baltic, Carpathian, and Karelian populations (Table 17).

However, population estimates in the Dinaric-Pindos, Carpathian, and Eastern Balkan population are still in part based on older estimates, expert opinion, and flawed methods (see Table 18). The population estimate for the Cantabrian mountains is from 2000, but the population is increasing and in 2023 there may potentially be as many as 400 bears. The population estimate for the small and isolated Central Apennine bear population has not been updated since 2014 and the actual trend for this isolated population is therefore unknown.

Table 17: Population trend of brown bears in Europe since the last update in 2016. ***Unknown*** *= it is not known what number or % of animals are counted in more than one country,* ***Excluded*** *= coordinated monitoring excluded double counting.*

Population	Countries	Estimate 2012-2016	Estimate 2017-2023	Trans-boundary double counts*	Trend	Comment
Alpine	Italy, Switzerland, Austria, Slovenia	49-69	100	Few	↑	
Baltic	Estonia, Latvia	700	1,090	Excluded for females with coys*	↑	
Cantabrian	Spain	321-335	324	No border	↑	Change in methods since 2016. The reported estimate is from 2020. The population is clearly increasing and as of 2023, may be around 400 bears.
Carpathian	Romania, Poland, Slovakia, Serbia, Ukraine, Hungary, Czech Republic	7,630	9,000	Considerable in some cases**	↑	Population estimates partly contested, some expert estimates, no robust data from UKR
Central Apennine	Italy	45-69	50	No border	→	**No update since 2014!**
Dinaric-Pindos	Slovenia, Croatia, Bosnia & Herzegovina, Montenegro, North Macedonia, Albania, Serbia, Kosovo*, Greece	3,950	4,112	Excluded only for SVN / HRV; there are also some regional	→	Data partly older, includes, expert opinion for RS

				trans-boundary initiatives		
Eastern Balkan	Bulgaria, Greece, Serbia	468-665	460	Unknown	→	Method flaws for estimates in BGR, includes expert opinion for SRB
Karelian	Norway, Finland	1,660	2,175	Unknown	↑	NOR did not report northern bears separately in 2022
Pyrenean	France, Spain	41***	86	Excluded	↑	Coordinated transboundary monitoring
Scandinavian	Norway, Sweden	2825	3,000	Excluded	→	Coordinated transboundary monitoring
Total (c.)		**17,000 - 18,000**	**20,400**		↑	

**coys = cubs of the year;* **Double counts exist on the Pan-Carpathian level, as there are only now some attempts within the Carpathian Convention and some international projects to synchronise monitoring between countries (e.g., LECA project https://www.interreg-central.eu/projects/leca/); ***Estimate was corrected from faulty previous estimate (which was 30)

Table 18: Population estimates for the brown bear in Europe by country and population. Note: Country level population estimates may include double counting of transboundary individuals. Where population level estimates were available these were used for the sum here and in Table 17. For references see Appendix 6.

Bear population	Year(s)	Estimate (indiv.)	Uncertainty	Details	% of range monitored	Trend	Trend quality	Reference
Alpine		**100**						
Austria	2023	4	transboundary	min. average/year	100	No obvious trend	Real	https://baer-wolf-luchs.at/verbreitungskarten/baer-verbreitung
Germany	2022/23		sporadic (1)	minimum	NA	NA	NA	https://www.lfu.bayern.de/natur/wildtiermanagement_grosse_beutegreifer/baer/monitoring/index.htm
Italy	2023	98	95% CI 86-120	>1 year, DNA profile	100	Increasing	Real	https://grandicarnivori.provincia.tn.it/Large-Carnivores-Report
Switzerland	2017-2023		sporadic (0-2)	minimum	NA	NA	NA	https://www.kora.ch/de/arten/baer/verbreitung
Baltic		**1,090**						
Estonia	2023	960	minimum	females & coys x 10	100	Increasing	Real	https://keskkonnaportaal.ee/sites/default/files/2023-08/SEIREARUANNE_2023-fin.pdf
Latvia	2023	130	expert opinion	minimum	100	Increasing	Real	*In prep.*
Lithuania	2023		sporadic	no estimate	NA	NA	NA	No publications
Poland	2023		sporadic	minimum (0-1)	NA	NA	NA	Diserens et al. 2020
Cantabrian[1]		**324**						
Portugal	2023		sporadic (1)		NA	NA	NA	Media report
Spain - Cantabria East	2017	49	95% CI: 33.8-67.6	genetic CMR	100	Increasing	Real	López-Bao et al. 2020
Spain - Cantabria West	2019	275	95% CI: 222.5-338.3	genetic CMR	100	Increasing	Real	López-Bao et al. 2021
Carpathian		**9,000**						
Czech Republic	2023	2	sporadic (1-3)	minimum	95	NA	NA	No publication for 2023
Hungary	2023	12	10-15	expert opinion	70	Increasing	Real	No publication for 2023
Poland -Tatra	2017	55	95% CI: 45-79	first genetic CMR	100	Unknown	no previous baseline	Konopiński et al. 2018
Poland - Podkarpackie	2014-2015	72	95% CI: 45.2–115.5	first genetic CMR	100	Unknown	no previous baseline	Berezowska-Cnota et al. 2023
Romania	2018	6,825	6,450-7,200 [2]	range	70	No obvious trend	Real	Romania's Habitats Directive Report Art. 17, 2019; National Action Plan, 2018
Serbia	2023	12	10-14	expert estimate	60	Increasing	Real	No publications
Slovakia	2023	2,000	1,900-2,100 [3]	extrapolated	100	Increasing	Real	Rigg, R. unpubl. data 2024
Ukraine - Carpathian	2019	???	Uncorrected counts: 375	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.				Cherepanyn et al. 2023
Central Apennine		**50**						
Italy	2014	50	range: 45-69	genetic CMR	22	No obvious change	Unknown	Ciucci et al. 2015
Dinaric-Pindos		**4,112**						
Albania	2021	200	range: 190-210		50	No obvious change	Real	Skrbinsek et al. 2022
Bosnia and Herzegovina	2017-2023	950	SD: 900-1,000		75	Increasing	Real	Zubić et al. 2023
Croatia	2018 [4]	937	95%CI: 846-1072	genetic CMR incl. coys	100	No obvious change	Real	Huber et al. 2019, Skrbinšek et al. 2017
Greece	2017; 2021; 2022; 2023 [5]	600	range: 550-650	genetics	90	Increasing	Real	Pylidis et al. 2021, Tsalazidou-Founta et al. 2022
Kosovo*				No population estimate available				
Montenegro				No population estimate available				
North Macedonia	2020	325	range: 300-350	Relative Abundance Index	60	Increasing	Unknown[6]	Gonev 2022 unpubl. MES Report
Serbia	2023	110	range: 100-120	expert estimate	75	Increasing	Real	No publications
Slovenia	2024	990	range: 810-1,000	genetic & mortality	99	Increasing	Real	Jerina 2024, Jerina & Ordiz 2021
East Balkan		**459**						
Bulgaria	2021	353	unknown, minimum	official data	48	Decreasing	Unknown	Serbezov & Spassov 2023, Ministry of Environment and Waters. 2023
Greece	2020; 2021; 2022	100	range	genetics	85	Increasing	Real	Pylidis et al. 2021, Tsalazidou-Founta et al. 2022
Serbia	2023	6	4-8	expert estimate	50	Increasing	Real	No publications
Karelian		**2,175**						
Finland	2023	2,175	2,100–2,250	females & coys x 10	100	Fluctating	Real	Heikkinen et al. 2023
Pyrenean		**86**						
France, Spain & Andorra	2023	86	95% CI: 82-92	genetic & PCRD	100	Increasing		Vanpé et al. 2022, Sentilles et al. 2023
Scandinavian		**3,002**						
Norway[7]	2023	178	identified	genetic	100	Increasing	Real	Brøseth et al. 2024
Sweden	2022	2,824	2,587-3,080 (post-harvest)	genetic	100	Fluctating	Real	Åsbrink et al. 2023
Total		**20,398**						

[1]In 2020, the regional government of Castilla y Leon and the three other Cantabrian regional administrations conducted another genetic survey. The results were: 370 bears in total (250 in the western and 120 in the eastern subpopulations). However, these results are inconsistent with the surveys of females with cubs of the year conducted during the past 30 years and with the previous genetic surveys. In addition, no publications or technical reports are available, only a press release from the regional government of Castilla y León: https://comunicacion.jcyl.es/web/jcyl/Comunicacion/es/Plantilla100Detalle/1281372051501/NotaPrensa/1285242547188/Comunicacion

[2]Offical numbers reported to the EU in 2019. There is a lot of discussion around the population size and its trend. A national survey based on genetic sampling is ongoing. The objective is to get a robust minimum number of bears; the first results should be available in 2025.

[3]A national population estimate was calculated by extrapolating from a 2013/14 genetic CMR estimate using the long-term population growth rate of 4.5% that was calculated in Rigg & Adamec (2007). There has been a more recent genetic CMR estimate, announced in 2023, but its reliability has been widely questioned so we did not use it.

[4]Samples collected in 2015

[5]Data on species population and conservation status are being updated in the frame of the current 6-year reporting cycle to the EC in compliance with article 17 of the Habitats Directive 92/43. Results will be available by beginning of 2026.

[6]Trend based on Relative Abundance Index in a reference area (Mavrovo National Park) only.

[7]Norway reported only at the national level; the northernmost bears in Finnmark county (likely ~35) should have been added to the Karelian population.

3.2.2. Eurasian lynx

Main methods to estimate Eurasian lynx populations in Europe

The main method to obtain population estimates of lynx in Europe is camera trapping, especially to detect reproduction. Detection of reproduction is also widely done via snow tracking in the Nordic countries. However, expert opinion still plays a significant role in Bulgaria (where there are only single dispersers), Latvia, Lithuania, Romania, and Poland (Table 19).

