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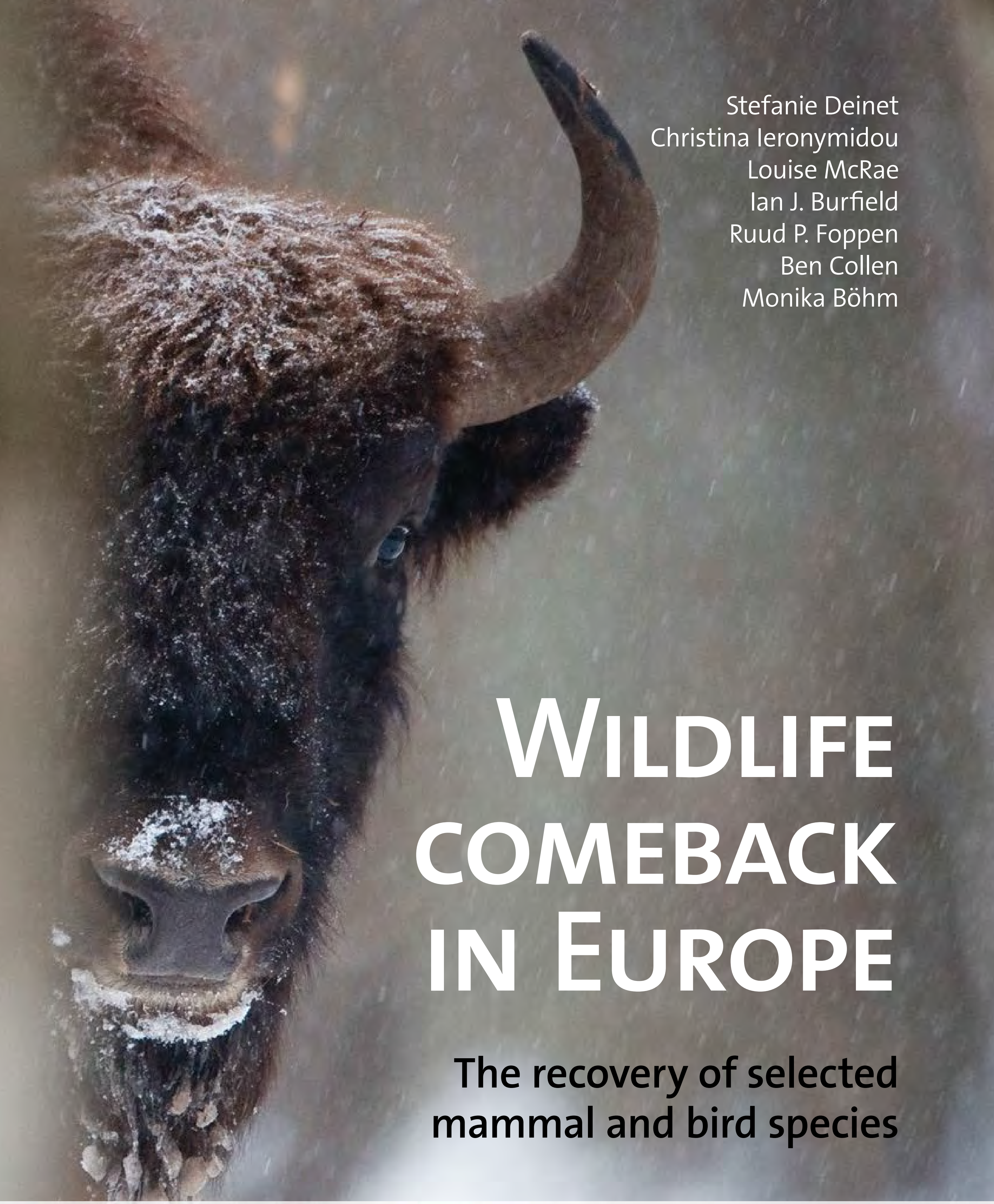

Wildlife comeback in Europe

The recovery of selected mammal and bird species

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ISBN

978–0–900881–73–2 Wildlife comeback in Europe: The recovery of selected mammal and bird species (paperback)

978–0–900881–74–9 Wildlife comeback in Europe: The recovery of selected mammal and bird species (online)

Suggested citation

Deinet, S., Ieronymidou, C., McRae, L., Burfield, I.J., Foppen, R.P., Collen, B. and Böhm, M. (2013) *Wildlife comeback in Europe: The recovery of selected mammal and bird species.* Final report to Rewilding Europe by ZSL, BirdLife International and the European Bird Census Council. London, UK: ZSL.

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A study commissioned by:

Rewilding Europe
Toernooiveld 1
6525 ED Nijmegen
The Netherlands
www.rewildingeurope.com

This study has been made possible by generous grants from the Swedish Postcode Lottery, the Liberty Wildlife Fund and ARK Nature.

Image sources:

Bruno d'Amícis: 44, 47, 49;
Juan Carlos Muñoz: 158, 198, 242, 245, 246;
Nature Picture Library, NPL:
José Luis Gomez de Francisco: 174, 178; Dietmar Nill: 204, 208; Rod Williams: 175; Xi Zhinong: 207
Rewilding Europe & Wild Wonders of Europe:
Peter Cairns: 62, 89, 150; Laurent Geslin: 126, 264; Magnus Elander: 228, 232; Erlend Haarberg: 32, 36, 50, 54, 57; Mark Hamblin: 18, 184; Grzegorz Lesniewski: 66, 70, 72; Juan Carlos Muñoz: 12, 216, 291; Florian Möllers: 74, 79, 82, 272, 297; Laszlo Novak: 164, 167, 168; Pete Oxford: 22, 112, 119; Jari Peltomäki: 191, 192, 193; Louis-Marie Preau: 132; Ruben Smit: 83; Stefano Unterthiner: front cover, 15, 29, 170, 254, 257; Markus Varesvuo: 187, 238, 241; Staffan Widstrand: 4, 6, 8, 10, 24, 38, 42, 96, 98, 103, 120, 140, 144, 147, 148, 183, 194, 196, 222, 223, 235, 236, 283, 284, 286, 287, 298, 301; Sven Zacek: 86
José B. Ruíz: 202
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Staffan Widstrand: 58, 65, 104, 106, 109, 124, 134, 137, 157, 280, 290, 305
Wild Wonders of Europe:
Peter Cairns: 155; Laurent Geslin: 188, 210, 211; Juan Carlos Muñoz: 219, 220; Staffan Widstrand: 41, 180, 185, 201, 279; Konrad Wothe: 248, 251, 252

Graphic design

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FOREWORD

Shifting baselines

In Europe, we have all grown up being used to very low numbers of almost all wildlife species. During the fifties and sixties of the previous century, numbers of many species were at an all-time low. Intensive persecution combined with massive hunting, poaching, poisoning, habitat loss, pollution and the impact of persistent chemicals in food chains were the main reasons. Even with bounties and other government involvement, we managed to actively reduce the numbers and distribution of many mammal and bird species all across Europe, except maybe in some of the most remote parts of our continent. To make a reference to our oceans: what we now regard as the depleting of fish populations by industrial fisheries, happened to our land areas already long before: we emptied our lands so that there was little wildlife left.