Table 19: Main monitoring methods for Eurasian lynx in Europe. Min = minimum number, Repro = reproduction, CMR = capture-mark-recapture, Pres = presence, YoY = Young of the Year, Obs = observation, Scats Repro = heaped occurrence of scats, suggesting a den site (this category was poorly explained).

Country/Region	Camera traps			Snow tracking				Non-invasive genetics		Scats	Vocalisation surveys		YoY obs	Hunter data		Expert estimate	Other
	Min	Repro	CMR	Min	Repro	Natal dens	Track index	Min	CMR	Repro	Repro	Pres		Obs index	Harvest data		
	Eurasian lynx																
Albania	>75%		>75%					25-50%									
Austria - Alps	25-50%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	10-25%	<10%	<10%	
Austria - BBA	>75%	>75%															
Belgium	25-50%							>75%									
Bosnia & Herzegovina	50-75%	25-50%	10-25%	25-50%				<10%								<10%	
Bulgaria	<10%															>75%	
Croatia	>75%	>75%	>75%	10-25%	10-25%	10-25%	10-25%	25-50%	25-50%				50-75%	10-25%	<10%		
Czech Republic	>75%	>75%	25-50%	25-50%	10-25%		10-25%	25-50%									
Estonia		25-50%			>75%	>75%							>75%				
Finland													>75%				
France	>75%	>75%						0					>75%				
Germany	>75%	>75%						10-25%									
Hungary	50-75%	<10%	<10%	10-25%	<10%	<10%	<10%	10-25%	<10%	10-25%	<10%	<10%	<10%	<10%		50-75%	10-25%
Italy	>75%	>75%	<10%	10-25%	10-25%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	>75%	<10%	<10%	25-50%	
Kosovo*	no population estimates available																
Latvia	<10%	<10%						<10%							>75%	>75%	
Lithuania																>75%	
Montenegro																	
North Macedonia	25-50%	<10%	25-50%													25-50%	
Poland	<10%	<10%		10-25%	10-25%		<10%	<10%					10-25%			>75%	
Romania	<10%	<10%	<10%	>75%			>75%	<10%					0	>75%		>75%	
Serbia	50-75%			<10%												<10%	
Slovakia	>75%	>75%	10-25%	>75%	>75%	<10%	<10%	<10%	<10%	<10%	<10%	<10%	>75%	<10%	<10%	<10%	
Slovenia*	>75%	>75%	>75%														
Sweden & Norway		25-50%			>75%												
Switzerland	>75%		50-75%														>75%
Ukraine - Carpathians	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.																

Most recent population estimates for the Eurasian lynx in Europe

The Eurasian lynx population in 2023 is estimated at around 9,000 individuals and thus is in the same magnitude than in 2016 (see https://www.lcie.org/Large-carnivores/Brown-bear; Table 19).

Most of the large populations are stable (Baltic, Karelian, Scandinavian populations) or are increasing slowly (Carpathian population). However, population monitoring does not allow for robust population estimates or trend analyses in most of the range countries and monitoring methods and population estimation methods have changed (Table 21). The Dinaric population seems to have started increasing after 2019, reflecting the success of the extensive population reinforcement in recent years (Fležar et al. 2024). The Bohemian-Bavarian-Austrian seems to also slowly increase and expand. The Harz population is clearly increasing, which is in line with the documented range gains (see section 2.5). The Vosges-Palatinian population remains very small, despite additional re-introduction attempts (Port et al. 2024). The remnant population of the Critically Endangered Balkan lynx remains small and isolated and in urgent need of conservation actions (Melovski et al. 2021); Table 20).

Lynx population monitoring is coordinated for most populations, e.g. the Alpine population is coordinated under the Status and Conservation of the Alpine Lynx (SCALP) project and started to include distribution maps for adjacent populations. However, the unit counted – all individuals versus independents individuals (excluding dependent kittens), versus family groups – differs among countries (Table 21) and double counts in transboundary populations are not always excluded. Although family group counts were converted to individuals for the population estimates, it was not necessarily specified if "individuals" included kittens (all individuals) or only referred to independent individuals (Table 21). The Scandinavian population is monitored jointly by Norway and Sweden but lacks coordination with the adjacent Karelian population in Finland. The Baltic and Carpathian populations lack coordinated monitoring.

Table 20: Population trend of Eurasian lynx in Europe since the last update in 2016.

Population	**Countries**	**Estimate 2012-2016**	**Estimate 2017-2023**	**Trans-boundary double counts***	**Trend**	**Comment**
Alpine	Switzerland, Slovenia, Italy, Austria, France	163	255	Excluded (SCALP)	↑	Data from FRA missing; Reintroduction to the Julian Alps took place in 2021-2023
Balkan	Albania, Kosovo*, Montenegro, North Macedonia, Serbia	20 - 40	34	Likely 2-4 shared between ALB, XKX*, MKD	→	
Baltic	Estonia, Latvia, Lithuania, Poland	1,200 - 1,500	1,141	Unknown	??	Pomeranian occurrence now listed separately
Bohemian-Bavarian-Austrian	Czech Republic, Germany, Austria	60-80	135	Excluded	↑	
Carpathian	Romania, Slovakia, Poland, Ukraine, Czech Republic, Hungary,	2,100-2,400	2,687	Unknown	↑	Robust data from UKR missing (in 2016: 330 lynx were assumed)

	Serbia, Bulgaria					
Dinaric	Slovenia, Croatia, Bosnia & Herzegovina	130	193	Excluded	↑	Population reinforcement took place in 2019-2023
Harz	Germany	46	113	No border	↑	
Jura	[France], Switzerland	140	>69	Excluded (SCALP) - data from FRA missing	??	likely increasing
Karelian	Finland	2,500	2,483	Only 1 country	→	Double counts between populations possible
Scandinavian	Norway, Sweden	1,300 - 1,800	1,820	Excluded	↑	
Vosges-Palatinian	France, Germany	1 - 3	>12	Excluded (SCALP) - data from FRA missing	↑/→	Data for FRA missing. Reintroduction to the German part took place 2016 - 2020.
Pomeranian occurrence	Poland	NA	31	No border	NA	Formally included in the Baltic population
Black Forest-Swabian Jura occurrence	Germany	NA	5	Excluded within SCALP	NA	No reproduction, yet. Population reinforcement started in 2023.
Total (c.)		**8,000 - 9,000**	**9,000**		↑/→	Data from FRA missing

Unknown = it is not known what number or % of animals are counted in more than one country, **Excluded** = coordinated monitoring excluded double counting*

Table 21: Population estimates for the Eurasian lynx in Europe by country and population. Note: Country level population estimates may include double counting of transboundary individuals. Where population level estimates were available these were used for the sum here and in Table 20. For references see Appendix 6.

Lynx population	Year(s)	Estimate (indiv.)	Uncertainty	Details	% of range monitored	Trend	Trend quality	Reference
Alpine		**255**						
Austria	2023	20	17-23 minimum	independend individuals	80	Fluctuating	Real	unpubl. data
France	2023	???	no population estimates are done in France		100	NA	NA	unpubl. data
Germany	2022/23		sporadic (1-2)			NA	NA	unpubl. data
Italy	2023	7	range: 5-10			Increasing	Real	unpubl. data
Slovenia	2022/23	6		minimum count	90-100	Increasing	Real	Fležar et al. 2023 & 2024
Switzerland	2021	222	222 (+/- 9)	independent individuals	100	Increasing	Real	https://www.kora.ch/en/species/lynx/abundance
Balkan		**34**						
Albania	2023	7	range: 5-10	individuals	100	Decreasing	Real	Bego et al. 2022, Hoxha et al. 2023
Kosovo*	2023		few - no population estimates available			NA	NA	
Montenegro	2023		sporadic - no population estimates available			NA	NA	
North Macedonia	2023	25	20-30	independend individuals	50	No obvious change	Real	Melovski et al. 2013, Stojanov et al. 2020
Serbia	2023	2	sporadic, range: 1-3	expert estimate	20	NA	NA	unpubl. data
Baltic		**1,141**						
Estonia	2023	86	minimum number	females with kittens	100	Increasing	Real	Veeroja et al. 2023
Latvia	2021	700	range: 600-800 +/- 200	individuals	100	No obvious change	Real	Bagrade et al. 2016
Lithuania	2023	250	100-400	guestimate; no estmates available	100	Increasing	Unknown	Trend unknown due to lack of scientific data
Poland	2023	105	range: 58-151	density extrapolation to range	100	Fluctuating	Real	S. Nowak, R.W. Mysłajek, unpubl. data
Bohemian-Bavarian-Austrian		**135**						
Austria	2017/18-2022/23	22	mean 2017-2022	independant individuals	75-80	Fluctating	Real	Belotti et al. 2023
Czech Republic	2022/2023	81	minimum number	independant individuals	80	Increasing	Changed monito	unpubl. data
Germany	2022/23	50	minimum number	independent individuals	100	Increasing	Real	preliminary estimate - not yet published
Carpathian		**2,687**						
Bulgaria	2017-2023		sporadic	data not sufficient for estimates	1	NA	NA	Spassov et al. 2023
Czech Republic	2022/2023	11			95	No obvious change	Real	unpubl. data
Hungary	2022	12	range: 10-25	expert estimate	80	No obvious change	Monitoring chan	Annual reports by National Parks
Poland	2023	130	range: 72-188	density extrapolation to range	100	Increasing	Real	https://www.gov.pl/web/gios/poiis---monitoring-wilka-i-rysia
Romania	2018	2,250	2,100-2,400	minimum count	100	No obvious change	Unknown	Current monitoring not suitable to detect trend
Serbia	2023	50	range: 40-60	expert estimate	20	No obvious change	Real	unpubl. data
Slovakia	2022	234	min/man error: 155-325	density (1.11/100 km^2) extrapolation to range	100	No obvious change	Real	Rigg unpubl. Data, Appendix 3
Ukraine - Carpathians	2019	???	Uncorrected counts: 435	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.				Cherepanyn et al. 2023
Dinaric		**193**						
Bosnia and Herzegovina	2017-2023	50	range: 40-60	individuals; incl. Expert estimate	85	Fluctuating	Monitoring chan	Fležar et al. 2021, Trbojević et al. 2020
Croatia	2023	101	SD: 72-141		100	Increasing	Real	Gomerčić et al. 2023
Montenegro	2023		sporadic			NA	NA	
Slovenia	2022/23	42	95%CI: 30-60	SCR camera traps	90-100	Increasing	Real	Fležar et al. 2023 & 2024
Harz		**113**						
Germany	2022/23	113	minimum number	75 independent individuals, including 20 reproductions	100	Increasing	Real	preliminary estimate - not yet published
Jura		**69**						
Switzerland	2019	69	69 (+/- 5)	individuals	100	Stable	Real	https://www.kora.ch/en/species/lynx/abundance
France	2023		no population estimates are done in France		100	NA	NA	
Karelian		**2,483**						
Finland	2023	2,483	2,390-2,575	modelling based sighting of lynx and females with kittens	100	increasing	Real	Valtonen et al. 2023

Table 24 continues the next page

Table 24 continuation

Lynx population	Year(s)	Estimate (indiv.)	Uncertainty	Details	% of range monitored	Trend	Trend quality	Reference
Scandinavian		**1,820**						
Norway	2023	420	95% CI: 350 - 500	family groups on snow	100	No obvious change	Real	Frank & Tovmo. 2023
Sweden	2023	1,400	95% CI: 1,200 - 1,600	family groups on snow	100	No obvious change	Real	
Vosges-Palatinian		**12**						
France	2023	???	no population estimates are done in France		100	Increasing	Real	likely due to dispersal from Germany
Germany	2022/23	12	minimum number	individuals	100	Decrease	Real	no reproduction in 2022/23; Port et al. 2024
Pomeranian occurrence		**31**						
Poland	2021	31	61 released 2014-2020; no population estimate					Tracz et al. 2021, Skorupski et al. 2022
Black Forest-Swabian Jura occurence		**5**						
Germany	2023	5	minimum number	individuals	90-100	NA	NA	no reproduction in 2022/23; preliminary estimate - not yet published
Total		**8,978**						

3.2.3. Wolf

Main methods to estimate wolf populations in Europe

Monitoring methods for the wolf are most variable among countries and cover the entire spectrum of the most used methods. In addition, there is variation in 1) the units that are monitored (some countries only count packs and pairs, whereas others count individual wolves), 2) the conversion factors from packs to individuals, 3) the time period of the population estimates (e.g., prior to or at peak reproduction, pre- or post-hunting/culling; cumulative sampling over the entire year versus only during a specific time window etc.), and 4) estimation methods (e.g., density estimates versus minimum counts). Although the same is true for bear and lynx, the differences in the resulting population estimates are more extreme for wolves due to their higher reproductive potential (larger litter sizes and annual reproduction). Regionally, expert opinion remains important (e.g., Bulgaria, Latvia and North Macedonia (Table 22).

Table 22: Main monitoring methods for wolves in Europe. Min = minimum number, Repro = reproduction, CMR = capture-mark-recapture, Pres = presence, YoY = Young of the Year, Obs = observation, Scats Repro = heaped occurrence of scats, suggesting a Rendezvous site of wolves with pups (this category was poorly explained).

Country/Region	Camera traps			Snow tracking				Non-invasive genetics		Scats	Howling surveys		YoY obs	Hunter data		Expert estimate	Other
	Min	Repro	CMR	Min	Repro	Natal dens	Track index	Min	CMR	Repro	Repro	Pres		Obs index	Harvest data		
	Wolf																
Albania		10-25%									<10%	<10%					
Austria		<10%						>75%					<10%				
Belgium	25-50%							>75%					>75%				
Bosnia & Herzegovina	50-75%			10-25%								25-50%			10-25%	<10%	
Bulgaria				25-50%											0	50-75%	
Croatia	25-50%	25-50%	<10%	10-25%	10-25%	<10%	10-25%	50-75%	50-75%	<10%	10-25%	10-25%	10-25%	10-25%	<10%	<10%	<10%
Czech Republic	50-75%	50-75%		10-25%			25-50%	10-25%		<10%	<10%	<10%					
Denmark	25-50%	25-50%	<10%	<10%	<10%	<10%	<10%	25-50%	<10%	10-25%	<10%	<10%	25-50%	<10%	<10%	<10%	<10%
Estonia		50-75%		0	>75%		>75%				<10%		>75%				
Finland		<10%			<10%			>75%					>75%				
France								0	>75%								
Germany	>75%	>75%						>75%									
Greece	10-25%	10-25%						0	0	10-25%	10-25%						10-25% & >75%
Hungary	50-75%	25-50%	<10%	25-50%	<10%	<10%	10-25%	10-25%	<10%	10-25%	<10%	10-25%	25-50%	<10%		25-50%	<10%
Italy - Alps	>75%	>75%		>75%				>75%	>75%	>75%	>75%	0	>75%				
Italy - Peninsula									25-50%								
Kosovo*	no population estimates available																
Latvia															>75%	>75%	
Lithuania	10-25%			<10%											>75%		
Luxembourg	50-75%							50-75%									
Montenegro																	
North Macedonia																>75%	
Norway				>75%	>75%				50-75%								
Poland	10-25%	10-25%		<10%	<10%		<10%	10-25%	<10%	10-25%	<10%	<10%					>75%
Portugal	>75%	>75%						25-50%		>75%	>75%	>75%	>75%				
Romania	0& & 10-25%			>75%	<10%		>75%	<10%					0	>75%			
Serbia	10-25%	<10%								<10%			<10%		50-75%		
Slovakia	>75%	>75%	<10%	>75%	>75%	<10%	<10%	10-25%	10-25%	<10%	<10%	<10%	>75%	<10%	<10%	<10%	
Slovakia	>75%	>75%	<10%	>75%	>75%	<10%	<10%	10-25%	10-25%	<10%	<10%	<10%	>75%	<10%	<10%	<10%	
Slovenia									>75%								
Spain		50-75%						<10%		50-75%	>75%		>75%				
Sweden				50-75%	>75%				>75%								
Switzerland								>75%									
The Netherlands	>75%	>75%						>75%	>75%								
Türkey - Europe	<10%																
Ukraine - Carpathians	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.																

Most recent population estimates for the wolf in Europe

The wolf population in 2023 is estimated at around 23,000 individuals, which is a 35% increase in population size since 2016 (see https://www.lcie.org/Largecarnivores/Wolf.aspx; Table 19). The trend is especially driven by the rapidly expanding Central European and Alpine populations. The estimate for the Carpathian population does not include Ukraine, and some of the estimates include expert estimates. The Dinaric Balkan population seems to be increasing, but in some areas, it is a struggle to get robust population estimates. The Alpine and Scandinavian populations are monitored at the transboundary level, and there is also increasing cooperation in the Dinaric-Balkan (e.g., via the Dinaric-Balkan-Pindos Large Carnivore Initiative) and the Central European (e.g., via the CEwolf consortium) populations. More specifically, monitoring of packs and pairs in the wider Alpine region is coordinated under the Wolf Alpine Group (WAG; Marucco et al. 2023) whereas the Scandinavian population is jointly monitored by Norway and Sweden. The CEwolf consortium, on the other hand, is working on a harmonised genetic monitoring of the Central European population to make genetic results comparable between different countries (Nowak et al. 2023). For several countries (e.g., Spain, Greece), only preliminary population estimates were available, as surveys and data analysis are still ongoing and for others there are currently no robust population estimates available (e.g., Ukraine, Turkey, Albania).

Table 23: Population trend of wolves in Europe since the last update in 2016.

Population	Countries	Estimate 2012-2016	Estimate 2017-2023	Trans-boundary double counts*	Trend	Comment
Alps and neighbouring areas	Italy, France, Switzerland, Germany, Austria, Slovenia	420 - 550	c. 2,000	Presence of double counts among countries in the estimate	↑	243 packs in the Alps were estimated in 2020-2021, with a coordinated effort among countries, avoiding double counts (Marucco et al. 2023)
Baltic	Estonia, Latvia, Lithuania, Poland	1,700 - 2,240	c. 3,000	Excluded between EE/LV; Unknown for rest	↑	
Carpathian	Slovakia, Czech Republic, Poland, Romania, Ukraine Hungary, Serbia	3,460 - 3,849	c. 4,000	Unknown, some local coordination and harmonisation efforts ongoing	→ / ↑	No robust data from UKR, includes expert estimates
Central European	Austria, Belgium, Czech Republic Germany, Denmark, Luxembourg, Netherlands, Poland	780-1,030	c. 3,000	Some local coordination and harmonisation efforts ongoing, but double counts e.g. between CZ and DE occur	↑	Estimates for POL are not based on packs & pairs, but rather density estimates
Dinaric-Balkan	Slovenia**, Croatia, Bosnia & Herzegovina, Montenegro, North Macedonia, Albania, Serbia, Kosovo*, Greece, Bulgaria	c. 4000	c. 4,700	Excluded between SVN / HRV; unknown for the rest of the range	↑	GRC only preliminary results; for ALB, XKX*, MKD no estimates available

Iberian	Spain, Portugal	No recent update, but 2007 estimate was 2,500	c. 2,400	Excluded at sub-nations scale (between regions). Likely of minor importance along with Portugal given the large number of packs.	→	For Spain, information on pack numbers will be updated by the end of 2024
Italian peninsula	Italy	1,100 - 2,400	2,557	Excluded Harmonized monitoring (WAG)	↑	Change in methods, first coordinated range wide census
Karelian	Finland	c. 200	310	52 wolves (7 packs) transboundary with Russia	↑	
Scandinavian	Norway, Sweden	c. 430	520	Excluded	↑	
Total (c.)		**17,000**	**23,000**		↑	

Unknown* = it is not known what number or % of animals are counted in more than one country, ***Excluded* = coordinated monitoring excluded double counting; **The estimated number of wolves in transboundary packs is divided by 2 to avoid double counting.*

Table 24: Population estimates for the wolf in Europe by country and population. Note: Country level population estimates may include double counting of transboundary individuals. Where population level estimates were available these were used for the sum here other and in Table 23, several estimates were rounded to reflect uncertainty. For references see Appendix 6.