Many species were driven into corners, especially into some of our forests, where they could hide, become shy and live a secret life. The Europeans got used to the idea that these almost 'homeopathic' amounts of wildlife and their shy behaviour was something normal. Many species became seen as 'forest species' while they are actually not, in particular some of the herbivores. Still today many Europeans refer to this situation as normal or even 'optimal', not recognizing that natural densities of wildlife are key to the normal functioning of our ecosystems: from forests to open lands, from floodplains to steppes, from maquis to taiga forests, from alpine grasslands to tundra's. Simply speaking, we had our baseline shifted. What we grew up thinking was normal, was actually not even close to normal.

However, increasing efforts over the last 50 years of the European Union, of national and local governments, conservation organisations, research institutions and private individuals to protect and restore habitats and species, and actively bring them back, is now beginning to yield results. Although the total biodiversity in Europe is still decreasing, many of the larger wildlife and bird species are coming back or show the first signs of that. The decades of hard and enduring fieldwork of many thousands of nature lovers, volunteers, researchers, scientists and professional institutions from all over Europe is now enabling us to describe and analyse this comeback process.

In 2011, Rewilding Europe asked the Zoological Society of London, later joined by BirdLife International and the European Bird Census Council, to describe and analyse this phenomenon. This report, with contributions from an impressive line-up of respected scientists and species specialists from all over Europe, provides some of the answers. What are the reasons for this wildlife comeback in our continent? Where and how is it happening? Which are the comeback species? What can we learn from it, and how can we apply this in our future conservation efforts? Which opportunities does it provide, and which challenges does it bring? And what could it mean for Europe and the Europeans?

In this report, for the first time ever, a comprehensive, state-of-the-art and science-based, peer-reviewed overview of the comeback of a number of selected – often iconic – wildlife species, is described and systematically analysed. More species could have been covered but resources, time and availability of data were limiting factors. As monitoring and research are continuing at a European scale, this can of course still be done, looking forward.

Wildlife will fairly quickly bounce back if we allow it to – this report shows that. With a continued and strong legal protection, an active boosting of existing wildlife populations or by reintroductions setting up new ones, a growing nature and wildlife-based tourism offer, combined with an increasing tolerance towards wildlife, more species will surely follow.

Wildlife is taking the opportunity – it is our turn to follow and find new ways in our modern society to live alongside our wild animals. Soon we get to know more about what really are the 'natural numbers of wildlife' and what is really their 'natural behaviour'.

I think we are in for some very pleasant and astonishing surprises ahead. And shift our baseline to new levels again.

Frans Schepers

Managing Director
Rewilding Europe

Brown bear at a bear watching site in Suomussalmi, Finland.

Executive summary

With biodiversity in continuing decline worldwide, and targets set to reduce biodiversity loss not being met, conservation successes are rare in comparison to the news on declining populations and extinctions. Wildlife in Europe is showing a variety of responses to human pressure: while certain groups are clearly in decline and require conservation attention, other wildlife species are showing resurgence from previously low levels. Understanding the mechanisms allowing this wildlife comeback is crucial to better conservation of wildlife both in Europe and across the world, if we can apply the principles underlying conservation success to reverse declines in other species.

In this report, we attempt to unravel patterns and processes behind wildlife comeback in Europe since the mid-20th century, focussing on a selected subset of mammals and birds. Of the many possible metrics of biodiversity change, we focus on two of the most useful and widely reported in order to understand the recent positive changes in some species. Firstly, we examine changes in species range. Secondly, we examine the change in population abundance and possible factors behind the trends, such as the mitigation of threats or targeted conservation action.

The story of conservation success against a backdrop of a biodiversity crisis is given centre stage by means of detailed accounts for 18 mammal and 19 bird species showing signs of comeback. For each, we examine population trends over time and evaluate historical and current ranges, highlighting where a species' range has contracted, persisted, expanded or been recolonised over time.

Our analysis shows that while these species have increased in abundance since the 1960s (with the exception of the Iberian lynx (*Lynx pardinus*), which declined), there is great variation between species and regions. For example, abundance increases ranged from less than 10% for the Red kite (*Milvus milvus*) to more than 3,000% for the European bison (*Bison bonasus*), Eurasian beaver (*Castor fiber*), White-headed duck (*Oxyura leucocephala*) and some populations of Pink-footed goose (*Anser brachyrhynchus*) and Barnacle goose (*Branta leucopsis*). For mammal species, increases in abundance were greatest in southern and western Europe.

Analysis of range change showed that the mammal species selected for this study have, on average, increased their distribution range by around 30% since the mid-20th century. Ranges of bird species selected for this study have on average remained stable over the same time period, although the majority of species at first contracted considerably, but then expanded again by 14% since the 1980s. There is much variation in species distribution trends among taxa and across space, from clustering of range expansions in Fennoscandia and eastern Europe for mammalian carnivores, to pan-European increases in deer, with opposing trends between central and northwestern Europe, where more bird species have expanded, and southeastern Europe where more have contracted.

We find that wildlife comeback in Europe since the mid-20th century appears to be predominantly due to species protection and active targeted conservation (both birds and mammals), habitat management and site protection (birds) and legal protection (both). Of the species management techniques, actively boosting existing or setting up new populations, via translocations and reintroductions, was the foremost type of species management linked to increased abundances amongst mammals and birds. Reduction in hunting pressure, protection from persecution and the phasing out of certain toxic chemicals, thus decreasing non-natural mortality, were also important for species recovery.

Despite a picture of increasing abundance and expanding distributions for a number of European bird and mammal species, many other species are still at risk. Furthermore, the results of this report have to be viewed in the context of large historical range declines. In some instances, such as with European carnivores and many bird species, ranges and abundances had already declined dramatically from historical distributions by the mid-20th century. Therefore, wildlife resurgence has to be

White-tailed eagle in Flatanger, Norway.