Wolf population	Year(s)	Estimate	Uncertainty	Details	% of range monitored	Trend	Trend quality	Reference
Alpine and neighboring areas		**c. 2,000**						
Austria	2023	58	minimum, includes 1 pack	mainly dispersers; cummulative per year; includes 12 culled individuals	100	Increasing	Real	Rauer & Selimovic 2024 https://baer-wolf-luchs.at/wp-content/uploads/2024/08/OeZ-Statusbericht-Wolf-2023-1.pdf; https://www.kora.ch/en/news/longest-known-dispersal-of-wolf-in-europe--551
France	2023	1,104	95%CI: 1,000-1,210	almost entire French wolf population	100	Increasing	Real	https://www.consultations-publiques.developpement-durable.gouv.fr/projet-de-plan-national-d-actions-2024-2029-sur-le-a2940.html?lang=fr
Germany	2022/23		only sporadic occurence		NA	NA	NA	DBBW 2024a,b
Italy - Alpine Regions (entire northern Italian wolf population)	2020-2021	952	135 packs	95%CrI: 816–1,120 (112-165 for packs)	100	Increasing	Real	Marucco et al. 2023
Switzerland	2023/24	312	without those killed in 2023/24	genetics	100	Increasing	Real	https://www.kora.ch/en/species/wolf/abundance
Baltic		**c. 3,000**						
Estonia	2023	330	33 packs	minimum number	100	Increasing	Real	Veeroja et al. 2023
Latvia	2023	650	CI for trend: 500-800		100	Increasing	Real	Šuba et al. 2021, Žunna et al. 2023
Lithuania	2023	736	92 packs, Minimum number		100	Increasing	Unknown: maybe more data & real	Špinkytė-Bačkaitienė 2023
Poland	2023	1,369	range: 1,111-1,667		100	Increasing	Real	https://www.gov.pl/web/gios/poiis---monitoring-wilka-i-rysia
Carpathian		**c. 4,000**						
Czech Republic	2022/23	28	6 packs	territories	95	Increasing	Real	no publications
Hungary	2022	50	40-60	expert estimate	100	Fluctating	Real	Monitoring reports from National Parks
Poland	2023	493	range: 406-580		100	Increasing	Real	https://www.gov.pl/web/gios/poiis---monitoring-wilka-i-rysia
Romania	2018	2,750	range: 2,500 - 3,000	minimum number	70	No obvious change	Real	Romania 2020 - Habitat Directive Report
Serbia	2023	10	range: 8-12	expert estimate	60	Fluctating	Real	
Slovakia	2023	700	Range: 668 - 722; Extrapolation from		100	Increasing	Real	R. Rigg unpubl. data; Appendix 3
Ukraine - Carpathians	2019	???	Uncorrected counts: 563	Population estimates are currently based on counts from protected areas, hunting grounds, and forest units, which are not corrected for double counts.				Cherepanyn et al. 2023
Central European		**c. 3,000**						
Austria	2023	31	minimum, includes 5 packs	mainly disperses; 2 transboundary packs with CZ; high turn-over in	100	Increasing	Real	Selimovic & Rauer 2023; https://baer-wolf-luchs.at/verbreitungskarten/wolf-verbreitung
Belgium	2023	20	4 packs		100	Increasing	Real	http://biodiversite.wallonie.be/fr/les-loups-wallonie.html?IDC=6456; Flanders: https://www.vlaanderen.be/inbo/media/2368/wolfmonitoring-22-23.pdf
Czech Republic	2022/23	172	34 packs	minimum number, incuds transboundary packs	70	Increasing	Real	No publication for 2023
Denmark	2024	40	range: 32-42	genetics	100	Increasing	Real	https://www.ulveatlas.dk/nyheder/marts-2024-maanedlig-status-fra-ulveovervaagningen/
Germany	2022/23	1,339	184 packs & 47 pairs	minimum number of all confirmed individuals within territories (439-565 adults individuals)	100	Increasing	Real	DBBW 2024
Luxembourg	2023		sporadic 0-1	minimum number, bycatch of		NA	NA	Schley et al. 2021
Netherlands	2023	50	45-55 (9 packs, 1 lone wolf, few dispersers)		95	Increasing	Real	https://publicaties.bij12.nl/voortgangsrapportage-wolf-13-mei-2024/overzicht-verspreiding-wolf Jasman et al. 2021
Poland	2023	1,686	range: 1,349-2,023		100	Increasing	Real	https://www.gov.pl/web/gios/poiis---monitoring-wilka-i-rysia

Table 24 continues the next page

Table 24 continuation

Wolf population	Year(s)	Estimate	Uncertainty	Details	% of range monitored	Trend	Trend quality	Reference
Dinaric-Balkan		**c. 4,700**						
Albania	2023	???	no robust population estimate available;					
Bosnia and Herzegovina	2017-2023	350	SD: 300-400		95	Decreasing	Real	Boitani et a. 2022
Bulgaria	2019	1,000	Range: 800-1,200	lack of regular monitoring	Unknown	Unknown	NA	Bulgaria 2019 - Habitat Directive Report
Croatia	2018-2019	163	minimum number	genetics	100	No obvious change	Real	Kusak et al. 2019, Kusak et al. 2023
Greece	2023	2,075	2,075 individuals, 255 packs; minimum		16	Increasing	Change in monit	Iliopoulos et al. 2021a,b,c, & 2022
Kosovo*	2023	???	no population estimates available			NA	NA	
Montenegro	2023	???	no population estimates available			NA	NA	
North Macedonia	2024	315	range: 270-360	based on Relative Abundance Index in Marovo NP	25	Unknown		Gonev 2022 - MES report
Serbia	2023	700	range: 800-900	expert estimate	60	No obvious change	Real	
Slovenia	2022/23	117	95%CI: 107-125	corrected for transboundary packs	100	No obvious change	Real	Bartol et al. 2023
Turkey	2023	???	no recent, robust population estimates		<10	NA	NA	Ambarli et al. 2016
Iberian		**>2,400**						
Portugal	2019-2021	295	190 to 400 wolves (based on 60 identified		variable	Decreasing		Pimenta et al. 2023, Nakamura et al. 2021
Spain	2012-2014	2,100	297 packs in 2014; more than 300 packs in 2023		100	Stable / Slight increase	Real	Ministry for Ecological Transition 2022; Ministerio de Agricultura Alimenacion y Medio Ambiente 2014; Update of wolf packs ongoing
Italian Peninsula		**2,557**						
Italy	2021	2,557	95%CI: 2,127-2,844	first representative sampling	35	Increasing	Real	Gervasi et al. 2024
Karelian		**310**						
Finland	2023	310	probability interval: 291-331 individuals or 42 (40-46) packs		100	Increasing	Real	Heikkinen et al. 2023
Scandinavian		**517**						
Norway	2023	67	range: 66-68	genetics, number of reproductions	100	No obvious change	Real	Svensson et al. 2023
Sweden	2023	450	95%CI: 360 - 580		100	Increasing	Real	
Total (c.)		**23,000**						

3.2.4. Wolverine

Main methods to estimate wolverine populations in Europe

The main methods to obtain population estimates for wolverine are heavily dependent on snow-tracking and non-invasive genetic analysis, with camera traps providing additional information in Sweden & Norway, and observations of young of the year in Finland (Table 25).

Table 25: Main monitoring methods for wolverine in Europe. Min = minimum number, Repro = reproduction, CMR = capture-mark-recapture, Pres = presence, YoY = Young of the Year, Obs = observation

Country/Region	Camera traps			Snow tracking				Non-invasive genetics		Scats	Howling surveys		YoY obs	Hunter data		Expert estimate	Other
	Min	Repro	CMR	Min	Repro	Natal dens	Track index	Min	CMR	Repro	Repro	Pres		Obs index	Harvest data		
	Wolverine																
Finland							>75%						<10%				
Norway		25-50%				>75%			50-75%								
Sweden		25-50%				>75%			50-75%								

Most recent population estimates for the wolverine in Europe

The wolverine population in Europe has stayed stable, with a slight increase in the Karelian population, but no obvious trend in the Scandinavian population (Table 26 & 27).

Table 26: Population trend of wolverines in Europe since the last update in 2016.

Population	Countries	Estimate 2012-2016	Estimate 2017-2023	Trend	Comment
Karelian	Finland	200 - 250	400	↑	increasing
Scandinavian	Finland, Norway, Sweden	800 - 1,000	900	→	stable
Total (c.)		**1,000 - 1,250**	**1,300**	↑	

Table 27: Population estimates for the wolverine in Europe by country and population.

Population	Year(s)	Estimate	Uncertainty	Details	% range	Trend	Trend quality	Reference
Karelian		**400**						
Finland	2023	400	390-504 Bayesian probability interval for national estimate	track density on winter transects	100	increasing	Real	Kojola et al. 2023
Scandinavian		**900**						
Finland	2023	50	part of national level estimate	track density on winter transects	50	No obvious change	Real	Kojola et al. 2023
Norway	2023	350	reproductions / natal dens (64)	winter checking of female reproductive areas	100	No obvious change	Real	Höglund et al. 2023
Sweden	2023	500	reproductions (91)		100	No obvious change	Real	
Total		**1,300**						

3.2.5. Golden jackal

Main methods to estimate golden jackal populations in Europe

The monitoring of golden jackals is largely based on passive, unstructured monitoring (e.g., hunting bags or incidental camera trapping) and fragmented, irregular active surveys (e.g., howling surveys or non-invasive genetic analysis of scat samples and saliva from livestock attacks) which prevents a rigorous estimation of population sizes. Combining hunting bags with expert-based assessments, the continental population may now number more than 150,000 individuals, with densities in the core range in the order of one territorial group per 10 km^2 and locally reaching up to five territorial groups per 10 km^2 (Salek et al. 2014).