The Adriatic coastline of the Velebit mountains rewilding area, Croatia.

assessed cautiously, as although species have come back, many are still below historical abundance levels and have not yet reached the level necessary to secure viable long-term populations.

Wildlife comeback is going to bring with it major benefits, by reconnecting people with nature which increases their wellbeing by contributions to local and national economies as well as rural development through wildlife tourism and marketing of wildlife-related products, and by restoring balance to the natural processes of ecosystems. Putting these opportunities into a local context is vital for sustainability and to mitigate any potential conflict with people. Recognising the spatial needs of species through an effective and linked-up protected area network and providing suitable habitat for many species will ensure the long term recovery of wildlife. Within the European Union, the Natura 2000 network has the potential to become such a network, but Member States need first to implement and enforce the EU Nature legislation. Understanding the issues that arise from an increasing interaction between wildlife and people and the opportunities that can be realised from it is critical to ensure a functioning European landscape for both humans and nature.

The case studies of wildlife comeback presented in this report seem to vindicate decades of conservation efforts in Europe. Sound legislation such as the Birds and Habitats Directives have led to better hunting regulation, species and site protection and focusing of conservation investments. They show that with sufficient resources and appropriate efforts, species can be brought back, even from the brink of extinction. Conservation seems to have been particularly successful where it has been able to work with the grain of social change, such as abandonment of marginal farming areas allowing many ungulates and predators to return. Success stories are more difficult to find among species faced with growing threats, such as agricultural intensification. Conservation in the coming decades must continue to build on recent successes, including by restoring functional landscapes, but must also consider those species that are threatened by land use and our ever growing appetite for resources.

1. Introduction

Biodiversity is in general decline globally [1, 2]. Since 1970, vertebrate populations have shown an average decline of around 30% [3] and long-term population trend data suggests that mammal populations have declined on average by 25% and birds by 8% [4]. Over the same time period, the global human population has approximately doubled, having reached a staggering 7 billion in 2011 [5]. Biodiversity targets set to reduce the rate of biodiversity loss have so far not been met [1], and the odds for success seem to be stacked against us. However, biodiversity trends are not universally negative, and within the broad-scale declines we see today, there are both winners and losers. For example, monitored vertebrates in the Palearctic, which includes Europe and Eurasia, exhibit an average 6% increase since 1970 [3].

The European mammal fauna comprises 219 species of terrestrial (59 endemics) and 41 species of marine mammal [6]. Europe's mammal fauna largely originates from Eurasia and Africa, and mammal species richness is highest in eastern Europe, most likely because of colonisation of Europe via western Asia and re-colonisation from eastern glacial refugia; consequently this region also shows the highest species richness of widespread species [7]. On the other hand, endemic species richness is highest in and around the Pyrenees and Alps, probably as a result of distance from the colonisation source of western Asia [7] and re-colonisation of species from southwestern glacial refugia (e.g. southern European peninsulas [8]).

The European bird fauna comprises around 530 bird species, representing about 5% of global bird diversity [9] . This includes regular breeding, migrating and wintering species, but excludes vagrants and non-native species. At the turn of the last millennium, the total European breeding population of all these species was estimated at between 1.4 and 2.7 billion breeding pairs [10]. Of the *c.* 530 regularly occurring species, only 30 are true endemics, most of them occurring on islands (especially in the Mediterranean and Atlantic). Bird diversity hotspots in Europe are scattered around the continent, with a slight focus in central Europe [11]. Many of the families and species found in Europe are shared with Asia and North America. However, in comparison with similar climatic zones, Europe's bird diversity seems rather poor. This might be due to climatic events in combination with spatial isolation [12].

Europe is also home to a human population of around 740 million people [13] which, through the effects of anthropogenic environmental change, has caused population declines in several species groups (e.g. common farmland birds [14], butterflies [15], molluscs [16]). Many species are threatened with extinction (e.g. 15% of mammals [6], 23% of amphibians [17] and 19% of reptiles [18]).

However human influence on the landscape is nothing new, as people have historically had a large impact on wildlife in Europe. Establishment of an agrarian society and later industrial development led to intensive levels of habitat alteration and harvesting of wildlife populations, and persecution of wildlife in direct conflict with human development. Large herbivores used to be a vital source of protein before becoming a stock for domestication of livestock [19]. Habitat loss was pronounced with the conversion of land for agricultural fields and grazing pasture, and logging of forests for timber and firewood. With improved hunting techniques, some species went locally or Europe-wide extinct [e.g. European bison (*Bison bonasus*); Alpine ibex (*Capra ibex*) in the early 18th century except for one population left in Gran Paradiso in Italy; Wild boar (*Sus scrofa*) in the UK; Wolverine (*Gulo gulo*) was considered functionally extinct in southern Norway by the 1960s; Iberian lynx (*Lynx pardinus*) extirpated in Portugal)] or were reduced to very low numbers or a small remnant range [(Eurasian beaver (*Castor fiber*) remained in five isolated European sites and the Iberian lynx was limited to the southwestern part of the Iberian peninsula by the mid-1960s]. Specifically, large carnivores were persecuted due to livestock depredation and fear of attacks on humans (e.g. wolf, bear).

Historical population declines occurred at different times in the past: for example, the beaver had contracted in range and numbers during medieval times [20], while Roe deer (*Capreolus capreolus*) populations were at their lowest point in the early 20th century [21].

Despite these documented historic and current declines, there is evidence of recent population increases and range expansion for a number of European species (see species accounts in section 3 and 4 of this report). This apparent trend across Europe provides us with an opportunity to identify species traits, environmental factors and conservation interventions which have contributed to population increases or range expansions, and attempt to apply the same techniques to other species which are likely to respond in a similar manner. Furthermore, it may be possible to understand the extent to which underlying drivers, such as human demographics and policy, contribute to wildlife comeback. For example, since the early 1960s, there has been a 28% decline in the rural population in Europe, a trend that is expected to continue and accelerate into the future and which is particularly pronounced in Eastern Europe (41% decline in rural population since 1961 [13]). In Eastern and Central European countries, drivers such as the European Union's Common Agricultural Policy (CAP) and its effect on agricultural intensification will most likely lead to more intensive use of productive areas and the abandonment of less productive and economically less viable areas [22]. Already we see an increase in urban populations, which is projected to continue across Europe by 16% between 2002 and 2045 [13]. Consequently, although increasing urbanisation has led to a larger disconnect between people and the natural world globally [23], it has also allowed wildlife comeback in areas of rural abandonment, particularly where coupled with legal protection and active reintroduction of species.