Most recent population estimates for the golden jackal in Europe

Given the aforementioned limitations and the fact that, once established and breeding, golden jackals are hard to reduce or eradicate, it is more the expansion of the population ranges that is currently monitored rather than population numbers or densities. However, population status can be ranked based on the level of the species establishment.

In the 29 range countries in Europe, the jackal is widespread and breeding in 11 and thought to be widespread and breeding in another 3, localised with local breeding in 3, has few individuals in 5, and has the first individuals recorded in 4 countries (Table 27).

Table 27: Ranking assessment of golden jackal status by country and status.

Country	Population status
Albania	Widespread and breeding
Bosnia & Herzegovina	Widespread and breeding
Bulgaria	Widespread and breeding
Croatia	Widespread and breeding
Greece	Widespread and breeding
Hungary	Widespread and breeding
North Macedonia	Widespread and breeding
Romania	Widespread and breeding
Serbia	Widespread and breeding
Slovakia	Widespread and breeding
Slovenia	Widespread and breeding
Kosovo*	Thought to be widespread and breeding
Montenegro	Thought to be widespread and breeding
Turkey	Thought to be widespread and breeding
Austria	Localised, locally breeding
Estonia	Localised, locally breeding
Italy	Localised, locally breeding
Czech Republic	Few individuals, breeding reported
Germany	Few individuals, breeding reported
Latvia	Few individuals, breeding reported
Poland	Few individuals, breeding reported
Denmark	Few individuals
France	Few individuals
Ukraine - Carpathians	Few individuals (in the plain part of the Zakarpattia region)
Lithuania	Few individuals
Switzerland	Few individuals
Finland	First individuals
Norway	First individuals
Spain	First individuals
The Netherlands	First individuals

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Appendix 3 – Selected examples on details concerning mapping and population estimates

These examples are just meant to illustrate the complexity of the mapping and monitoring methods, which can never be summarised in a simple overview.

Mapping

Example 1: Italy – Peninsula – wolves (Francesca Marucco)

Cut-off value for modelled probability presence

The distribution map for the Italian peninsular is based on an integrated spatial model, based on the data collected during a 7-month sampling campaign in 2020–2021 and the method is described in detail in Aragno et al. 2023 and Gervasi et al. 2024. The distribution map is based on occupancy probabilities, but for this report had to be converted into a presence / absence map.

To do so, the authors considered that the psi (average occupancy estimate per cell) estimated by the occupancy model described in Gervasi et al. 2024 has a range that goes from 0.99 – 0.04, related to an averaged CV per cell. We plotted those values and identified a point where the slope of the curve changes dramatically, with the accuracy decreasing very quickly as psi decreases. That point, which graphically is at psi = 0.2 and CV = 0.85, separates these two groups of cells. Therefore, we applied this cutoff, thereby excluding all cells with psi < 0.2 and CV > 0.85, as cells that do not indicate a sufficient probability of wolf presence.

Example 2: Switzerland – wolf distribution (Ines Morena)

Small corrections sporadic versus permanent

Permanent: presence confirmed in ≥3 years in the last 5 to 7 years or reproduction confirmed at least once within the last 3 years.

Sporadic: (highly fluctuating presence) presence confirmed in <3 years in the last 5 to 7 years.

In some specific areas where there were isolated cells classified as "permanent," we checked whether the evidence of presence concerned isolated wolves or established isolated wolves (living in an area for ≥6 months). We changed those isolated cells to "sporadic" where there was never an established isolated wolf.

Example 3: Slovenia – lynx mapping (Miha Krofel)

Multiple methods

Main method is systematic camera trapping conducted throughout entire area with reproduction and about 90% of the species range in the country. Details on camera trapping (grid size etc. available in Fležar et al. 2023a, 2024). In addition, we are conducting snow tracking and non-invasive genetic sampling, focused primarily in areas with suspected reproduction of translocated animals. We are also conducting questionnaires sent to all hunting clubs in the potential species range, which guides us in where to conduct systematic camera-trapping.

Population estimates

Example1: Greece – wolves (Yorgos Iliopoulos, CALISTO)

Population estimates based on sampling areas and multiple signs

Monitoring was systematic in 48 sampling areas (10.000 km^2) and focused on counting wolf reproductive packs during late summer after births of the year's puppies.

Sampling areas were scattered across the country in a stratified manner to include all habitat types and altitudinal zones.

Multiple methods were used at each site: habitat modelling sign surveys, camera trapping and howling sessions.

Detection probability of wolf reproduction was high after combination of those methods.

Average size of wolf territories was estimated per sample area (dividing each study area surface with number of verified wolf packs) and then used for estimation of the total number of wolf packs in the country after extrapolations.

Average size of reproductive wolf packs was estimated from camera traps including pups of the year (summing maximum number of adults and maximum number of pups located per pack).

Then, the estimated average number of packs multiplied with the average pack size was used to estimate wolf population size in number of individuals.

Potential wolf distribution for the period 2017-2023 was estimated with the use of field data and spatial distribution of wolf livestock depredation events provided by HFIO to 67.000 km^2. Actual wolf distribution for 2023 (occupied area for reproductive wolf packs) is assumed to be 75% of the potential wolf distribution (i.e. 50.000 km^2).

Estimations provided **should be considered preliminary** and may differ from final estimations after analyses (occupancy analysis and habitat modelling) and the inclusion of more field data in 2024.

Example 2: Slovakia – wolves & lynx (Robin Rigg, Slovak Wildlife Society)

Extrapolating local densities to obtain national estimates

The official report with hunters' statistics for the 2023 season is available online (http://www.forestportal.sk/wp-content/uploads/2024/06/Polovnicka-statisticka-rocenka-SR-2023.pdf). It includes hunting ground-based estimates of LC distribution areas which can be used to calculate national estimates based on the densities in a reference area in Liptov. To do so, we used three different extrapolation approaches.

Wolves

Method 1: extrapolation from density in model area

We (Slovak Wildlife Society in collaboration with colleagues at the University of Ljubljana Biotechnical Faculty) conduct annual non-invasive genetic monitoring in a model area (Liptov). We have CMR estimates of wolf numbers in this area for every year except 2021. I used these estimates and the total area of hunting grounds (PR) to calculate an estimate of wolf density in Liptov. I then used these density estimates, and the total wolf distribution area as reported by hunters to estimate the total number of wolves in Slovakia by year. For 2023 the result is 722 (Table 1).

Table 1: Extrapolation of wolf densities from study area to national level – method 1.

Year	Wolf range Liptov			Wolf range Slovakia	
	Wolf numbers Genetic CMR	**Size (km2)**	**Wolf density / 100 km2**	**Size (Km²)**	**National wolf numbers**
2017	57	1,903	3.00	18,326	549
2018	53	1,878	2.82	17,807	503
2019	34	1,933	1.76	18,673	328
2020	58	1,933	3.00	19,155	575
2021	NA	1,973	NA	19,395	NA
2022	48	2,007	2.39	19,421	464
2023	72	2,007	3.59	20,136	**722**

Method 2: recalibration of hunter-based estimates for each year separately

Secondly, I compared our genetic CMR estimates with hunters' estimates for the same area ("JKS Liptov" and then calculated the difference as a coefficient ("JKS/CMR") which I then used to recalibrate hunters' estimates for the whole country ("JKS SR"). The result for 2023 is 674 (Table 2).

Table 2: Extrapolation of wolf numbers from study area to national level – method 2.

Year	Wolf range Liptov study area			Wolf range Slovakia	
	Wolf numbers Genetic CMR	**JKS Liptov count**	**Coefficient (JKS/CMR)**	**JKS SR count**	**JKS SR / coefficient**
2017	57	293	5.14	2621	510
2018	53	284	5.36	2561	478
2019	34	249	7.32	2786	380
2020	58	295	5.09	3099	609
2021	NA	354	NA	3291	NA
2022	48	370	7.71	3606	468
2023	72	436	6.06	4082	**674**

Method 3: recalibration of hunter-based estimates using mean coefficient +/- SE

Finally, instead of calculating a coefficient for each year separately, as above, I calculated a mean coefficient for 2017-2023 (= 6.11 SE +/- 0.47) and used this to recalibrate hunters' estimates for the whole country (Table 3). The result for 2023 is 668 (SE: 620 - 723).

So, my conclusion is that a reasonable estimate for 2023 based on available data is approx. 700 individuals (668 - 722 being the range of estimates obtained using the 3 methods described).

Table 3: Extrapolation of wolf numbers from study area to national level – method 3.

Year	JKS SR	JKS SR / mean coefficient	(-SE)	(+SE)
2017	2621	429	398	464
2018	2561	419	389	454
2019	2786	456	423	494
2020	3099	507	471	549
2021	3291	538	500	583
2022	3606	590	548	639
2023	4082	668	620	**723**

Lynx

I went through available sources of lynx density estimates to recalculate estimates of lynx numbers in Slovakia. I found camera trap-based SCR estimates from 7 different study areas in Slovakia, with a mean density estimate of 1.11 (SE 0.13) independent lynx per 100 km^2 of suitable habitat (Table 4).

Table 4: Lynx densities in 7 study sites in Slovakia.

Year	Study area	Lynx density /100 km2	SE
2016-2017	Muránska planina	1.47	
2017-2020	mean Beskydy	0.55	
2017-2020	mean Javorníky	0.84	
2017-2020	mean Kysuce	1.53	
2017-2018?	Strážovské vrchy	0.97	
2018-2019	Veporské vrchy	1.2	
2019-2020	Vtáčnik	1.18	
	Mean	**1.11**	**0.13**

Using the hunting ground-based map for the total distribution area, I calculated density-based estimates of numbers by year (Table 5).

Table 5: Lynx numbers based on average lynx numbers from CMR estimates.

Year	Lynx distribution area Slovakia (km^2)	N lynx in Slovakia (Distribution area x average density)	SE
2017	21,070	233	28
2018	20,109	222	26
2019	20,365	225	27
2020	21,023	232	28
2021	21,051	233	28
2022	20,785	230	27

I also used a second method: comparing SCR estimates with hunters' estimates in study areas and recalibrating hunters' estimates on the national level. For this, I found 5 different study areas for which the hunter error was mentioned (hunters' estimate / SCR estimate; Table 6).