This report focuses on those species for which we see positive changes in Europe. For many of these, Europe now hosts larger populations than for centuries. In this report, we focus on the following questions:

- Which European species are showing comeback?
- By how much have populations increased and ranges expanded since the mid-20th century?
- How does wildlife comeback relate to historical distributions and population sizes?

96 year old olive farmer with his donkey at Castelo Rodrigo, Portugal. Neither his children nor grandchildren are taking over the farm from him.

- Where in Europe is wildlife comeback most pronounced?
- What are the most likely drivers of wildlife comeback and how can we use this knowledge to improve wildlife conservation in Europe?
- What are the challenges and benefits of wildlife comeback in Europe?

To answer these questions, we focus on two informative pieces of information to understand wildlife comeback in a selected group of European mammals and birds. Firstly, we examine the extent to which species have expanded their range (the area over which a species is routinely found). We plot where species are recolonising areas from which they have previously been extirpated, and areas into which they are expanding for the very first time. Due to the large changes in the European environment over the past 200 years, we attempt to draw together range changes at various time points within this period. Because many species persist in small and often fragmented populations, understanding change requires us to define species occurrence prior to large-scale human disturbance [24, 25].

Secondly, and linked to range expansion, we examine increase in population size (i.e. the numbers of individuals) of comeback species. We evaluate the extent to which their populations have grown, and identify where the greatest gains have occurred. In both cases, we try to identify the causative factors behind positive change in European wildlife. This report presents this information in a series of species accounts, in an effort to bring together both the current peer-reviewed status and trends of species, supplemented with the most recent sightings and expansions, which may not yet have made their way into the scientific literature. We are careful to discern between these sources of information.

We also provide an overview of the changes in the selected bird and mammal species to discuss the overall patterns and main drivers of wildlife comeback. Finally, we examine the opportunities that arise from increasing wildlife populations and what the future holds for the evolving relationship between wildlife and people in Europe. Our aim is to provide a new outlook on species comeback in Europe, presenting information from which strategic decisions can be taken for wildlife policy.

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2. Methods

Taxonomic and geographic scope

We collected data on species distribution and population abundance over time for a list of predetermined bird and mammal species (see species accounts in section 3 and 4 of this report), which are believed to have experienced significant comebacks in Europe over the last few decades. The geographic scope of the study followed the definition presented in the IUCN European Mammal Assessment [1]. For terrestrial species, we included populations from mainland Europe to the Black Sea, European Russia to the Urals, Iceland, islands in the English Channel and the North and Norwegian Seas, Atlantic offshore islands (Madeira, Azores, Canary Islands) and all Mediterranean islands. For marine species, we included populations from the Baltic Sea, North Sea, Mediterranean Sea, and Atlantic coastal waters of Europe (consistent with the geographic scope for terrestrial species) (Figure 1).

Data collection

Distribution

In order to produce depictions of spatial range change over time for each species, we compiled distribution maps for three time points: historical (pre-1900, most data from 1700–1850), past (1950s/1960s, to coincide with the start point of the majority of abundance data [2]) and present distributions (2005–2013). For past and historical distributions, we used distribution maps from the literature, or range descriptions in the few cases where the former was not available. The literature search encompassed scientific papers, text books, atlases, species status reports and conservation action plans. For present distributions, we used standardised sources in form of the IUCN Red List [3, 4], verified and amended through further literature sources and comments by species experts. Ranges were produced for all species, with the exception of

Red kites at Gigrin Farm in Wales, UK – a kite-watching site where hundreds of them congregate during winter.

Figure 1. Geographic scope of the study, following the IUCN European Mammal Assessment [1].

Limitations of population trend data

It is important within a study such as this one, to recognise the limitations of the data that are being used to draw inference on change in wildlife status. Long-term wildlife monitoring programmes have repeatedly demonstrated their worth, but are very few and far between. While several good national and regional monitoring systems are becoming increasingly widely applied, e.g. the Pan-European Common Bird Monitoring Scheme [1], they are still restricted in species coverage and geographic scope.

To a large extent, bird monitoring remains more widely spread and better focussed than the equivalent mammal, amphibian, reptile and fish monitoring schemes. This lack of equivalence across vertebrate classes is driven by the comparative simplicity of obtaining bird time series data from one type of monitoring (whereas many different, often species-specific techniques are required for other vertebrate classes) and the high level of amateur interest and citizen science that enables broad-scale cost-effective monitoring to be carried out. That avian data are frequently more widely available is not a new observation [2]; nevertheless little has been achieved in replicating the success of bird monitoring for other groups.

There is also the possibility that population estimates may vary in quality across a time series. This is minimised in the sampling scheme that we use for individual population estimates (where the same methods are used to generate population estimates over subsequent years), but when combining multiple population estimates within a species, different techniques may yield slightly different results.

There is also some evidence that long term schemes can undergo quality improvements over time (e.g. people become more skilled in counting the species that they are studying [3]); obviously a desirable end point, though one which can affect long-term population trajectories if not corrected for.

Finally, while both relative and absolute trends in abundance tell us the trajectory that a population might be moving in, it does not give any information about where that population is in relation to some pre-defined target population size, or how a population is functioning in its environment. Historic reference points are therefore important [4], as well as clear management goals on how monitoring and conservation action need to be targeted for individuals of any given species.

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colonial nesting bird species, for which individual colonies rather than distribution were mapped.

Species distributions were digitized in ArcGIS 9.3 (mammals) and 10 (birds) (ESRI), by georeferencing existing maps where these were available, producing new maps from range descriptions where appropriate, and editing already existing shapefiles provided by IUCN and BirdLife. A list of all data sources used for the collation of distributional information can be found in Appendix 1.

Population time series data for mammals

Time series trends for each species were drawn from the Living Planet Database [2, 5], which contains data compiled from published scientific literature, online databases, researchers and institutions, and from grey literature (for full details see [2]). The following requirements had to be met in order for abundance trend data to be included [2]:

- a measure or proxy measure of population size was available for at least two years, e.g. full population count, catch per unit effort, density
- information was available on how the data were collected and what the units of measurement were
- the geographic location of the population was provided and lay within the defined European boundaries
- the data were collected using the same method on the same population throughout the time series and
- the data source was referenced and traceable.

These data were used to evaluate overall trends in abundance for each species. In addition, national level estimates of current total abundance were collated for each species.

In order to understand the nature and reasons for abundance change, ancillary information was collated at the population level relating to geographic, ecological and conservation management themes. Habitat type was coded following the WWF biome and ecoregion classification [6]. Countries were combined into regions following the United Nations Statistics Division [7] (Appendix 2). Records with missing information on management intervention, threats and utilised status were recoded as 'unknown'. For threats, we additionally combined threat levels by assigning each record to threatened, non-threatened or unknown categories.

Because range-wide monitoring of abundance is comparatively rare for widespread species [8] such as some of those presented in this study, we tried to obtain a measure of the representativeness of our mammal abundance data set. For this, we calculated two different measures of coverage:

- The minimum percentage coverage of the total European population; for each species, we averaged the number of individuals in each time series collected over the study period and summed those averages. We then divided this by the latest European population estimate and multiplied it by 100.
- The country coverage; calculated as the percentage of countries for which data were available compared to the number of European countries in which the species occurred as listed on the IUCN Red List [4].

Efforts were also made to collate population data from specific locations or a smaller scale over those at a national or larger scale to ensure more accurate information on perceived threats and management interventions.

Population time series data for birds

For each species, a time-series of population size in Europe was produced by collating and compiling data of population size estimates from a variety of sources. Key sources included the pan-European assessments of population size, trends and conservation status carried out by BirdLife International for the years 1990 and 2000 [9, 10] and Species Action Plans (SAP) and their implementation reviews [11, 12]. SAPs are conservation documents that are based on the most up-to-date information available at the time of compilation and are endorsed by various international treaties, such as the ORNIS Committee, which assists the European Commission in the implementation of the EU Birds Directive [13], the Standing Committee of the Bern Convention [14], the Convention on Migratory Species (CMS) [15], and the African-Eurasian Migratory Waterbird Agreement (AEWA) [16] (Table 1).

Population size estimates in each country in Europe over time, and in particular current total abundance, were also provided by a large number of BirdLife partner organisations and collaborators, as well as species experts from across Europe. Much data were also derived from published scientific literature, including conference proceedings. Sources are detailed in the references of each species account presented in this report.

For many wintering waterbirds, mid-winter population size estimates are available from Wetlands International, which coordinates the International Waterbird Census (IWC) [17]. The census uses rigorous standardised methods to survey waterbirds at individual sites in more than 100 countries. Results from IWC are published in

Eurasian cranes in April at Lake Hornborga, Sweden

Constructing historical distribution maps – pitfalls, biases and advances in technology

As with population time series, knowledge of both historical and current species distributions can help underpin understanding of wildlife comeback and declines and help to provide tangible solutions to conservation issues [1]. While locality records for species are generally widely available, for example through museum data, literature data, atlas publications and online databases [2], reconstructing species distributions over time often relies on a variety of sources, each of which may harbour distinct biases and shortcomings, which in turn may have a direct bearing on the accuracy and resolution of the resulting distribution map.

Compared to other regions of the world, European wildlife has received a large amount of research attention over time. As a result, there is a large pool of knowledge available on current species occurrences and distributions, and obtaining current data is made even more straightforward through the establishment of records centres and databases which contain up-to-date information. In the case of the IUCN Red List of Threatened Species [3], current distribution maps are verified by experts and regularly updated; moreover, the data are freely available.

Construction of historical distributions is much less straightforward. Most often, distributions are amalgamated from different sources, and this can lead to biases within the resulting distribution data. It is therefore imperative to understand the shortcomings when constructing historical distributions, many of which have been discussed in the literature (see [2] for a good overview). Here, we summarise the three most likely pitfalls when reconstructing historical distribution maps:

1. Data from different sources are likely to vary in terms of spatial resolution and may be biased towards certain parts of the species range, while other areas within the species range may only be broadly covered or even overlooked.

2. The age of technology has advanced our ability to map species distributions: while in the past, distribution estimates were generally based on species occurrence records and broad inferences about suitable habitat, we now have the use of advanced habitat suitability models which are fed by detailed data layers on climatic and habitat factors. For example, some mammalian range maps on the IUCN Red List have been produced that way. This creates a dichotomy in spatial resolution between current and past range maps.

3. Focus on previously understudied taxa (for example as a result of increased conservation focus) may have led to recent discoveries of new populations and locations. Such new records suggest range expansion, while in fact the species may have persisted in that location undiscovered for a long period of time.

Certain precautions can be taken to avoid these pitfalls and biases in the resulting data. For example, smoothing of overly detailed distribution maps may help to find some middle ground between different spatial resolutions. Including areas for which species presence is uncertain in our construction of historical distributions can help to reduce bias towards overstudied areas. However, these sources of bias remain a major issue when considering range changes from historical baselines.

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the Waterbird Population Estimates (WPE) information portal [18], an online database providing information on the current status of waterbird species, including long-term population trend analyses carried out using TRIM software [19].

Pan-European trends of breeding population size for two species (White stork and Common crane) are available in the form of Pan-European Common Bird Monitoring Scheme (PECBMS) Index trends [20]. PECBMS is a joint initiative of the European Bird Census Council (EBCC) and BirdLife International, which aims to collate data on the breeding population trends of common well-monitored species in Europe. PECBMS combines the results of national bird monitoring schemes to produce yearly population indices of bird species across Europe, using TRIM software [19, 21]. The method takes into account differences in survey methodologies between countries, as well as differences in population size, and imputes any missing values for survey localities and years [21]. It was possible to adapt this method to calculate pan-European trends in abundance for five raptor species [White-tailed eagle (*Haliaeetus albicilla*), Eastern Imperial eagle (*Aquila heliaca*), Lesser kestrel (*Falco naumanni*), Red kite (*Milvus milvus*) and Peregrine falcon (*Falco peregrinus*)], using the time-series of estimated population size and treating each

IUCN Red List Criteria	
A	Reduction in population size
B	Small range – fragmented, declining or fluctuating
C	Small population – declining or fluctuating
D/D1	Very small population
D2	Very small range
E	Quantitive analysis – probability of extinction

IUCN Red List Category		
Global	Regional/national	
Extinct	Extinct	EX
Extinct in the Wild	Extinct in the Wild	EW
	Regionally Extinct	RE
Critically Endangered	Critically Endangered	CR
Endangered	Endangered	EN
Vulnerable	Vulnerable	VU
Near Threatened	Near Threatened	NT
Least Concern	Least Concern	LC
Data Deficient	Data Deficient	DD
	Not Applicable	NA
Not Evaluated	Not Evaluated	NE

Figure 2. IUCN Red List Categories and Criteria for assessing species' extinction risk at the global and regional/national level [25, 26].

country as a survey locality. Trend output was smoothed using the tool TrendSpotter, which uses a structural time-series model in combination with the Kalman filter to smooth trends [22–24]. For the remaining species, data were either too sparse to produce meaningful trends, or constituted complete population censuses, for which an overall trend would not contribute any additional value.