Table 6: Correction factor for hunter estimates based on CMR estimates.

Year	Study area	Correction factor CF (hunters' estimate / SCR estimate)
2013-2014	Štiavnicke vrchy	5.6
2014-2015	Veľká Fatra	6.9
2016-2017	Muránska planina	6.3
2018-2019	Veporské vrchy	11.7
2019-2020	Vtáčnik	8.3
	Mean	**7.8**

Recalibrating the national hunter estimate using the mean correction factor (CF) of 7.8 (min 5.6, max 11.7), I obtained annual estimates for numbers of lynx in Slovakia (Table 7), which are similar to those obtained using the density-based method.

Table 7: Lynx estimates for Slovakia based on hunter observations and the CMR correction factor.

Year	Hunter estimate	Hunter estimate / mean CF	Hunt. est. / max CF	Hunt. est. / min CF
2017	1,768	228	151	316
2018	1,649	213	141	294
2019	1,688	218	144	301
2020	1,723	222	147	308
2021	1,804	232	154	322
2022	1,743	225	149	311
2023	1,819	**234**	155	325

Sources/references for lynx densities:

Kubala J. et al. (2017) Robust monitoring of the Eurasian lynx *Lynx lynx* in the Slovak Carpathians reveals lower numbers than officially reported. Oryx, doi:10.1017/S003060531700076x.

Smolko P. et al. (2018). Lynx monitoring in the Muránska Planina NP, Slovakia and its importance for the national and European management and conservation of the species. Technical report. DIANA – Carpathian Wildlife Research, Banská Bystrica, Slovakia, 30 pp.

Kubala J. et al. (2019). Monitoring of Eurasian Lynx (*Lynx lynx*) in the Vepor Mountains and its importance for the national and European management and species conservation. Technical report.

Kubala J. et al. (2020). Monitoring rysa ostrovida (*Lynx lynx*) v Strážovských vrchoch a jeho význam pre národný a európsky manažment a ochranu druhu. Technická správa. [Monitoring of lynx (Lynx lynx) in Strážov Mountains PLA and its importance for national and European management and species protection. Technical report]. Občianske združenie DIANA – Výskum karpatskej fauny, Banská Bystrica, Slovensko. (in Slovak)

Kubala J. et al. (2020). Eurasian lynx (Lynx lynx) monitoring in the Vtáčnik Mountains and its importance for the national and european management and conservation of the species. Technical report. Technical university in Zvolen, Zvolen, Slovakia, 26 pp.

Duľa M. et al. (2021). Multi-seasonal systematic camera-trapping reveals fluctuating densities and high turnover rates of Carpathian lynx on the western edge of its native range. Scientific Reports 11: 9236.

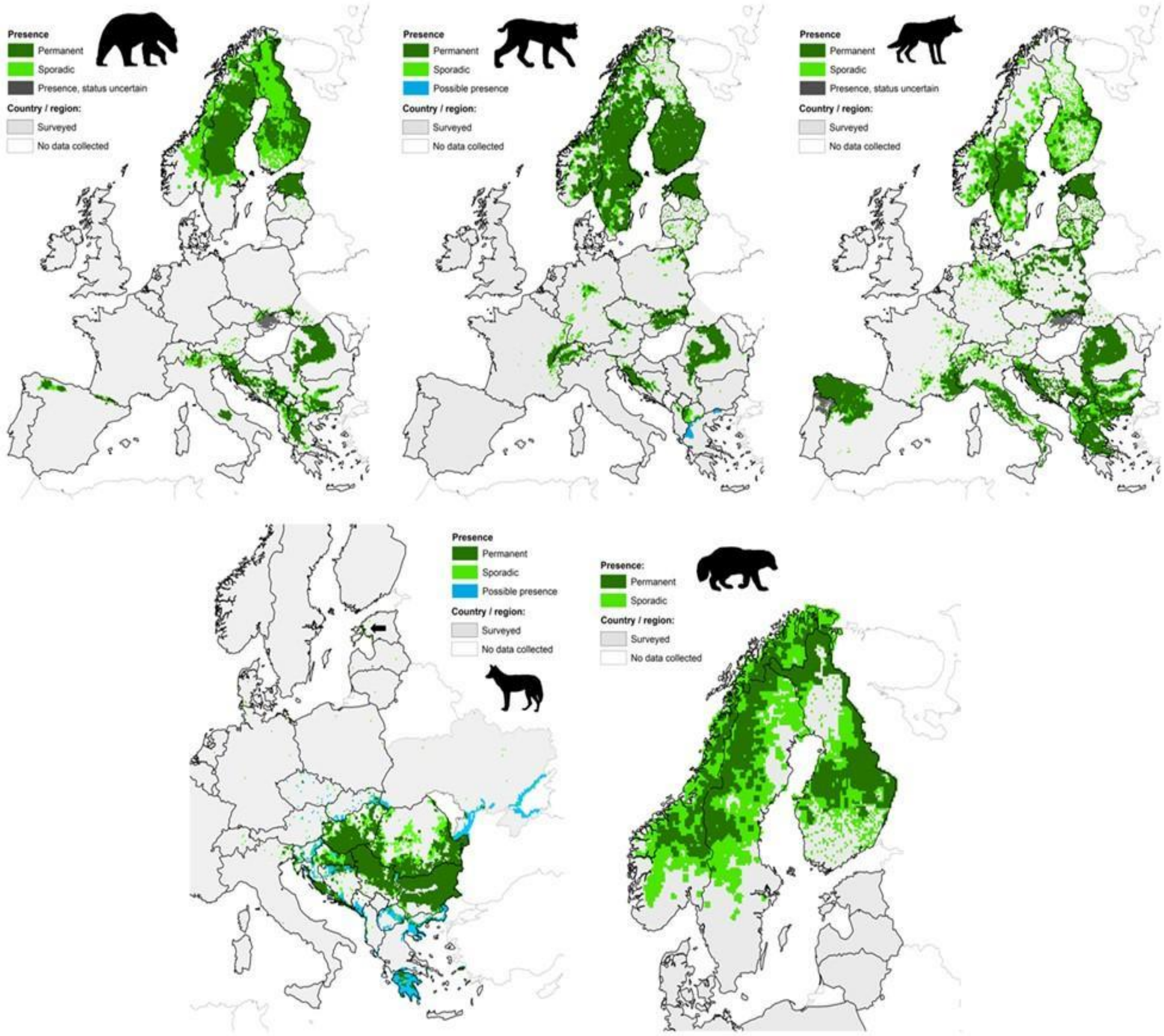
Example 3: Bulgaria – bear (Diana Zlatanova, Faculty of Biology, Sofia University)

Bear tracking transects for population trend

This monitoring with measuring footprints for estimating individual animals has many flaws such as subjectivity in the measurement; control for the error margins during measurements or recording the locations of the tracks; the participants in the monitoring are not always properly trained; etc. Additionally, the climatic conditions in the last few years (dry autumn, when the monitoring is conducted) contribute to a very low track encounter rate introducing additional errors in the trend assessment.

Appendix 4 – Online Questionnaire Mapping (simplified)

LCIE – Update of distribution maps for Eurasian lynx, wolf, brown bear, and wolverine in Europe



BACKGROUND:

For the EU Commission contract N° 09.0201/2023/907799/SER/ENV.D.3 "Support for Coexistence with Large Carnivores", the Large Carnivore Initiative for Europe (LCIE) has been subcontracted, among other tasks, for task "B.4 Update of the distribution maps" which encompasses: Updating the distribution maps (permanent & sporadic) of wolf, brown bear, European lynx, and golden jackal using the latest available data for the **period 2017 – 2022/23** for the whole EU and adjacent non-EU countries on the level of 10x10 km grid cells (ETRS89-LAEA)with a stronger focus on data quality for each 10 x 10 km cell. LCIE will use the opportunity to also update the population numbers and include the wolverine in the update.

What is new, is that this time we will have to produce two maps:

- Map 1 showing large carnivore presence (which cells have carnivore presence)

- Map 2 showing data quality (which of the presence cells are based on confirmed signs and which are based on extrapolation or soft information)

This questionnaire has 20 questions and will take about 20-30 minutes to fill. It is relevant for the mapping part of the LC status update and asks about data types, sources, and mapping details. The information will be summarised in a meta-document which will be provided together with the updated distribution maps.

Please fill one questionnaire for each species for each country (or region, where data sources and mapping methods vary widely).

Data identifying part

Name:
Country:
Email address:
Full affiliation:

1. What species are you reporting on? Please, fill a different form for each species in your country/region

(1) ❍ Eurasian lynx

(2) ❍ Wolf

(3) ❍ Brown bear

(4) ❍ Wolverine

(5) ❍ Golden Jackal

2. What part of the country are you reporting on here? If different people fill in for different parts of the country or monitoring varies fundamentally between different regions, please fill in a separate form for each area.