Ancillary data on threats and conservation actions

The IUCN Red List of Threatened Species [4] is a key tool for biodiversity conservation, providing a framework for the classification of animal and plant species according to their risk of extinction in order to inform conservation efforts. Each species' extinction risk is classified based on a range of quantitative criteria (Figure 2). Threatened species are listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) according to quantitative thresholds. More details on the IUCN Categories and Criteria and their application can be found on the IUCN website [25].

The IUCN Red List Categories and Criteria assess the global extinction risk of species, but the framework can also be used for regional and national assessments [26]. The status of bird species has been evaluated by BirdLife International at a global [27], pan-European [9] and European Union (EU) scale [28]. Similarly, mammals have been assessed at the global level [29] and at the pan-European/EU scale [1]. At the European scale, the conservation status of species is evaluated against various quantitative criteria (including the IUCN system; Figure 2). Birds are classified at the European scale as Favourable (Secure) or Unfavourable (classified as Threatened Globally, Declining, Rare, Depleted, or Localised) (Table 3). Following this assessment, species are classified into categories of Species of European Conservation Concern (SPECs) and Non-SPECs (Table 4).

For each species, the main threats that have driven declines and that continue to affect the European populations, as well as the conservation actions that enabled or contributed to recovery, were identified from the literature. SAPs were a key source for this information for birds, as they aim to identify priorities for conservation action and document limiting factors and threats. For mammals, ancillary data on threats and conservation actions were extracted from the information provided for populations underlying the abundance trend, species-specific literature and communication with species experts.

Threats and conservation actions were classified according to the IUCN Threat and Conservation Actions Classification schemes [30, 31] to ensure comparability across species (note that only conservation actions linked to positive change are included in the tables accompanying the mammal species accounts, although threats responsible for declines are discussed in the text). These classification schemes follow a hierarchical structure of comprehensive and exclusive upper level categories and expandable lower level categories, which can be easily scaled, and aim to standardise descriptions of direct threats and conservation actions for systematic use in conservation projects [32]. Threats are classified into twelve upper level categories, including residential and commercial development, agriculture and aquaculture, transportation and service corridors (e.g. roads and railroads, utility and service lines), biological resource use (direct and indirect effects of hunting, fishing and harvesting), natural system modifications, pollution, and climate change and severe weather [30]. Conservation actions are classified into the following upper level categories: Land/water protection, Land/water management, Species management (e.g. reintroduction, ex-situ conservation), Education and awareness, Law and policy, and Livelihood, economic and other incen-

Red deer at the Oostvaardersplassen nature reserve in The Netherlands. Deer densities here are almost 1 deer per 2 hectares of land. That is higher than in the Serengeti.

tives (e.g. conservation payments) [31]. Land/water protection and Land/water management were combined for the purpose of mammal species accounts, based on the IUCN Red List guidelines for describing conservation actions in place [33]. In addition, information was included on the pan-European legislation for each species (see Table 1).

Preparation of species accounts

The information on population and distribution trends, threats, conservation actions and reasons for recovery was compiled into individual species accounts. Each species account was reviewed by at least one species expert, in order to ensure the accuracy of the abundance and distribution data presented, as well as that of the threats and conservation actions identified and their interpretation.

Data analysis

Distribution

The area occupied was calculated at each time point (historical, past, and present) to examine changes in the range area for each species except colonial nesting bird species, for which individual colonies were mapped rather than distribution. As the majority of information on the distribution of bird species derives from atlas data, changes in range area were also calculated on the basis of a 50 km x 50 km grid, in order to better capture the changes in area of distribution of species with small ranges in particular.

Species varied in terms of the precise date for which historical range extents could be reconstructed. For many species, dated information was available, although for some species [e.g. European bison (*Bison bonasus*), Red deer (*Cervus elaphus*) and Iberian lynx (*Lynx pardinus*)], ranges were mapped based on data from an imprecisely dated time point in history (e.g. Pleistocene, pre-1900, 1800s). We aimed to map distributions for those dates closest to 1850 and no later than 1900.

Recent range changes

We produced species richness maps for past and present distributions of our study species. For this, we overlaid a hexagonal grid onto the aggregated species' distribution. The grid is defined on an icosahedron, projected to the sphere using the inverse Icosahedral Snyder Equal Area (ISEA) projection. We then summed the number of species occurring in each hexagonal grid cell (cell

Table 1. Relevant international Directives and Conventions for the legal protection and conservation of wildlife (adapted from BirdLife International 2004 [9]).

Legal instrument	Aim	Addendums	Definition
EU Council Directive on the Conservation of Wild Birds (79/409/EEC, 'Birds Directive')	To protect all wild birds and their habitats, e.g. through the designation of Special Protection Areas (SPAs)	Annex I	Species subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution. Member states shall classify in particular the most suitable territories in number and size as special protection areas for the conservation of these species, taking into account their protection requirements in the geographical sea and land area where this Directive applies
		Annex II	1. Species may be hunted in the geographical sea and land area where the Directive applies 2. Species may be hunted only in Member States in respect of which they are indicated
		Annex III	1. Member States shall not prohibit 'trade activities' 2. Member States may allow 'trade activities' These activities are prohibited for all other species of naturally occurring wild birds in the European territory of EU Member States
EU Council Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC, 'Habitats Directive')	To contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora of community interest	Annex II	Species whose conservation requires the designation of special areas of conservation
		Annex IV	Species in need of strict protection
		Annex V	Species whose taking in the wild and exploitation may be subject to management measures
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)	To maintain population of wild flora and fauna with particular emphasis on endangered and vulnerable species, including migratory species	Appendix II	Strictly protected fauna species
		Appendix III	Protected fauna species
Convention on the Conservation of Migratory Species of Wild Animals (CMS, or Bonn Convention)	To provide a framework for the conservation of migratory species and their habitats by means of, as appropriate strict protection and the conclusion of international agreements	Appendix I	Species in danger of extinction throughout all or major parts of their range
		Appendix II	Species which would benefit from international cooperation in their conservation and management
		Appendix III	Species for which Agreements should be concluded covering their conservation and management, where appropriate by providing for the maintenance of a network of suitable habitats appropriate disposed in relation to migratory routes
Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA, under CMS)	The conservation of African-Eurasian migratory waterbirds through coordinated measures to restore species to a favourable conservation status or to maintain them in such a status	Species are classified into Columns according to the degree of protection that signatories are expected to implement and then further categorised according to the level of threat (see Table 2).	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	To ensure that international trade in specimens of wild animals and plants does not threaten their survival	Appendix I	Species that are most endangered among CITES-listed animals and plants. Threatened with extinction and CITES generally prohibits commercial international trade in specimens of these species
		Appendix II	Species that are not necessarily now threatened with extinction, but that may become so unless trade is closely controlled

size was approximately 865 km^2) to obtain the species richness pattern of our sample.

Range changes were analysed between past and present distributions. For mammals, we analysed the effects of taxonomic order and body size (defined as average weight and defined in weight classes of <25 kg, <50 kg, <100 kg and >100 kg) on range size. Where distributional area changes were not normally distributed, we used non-parametric tests in the analysis.

Range change maps were produced for all species, depicting range persistence, expansion and contraction between past and present distributions. Similarly, range changes were depicted for expansions or contractions of historical baselines. Combining range gains and range contractions of different species into taxon groups, we produced European-wide maps highlighting patterns of distributional gain and loss for a number of taxa. The approach taken was the same as for species distribution maps: we expressed the pattern of gain and loss as the number of species gaining or contracting in distribution.

Abundance trends for mammals

To evaluate abundance change in mammal species, we used a method of aggregating population abundance trends developed to calculate the Living Planet Index [2, 5]. The method aggregates multiple population time-series for a species,

Table 2.
Definitions of classification columns of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) [35].

Column	Category	Definition
A	1	(a) Species, which are included in Appendix I to the Convention on the Conservation of Migratory species of Wild Animals; (b) Species, which are listed as threatened on the IUCN Red list of Threatened Species, as reported in the most recent summary by BirdLife International; or (c) Populations, which number less than around 10,000 individuals.
	2	Populations numbering between around 10,000 and around 25,000 individuals.
	3	Populations numbering between around 25,000 and around 100,000 individuals and considered to be at risk as a result of: (a) Concentration onto a small number of sites at any stage of their annual cycle; (b) Dependence on a habitat type, which is under severe threat; (c) Showing significant long-term decline; or (d) Showing large fluctuations in population size or trend.
	4	Species, which are listed as Near Threatened on the IUCN Red List of Threatened species, as reported in the most recent summary by BirdLife International, but do not fulfil the conditions in respect of Category 1, 2 or 3, as described above, and which are pertinent for international action.
B	1	Populations numbering between around 25,000 and around 100,000 individuals and which do not fulfil the conditions in respect of Column A, as described above.
	2	Populations numbering more than around 100,000 individuals and considered to be in need of special attention as a result of: (a) Concentration onto a small number of sites at any stage of their annual cycle; (b) Dependence on a habitat type, which is under severe threat; (c) Showing significant long-term decline; or (d) Showing large fluctuations in population size or trend.
C	1	Populations numbering more than around 100,000 individuals which could significantly benefit from international cooperation and which do not fulfil the conditions in respect of either Column A or Column B, above.

Table 3.
European threat status of birds [9], also applicable to populations in the European Union [28].

European threat status	Definition
Critically Endangered (CR)	European population meets any of the IUCN Red List Criteria for Critically Endangered
Endangered (EN)	European population meets any of the IUCN Red List Criteria for Endangered
Vulnerable (VU)	European population meets any of the IUCN Red List Criteria for Vulnerable
Declining (D)	European population does not meet any IUCN Red List Criteria, but declined by more than 10% over 10 years (1990–2000) or three generations, whichever is longer
Rare (R)	European population does not meet any IUCN Red List Criteria and is not Declining, but numbers fewer than 10,000 breeding pairs (or 20,000 breeding individuals, or 40,000 wintering individuals) and is not marginal to a larger non-European population
Depleted (H)	European population does not meet any IUCN Red List Criteria and is not Rare of Declining, but has not yet recovered from a moderate or large decline suffered during 1970–1990, which led to its classification as Endangered, Vulnerable or Declining in the preceding assessment [10].
Localised (L)	European population does not meet any IUCN Red List Criteria and is not Declining, Rare or Depleted, but is heavily concentrated, with more than 90% of the European population occurring at 10 or fewer sites
Secure (S)	European population does not meet any of the criteria listed above
Data Deficient (DD)	Inadequate information to make a direct, or indirect, assessment of risk of extinction based on distribution and/or population status
Not Evaluated (NE)	European population has not yet been evaluated against the criteria

Table 4.
Categories of Species of European Conservation Concern (SPEC) and Non-SPECs [9] (for birds).

SPEC Category	Definition
1	European species of global conservation concern, i.e. classified as Threatened of Data Deficient under the IUCN Red List Criteria at a global level
2	Species whose global populations are concentrated in Europe, and which have Unfavourable conservation status in Europe
3	Species whose global populations are not concentrated in Europe, but which have an Unfavourable conservation status in Europe
Non-SPEC^{E}	Species whose global populations are concentrated in Europe, but which have a Favourable conservation status in Europe
Non-SPEC	Species whose global populations are not concentrated in Europe, and which have a Favourable conservation status in Europe

calculating the average change in abundance for each year compared with the preceding year. This value is then chained to the previous average annual population change to produce an index, with an initial value set to 1 in 1960.

More specifically, the method measures trends in the abundance of populations of species (i.e. changes in the number of individuals within populations) and, because population-based trends are aggregated to a species level, it also tracks species abundance (i.e. the change in the number of individuals of a particular species).

All trend analyses were carried out in R version 2.12.0 [34]. Indices of change in species abundance were calculated from 1960 using a Generalised Additive Modelling framework to obtain population trends, followed by a geometric aggregation method to produce an index [2]. The change per decade and overall change were presented as bar charts. Decadal change was calculated for the 1960s, 70s, 80s, 90s, and 2000–2005 as the difference between the last and first year of the decade. The overall change was drawn as the difference between the first year of the time series (usually 1960) and 2005.

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3. Mammal species accounts

Here we present detailed species accounts for 18 species of European mammals. Each account covers the background ecology and status of the species, details of current distribution and abundance estimates, an evaluation of how distribution and abundance have changed since the early 19th century, and where appropriate, details of recent developments noted for the species.