(1) ❍ Known species range of the entire country

(2) ❍ Other: _____

Spatial and temporal scale of range monitoring

3. What time period does your species presence map cover?

(1) ❍ 2017 – 2022/23

(2) ❍ Other: _____

4. When does the monitoring period for the species start and end?

_____

5. At what time intervals is species presence monitored?

(1) ❍ Annually

(2) ❍ Cumulative over a regular time period

(3) ❍ Irregular / opportunistic

(4) ❍ Other: _____

6. At what spatial extent is the species range monitored?

(1) ❍ Entire known range

(2) ❍ Entire known range but via rotating monitoring areas

(3) ❍ Only in certain reference areas

(4) ❍ Other: _____

7. Approximately what % of the known species range is monitored by actively looking for species presence to confirm the range:

_____

8. Approximately what % of the known species range is monitored by opportunistic monitoring:

_____

INFO ONLY - Data base for maps - recap on "presence" categories for your information

We will use the following presence categories, which are derived from the SCALP criteria for lynx in the Alps (Molinari-Jobin et al. 2012) but supplement them with two additional data quality information:

1. Confirmed presence signs

- **Category 1 (C1)**: "Hard facts", verified and unchallenged large carnivore presence signs (e.g. dead animals, DNA, verified camera trap images);
- **Category 2 (C2)**: "Confirmed signs", large carnivore presence signs controlled and confirmed by a large carnivore expert (e.g. trained member of the network), which requires documentation of large carnivore signs; and

2. Extrapolated confirmed presence signs

- **Category "buffered":** Confirmed presence signs with a buffer around them based on well documented/ published methods.
- **Category "modelled": confirmed presence signs and modelling** based on habitat suitability and/or proximity criteria based on well documented/published methods. For areas of poor coverage and infrequent monitoring, we will also include:

3. Unconfirmed presence signs - ideally this category is only included where monitoring is extremely fragmented

- **Category 3 (C3)**: Unconfirmed category 2 large carnivore presence signs and all presence signs such as sightings and calls which, if not additionally documented, cannot be verified.
- **Category "Soft":** Extrapolation of large carnivore presence based on interviews questionnaires, and media coverage from 2017-2022/23
- **Category "Past presence"**: Documented presence from the past (but no older than from 2010) and no indication that the situation has changed.

9. What documented signs of the species do you accept as confirmed presence? (basically, SCALP criteria 1 & 2 or an equivalent)

____
____
____
____
____
____

10. On what type of spatial data is your presence data based on?

(1) ❍ Presence is based on the location of confirmed presence signs which were overlaid with the 10 x 10 grid

(2) ❍ Presence is based on buffered confirmed presence signs which were overlaid with the 10 x 10 grid

Please describe buffer size and reason/reference for the size:

(3) ❍ Presence is based on confirmed presence signs and modelling based on habitat suitability and/or proximity criteria which were overlaid with the 10 x 10 grid

Please provide model details and reference:

(4) ❍ Presence is based on larger areas (e.g. hunting grounds) with confirmed presence signs (e.g. hunted individuals) which were overlaid with the 10 x 10 grid

Did you use a cut-off value for intersection (e.g, > 10% overlap with 10x10 cell):

(5) ❍ Presence in part of the range is based on unconfirmed presence signs, or assumed presence based on interviews, questionnaires, and media reports, or documented past presence (this past presence cannot be older than from 2010)

Please provide a short description of the unconfirmed / soft data you used:

INFO ONLY - Presence status - recap on "presence status" categories for your information

We will again aim for presence maps where we can distinguish between two presence levels:

- **Permanent** = suggesting an established population which is reproducing
- **Sporadic** = suggesting only occasional presences of dispersers or lone individuals

Where this distinction is not possible, but presence has been confirmed, we will use

- **Present** = no information about the presence status possible

However, finding a common definition that fits all monitoring circumstances is difficult and the distinction will in parts require expert assessment. Here are the most common scenarios from the last mapping round:

1) For **countries where the known annual species range is monitored annually**, the distinction between permanent and sporadic can be made based on how reliably the species was detected in a cell over the 5–7-year monitoring period:

- **Permanent** = presence confirmed in ≥ 3 years in the last 5 - 7 years OR reproduction confirmed at least once within the last 3 years
- **Sporadic (highly fluctuating presence)** (presence confirmed in <3 years in the last 5 years OR in <50% of the time)

2) For **countries where the probability of species presence is modelled** based on present signs in combination with habitat parameters and distance rules, the distinction between permanent and sporadic can be made based on the probability of presence value. As models used for different populations will vary in their approach, **the cut-off values for permanent, sporadic, and absent need to be defined by the national/population level species experts together with the modeller**.

3) For **countries where the known range is covered cumulative over a 5–7-year period** (period since last update), other criteria need to be used such as: comparison to presence in a cell (or adjacent cells) when the same area was monitored last, or buffers around cells with confirmed reproduction to delineate permanent presence from sporadic presence.

However, where monitoring is too fragmented and infrequent so that and no reasonable distinction between permanent and sporadic can be made, just use the category “present” for cells of confirmed presence.

In general, telemetry data of long-distance dispersers out of the known range and once off documentation of individuals outside the known range should be categorised as sporadic presence.

11. What criteria did you use to distinguish between permanent and sporadic presence?

(1) ❍ Use of re-occurring presence (presence confirmed in ≥ 3 years in the last 5 - 7 years in a cell) and/or reproduction confirmed at least once within the last 3 years

(2) ❍ Use of modelled probability of species presence using a certain cut-off value (see 11b)

(3) ❍ Other criteria were used to distinguish between permanent and sporadic (see 111b)

(4) ❍ No distinction was made, and cells were defined as "present" because monitoring is too fragmented and infrequent for making a reasonable distinction between permanent and sporadic presence

11b. Please describe briefly how the distinction between permanent and sporadic was done:

____
____

Trend of species range

12. Has the method to produce species presence map change since the last reporting for 2012-2016?

(1) ❍ No

(2) ❍ Yes , please explain: ______

13. Are there recent official maps of the species distribution range which vary clearly from your map?

(1) ❍ No

(2) ❍ Yes, please explain why and in which way are they differing:_______

14. How is the trend in the species distribution since 2012-2016?

(1) ❍ Increasing

(2) ❍ No obvious change

(5) ❍ Fluctuating

(3) ❍ Decreasing

(4) ❍ Unknown

15. In your opinion, is the trend real or more likely a result of changed monitoring methods?

(1) ❍ Real

(2) ❍ Different method

(3) ❍ Different environmental conditions

(4) ❍ Other _____

Main monitoring method for the species

16. How much of the species known range is approximately mapped with these method(s)?

	Not relevant	<10%	10-25%	25-50%	50-75%	>75%
Dead animals (hunting, culling, traffic, other)						
Non-invasive genetics						
Camera traps						
GPS tracking						
Active snow tracking						
Howling surveys						
Family group monitoring (natal dens, family groups, female bears with coys)						
Confirmed presence signs such as kills and tracks (SCALP C2 equivalents)						
Damage statistics (consisting of a mix of confirmed and non-confirmed records)						
Unconfirmed presence signs						
Questionnaire surveys & interviews						
Past presence signs based on confirmed signs (but not older than from 2010)						
Other						

16a. Please describe your other method

____

____

Data source and data provider part

17. Which publications best describe range the current monitoring in your country/region? Please, list reference with DOI for published papers and provide link to reports where available. Please use a ";" at the end of each reference.

____
____
____
____
____
____

18. Who needs to be listed as co-author in the report and potential subsequent publication? Please, list with full name and affiliation in the online document at: LINK

19. Who needs to be acknowledged as data provider? Please, list with full name and affiliation.

____
____
____
____
____
____

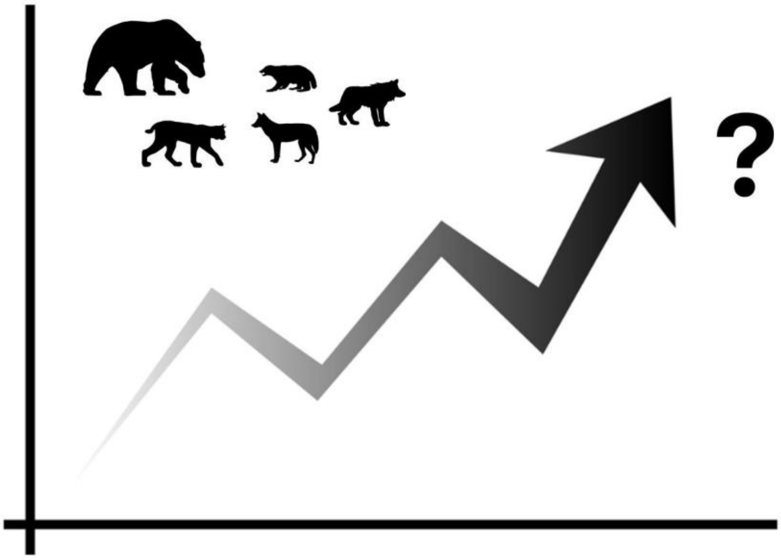
20. Do you have any additional comments:

____
____
____
____
____
____

Thank you!

Appendix 5 – Online Questionnaire Population estimates (simplified)

LCIE – Update on large carnivore status in Europe



BACKGROUND:

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This questionnaire has 27 questions and will take about 30 minutes to fill. The information will be summarised in report together with the updated distribution maps.

Please fill one questionnaire for each species for each country (or region, where data sources and mapping methods vary widely).

You can abort data entry any time and the data already filled will be saved. You can return to your questionnaire via the individual link you received by e-mail from SurveyXact.

Data identifying part

Name:	_____
Country:	_____
Email address:	_____
Full affiliation:	_____

What species are you reporting on? Please fill a different form for each species in your country/region

(1) ❍ Eurasian lynx

(2) ❍ Wolf

(3) ❍ Brown bear

(4) ❍ Wolverine

(5) ❍ Golden jackal

Population estimate for the species in your country
We will ask for population estimates at national level and where relevant also for population estimates for population segments in your country which belong to different populations as defined by the LCIE.

However, if you only report for a specific region of your country, you can select this option in the first question and will not be asked for national estimates.

1. What part of the country are you reporting on here? If different people fill in for different parts of the country or monitoring varies fundamentally between different regions, please fill in a separate form for each region.

(1) ❍ Entire country - national population

(2) ❍ Specific region (please list name): _____

2a. What is the most recent population estimate for the species in your country/region?

Region	
Year estimated	
Population estimate	
Unit of estimate (e.g., Individuals, packs)	
Measure of uncertainty (e.g., range, 95% CI, SD, SE, minimum number)	
If relevant, conversion factor to number of individuals, else type "No"	
How much of the species known range is approximately monitored (in %)?	____________________________ _______________

2b. How is the current trend of the species population (since 2016)?

(1) ❍ Increasing

(2) ❍ Fluctuating

(3) ❍ No obvious change

(4) ❍ Decreasing

(5) ❍ Unknown (please comment) _____

2c. Do you believe that the population trend since 2016 is real or an artefact of changes in monitoring or management?

(1) ❍ The trend reflects a real population change

(2) ❍ The trend is an artefact of changes in monitoring

(3) ❍ The trend is due to changes in management

(4) ❍ Unknown (please comment) _____

2d. What are the most recent relevant publications / report supporting the species' population estimate(s) in your region? Please list references or links to reports. Please write a ";" after the end of each reference or link.

____

Just for INFO - Sub-national estimates of population segments belonging to different European populations as defined by LCIE –

This section is only relevant if you have more than 1 population in your country. The following main populations have been delineated by LCIE :

- **Eurasian Lynx (11 populations):** Alpine, Balkan, Baltic, Bohemian-Bavarian-Austrian, Carpathian, Dinaric, Harz Mountain, Jura, Karelian, Scandinavian, Vosges-Palatinian
- **Brown bear (10 populations):** Alpine, Baltic, Cantabrian, Carpathian, Central Apennine, Dinaric-Pindos, East Balkan, Karelia, Pyrenean, Scandinavian
- **Wolf (9 populations):** Alpine, Baltic, Carpathian, Central European, Dinaric-Balkan, Italian Peninsula, NW Iberia, Scandinavia, Karelia
- **Wolverine (2 populations):** Karelian, Scandinavian
- **Golden jackal (4 populations):** Adriatic, Continental, Pelopennese, Samos

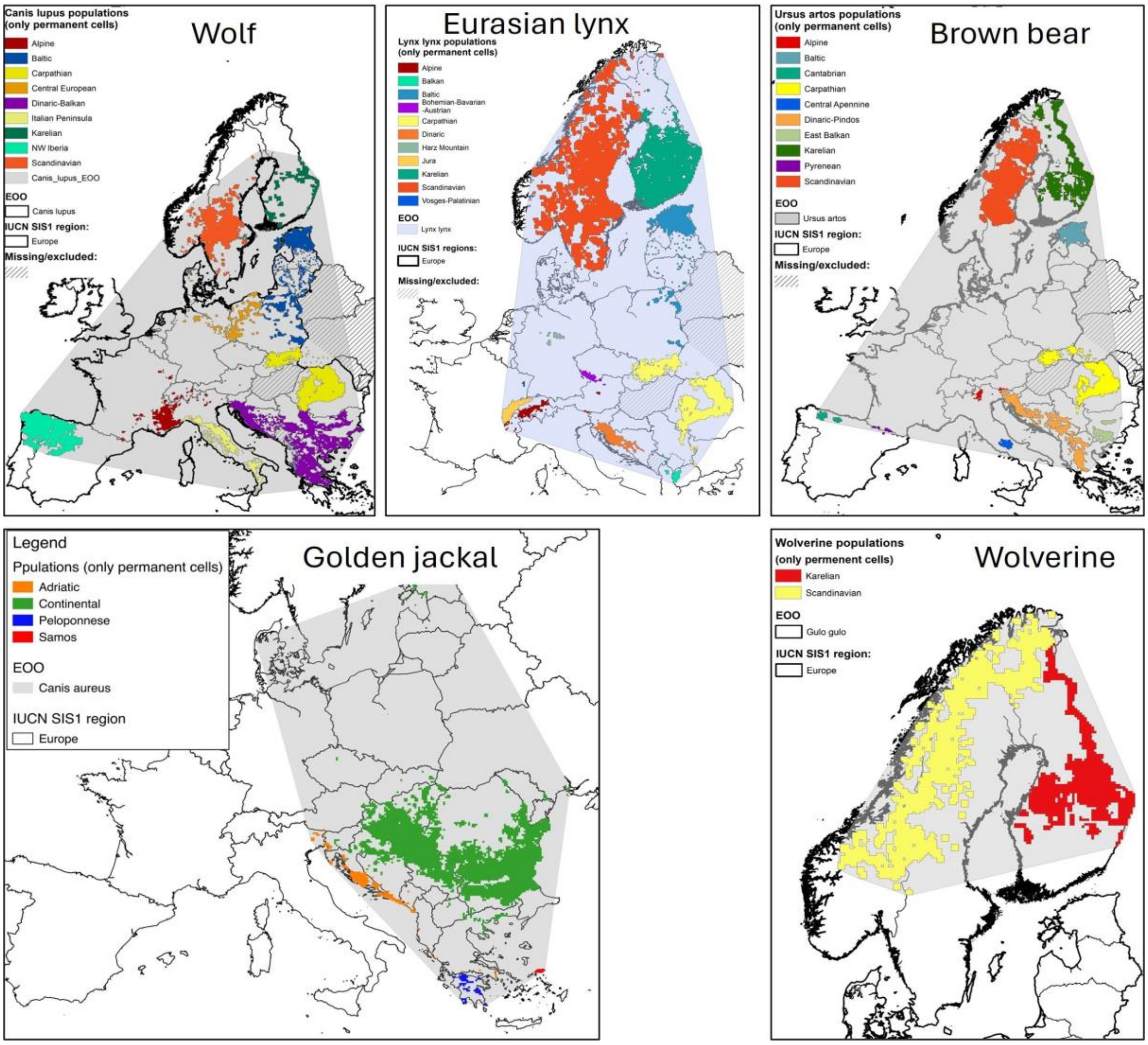

Figure showing the population delineation used for the 2012-2016 update.

4. How many different populations – as defined by LCIE – of the species are found in your country?

(1) ❍ Only 1 population - no need for further details

(2) ❍ 2 populations

(3) ❍ 3 populations

(4) ❍ 4 populations

If available, please provide data on the population size of the different population segments in your country:________________

……

8. Your population estimates represent what time period of the year? More than 1 answer is possible

(1) ❑ Population estimate in winter (before the next generation is born)

(2) ❑ Population estimate in summer (after the new generation was born)

(3) ❑ Population estmate before the hunting season

(4) ❑ Population estimate after the hunting season

(5) ❑ Information is collected throughout the year

9. Is there any population-level transboundary cooperation in monitoring the species along shared boundaries with neighboring countries? If so, Please briefly describe, else write "no".

____
____
____

10. Do you have an estimates of the number of individuals shared with neighbouring countries (to avoiding double counting cross-border individuals)? If so, Please briefly describe, else write "no".

____
____
____

11. Are there any recent population-level population estimates available, which correct for double counting transboundary individuals? If so, Please briefly describe, else write "no".

____
____
____

Main monitoring method for the species

12. What is the main monitoring method to obtain population estimates and how much of the species range is approximately monitored with this method (% area)?

	<10%	10-25%	25-50%	50-75%	>75%
Camera traps: Minimum number of individuals					
Camera traps: Detection of reproductive units					
Camera traps: Capture-Mark-Recapture estimate of population size					
Snow tracking: Minimum number of individuals					
Snow tracking: Detection of reproductive units					
Snow tracking: Natal den counts					
Snow tracking: Track count index					
Non-invasive genetics: Minimum number of individuals					
Non-invasive genetics: Capture-Mark-Recapture estimate of population size					
Scat surveys: Identify rendezvous sites					
Howling surveys: Confirm reproduction					
Howling surveys: Confirm presence					
Observations: Detection of reproductive units					

(observations of young of the year / family groups)
Observations: Hunter observation index
Hunting bag: population reconstruction based on age / sex structure of harvest
Expert «guestimate»
Other

12a. Please describe your other method

____
____
____

13. Any additional comments on monitoring?

____
____
____

Management

14. Is there an official management plan, action plan, or strategy?

(1) ❍ No

(2) ❍ Yes, please add reference and link _____

15. Is there an official goal for the size of the population?

(1) ❍ No

(2) ❍ Yes

(3) ❍ Don't know

16. What is the population size goal?

_____

17. How is the population size goal interpreted?

(1) ❍ Minimum population size

(2) ❍ Maximum population size

(3) ❍ Not clarified

(4) ❍ Other _____

18. Is there any formal transboundary cooperation in management?

(1) ❍ No

(2) ❍ Yes

19. What is the nature of the transboundary agreement? If possible, provide reference or links.

____
____
____

20. Is the conservation status of the species in your country officially classified as being in favourable conservation status (FCS)?

(1) ❍ Yes

(2) ❍ No

(3) ❍ Not relevant (Non-EU country) / Don't know

21. How has the favourable conservation status defined and what method was used to define it? If possible, provide reference or links.

____
____
____

Data source and data provider part

Please use online spreadsheet: LINK

24. Do you have any additional comments:

____
____
____

Thank you!

Appendix 6 – Most recent publications on population and range estimates

Albania

????, ????. Feasibility study on enhancing connectivity conservation in the PONT Focus Region: Albania and North Macedonia - Description of the selected Connectivity Conservation Areas. Habitat model Balkan lynx and brown bear, Annex to a report.

Catsadorakis, G., Alexandrou, O., Dimidjijevski, D., Hoxha, B., Koutseri, I., Melovski, D., Mertzanis, G., Petridou, M., Shyti, I., Stojanov, A., Trajce, A., 2021. Jackal status in Prespa basin. https://www.researchgate.net/publication/350912059

Bego, F., Trajçe, A., Hoxha, B., 2022. Results on the small, medium and large mammal presence and distribution obtained by sherman and camera-trapping surveys in Gjirokastra region, Albania. PPNEA report. http://dx.doi.org/10.13140/RG.2.2.21207.55202

Hoxha, B., Lama, O., Trajçe, A., 2021. Support to the management of protected areas in border region of Albania, Kosovo, North Macedonia in monitoring of endangered species. PPNEA report. http://dx.doi.org/10.13140/RG.2.2.19529.83045

Hoxha, B., Nezaj, M., Shyti, I., Trajce, A., 2023. Results of the Balkan Lynx Intensive Camera Trapping Survey -Winter/ Spring 2023, conducted in Munella Nature Park and its surrounding areas, Puka-Mirdita Region. PPNEA report. https://www.researchgate.net/publication/380029684

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