1. European bison (*Bison bonasus*)
2 Alpine ibex (*Capra ibex*)
3. Iberian ibex (*Capra pyrenaica*)
4. Southern chamois (*Rupicapra pyrenaica*)
5. Northern chamois (*Rupicapra rupicapra*)
6. Eurasian elk (*Alces alces*)
7. Roe deer (*Capreolus capreolus*)
8. Red deer (*Cervus elaphus*)
9. Wild boar (*Sus scrofa*)
10. Golden jackal (*Canis aureus*)
11. Grey wolf (*Canis lupus*)
12. Eurasian lynx (*Lynx lynx*)
13. Iberian lynx (*Lynx pardinus*)
14. Wolverine (*Gulo gulo*)
15. Grey seal (*Halichoerus grypus*)
16. Harbour seal (*Phoca vitulina*)
17. Brown bear (*Ursus arctos*)
18. Eurasian beaver (*Castor fiber*)

3.1. European bison

Bison bonasus

Summary

The European bison, the largest herbivore in Europe, went extinct in the wild in the early 20th century due to habitat degradation and fragmentation, forest logging, and unlimited hunting and poaching. Only 54 individuals with known pedigree from 12 ancestors remained in captivity, and these formed the basis for a large-scale breeding, reintroduction and translocation programme, which resulted in the re-establishment of a number of wild populations. The species currently exists in 33 free-living, isolated herds of two genetic lines in central and eastern Europe, with particular strongholds in Poland and Belarus. Although the situation of the European bison has undoubtedly improved over the past 50 years, the species remains at risk from its low genetic diversity and lack of connectivity between populations.

Background

General description of the species

The European bison or wisent (*Bison bonasus*) is the largest herbivore in Europe and one of the few surviving megafauna species [1, 2]. A gregarious, ruminant species, bison feed on up to 60 kg of lichen, mosses, leaves, grasses, shrubs, acorns and bark per day [3]. The social unit is the herd, which shows synchronised daily activity rhythms [3]. Movements relate mainly to feeding activity and habitat utilisation is dependent on group size and structure, and habitat preferences [3]. Mixed groups of cows, young, calves and adult bulls are of varying size dependent on the environment, while bull groups contain two animals on average [3]. More than half of males, which make up 25% of the bison population, lead a solitary life [3]. Bulls become sexually mature at three years but usually do not take part in reproduction until the age of six due to aggressive behaviour from older individuals [3]. Cows reach maturity in the third year of their life, giving birth to one calf between May and July, although late parturition does occur [3].

Distribution in Europe

The earliest record of European bison in Europe is from the early Holocene based on fossil deposits found in northern central Europe [1]. Other archaeozoological evidence suggests that the species was once widespread on the continent, reaching from France to the Ukraine and up to the northern shores of the Black Sea [1, 3]. Palynological finds further point to bison inhabiting woodland habitat such as deciduous, pine and oak forests [1]. The species is thought to have declined initially due to a changing climate [4], while deforestation and over-hunting were implicated in later range contraction and population crashes [1, 4, 5]. Although protected as royal game in Poland, Lithuania and Russia, the European distribution significantly reduced from the 15th century from west to east, going extinct in various countries such as Hungary in the 16th century, Ukraine in the early 18th century and Romania in 1762 [3]. This process resulted in the persistence of only two populations by the early 20th century [3]. During the First World War natural populations became almost entirely extinct due to habitat loss, degradation and fragmentation, competition with abundant deer species, and over-hunting [3]. The last free population survived in the Caucasus until 1927, after which 54 captive individuals with known pedigree from 12 ancestors remained [2, 3]. The species currently exists in 33 free-living, isolated herds of two genetic lines (lowland and lowland-Caucasian) in central and eastern Europe, which have become established following reintroductions in the 20th century [3, 6].

Habitat preferences and general densities

The bison occurs in a variety of wooded habitats across Europe, including deciduous, mixed coniferous and coniferous forest year-round in its central European range, as well as alpine meadows in the Caucasus in the summer [3]. It has been suggested that the species has historically been a grazer suited to more open habitat and is currently occupying a 'refuge' habitat, which it was forced into after a reduction of open steppe and an increase in human pressure [7]. Around 80% of the bison's diet consists of grasses, so a connection with open spaces is necessary; however, the species seeks the safety of the forest to ruminate, thus making it a forest species [8]. The optimum habitat therefore consists of forested environments for cover with areas of open habitat such as meadows or forest clearings for grazing [3]. In terms of population density, the number of free-living bison herds is low and many inhabit small patches of habitat, so little information is available on the density the species naturally occurs at. However, as mixed groups do not usually exceed 20 animals, the maximum density of the species is rather low [9], ranging from 13 indivduals per 1,000 hectares in the mountainous forests of the Caucasus to less than 10 per 1,000 hectares in the Carpathians [10]. For most ecosystems, optimal population density is provisionally assumed to be 5 animals per 1,000 hectares [10].

Legal protection and conservation status

In the past, European bison were protected as a game species, but still suffered population decline [3]. Since the loss of wild populations in the 20th century, conservation efforts have been largely centred on re-establishing wild populations through reintroductions of individuals from breeding programmes in zoological collections. More recently, the focus has been on expanding the European bison's current geographical range, as well as the diversification and maintenance of the gene pool. Breeding is controlled by the European Bison Pedigree Book (EBPB), which represents the first studbook for any wild species [11] and is updated annually [3]. Because natural mortality tends to be low in large or medium-sized free-ranging herds, it does not normally contribute significantly to population regulation. In some areas, culling is used to ensure stability at a certain population

Table 1. Summary of Global and European Red List assessments and threats listed for the European bison.

Scale	Status	Population trend	Justification	Threats
Global/Europe [14, 15]	Vulnerable	Increasing	<1,000 mature individuals	1. Habitat degradation/fragmentation 2. Illegal poaching 3. Conflict and political instability 4. Inbreeding depression 5. Disease 6. Hybridisation
Europe — regional populations	Vulnerable: Lowland line Endangered: Lowland-Caucasian line [15]	N/A	Small population size resulting in compromised long-term viability [15]	1. Lack of habitat due to human encroachment 2. Limited gene pool resulting in inbreeding depression 3. Fragmentation and isolation of herds, preventing gene flow 4. Declines of reconstructed ranges, e.g. in the Caucasus 5. Mixing of genetic lines 6. Hybridisation with American bison and bison-cattle hybrids 7. Inappropriate management (not based on forest ecology), including supplementary feeding 8. Disease, e.g. foot-and-mouth, balanoposthitis, and parasitic diseases including Cervidae-specific illnesses 9. Poaching 10. Conflict with humans [3]

size, for example in Białowieża since 1970 [2], where the mean annual reduction in European bison numbers was 11% between 1971 and 1999 [3]. The bison is listed under the Bern Convention (Appendix III) [12] and the Habitats Directive (Appendices II and IV) [13]. Bison populations are protected in their range countries and recognised by conservation bodies as vulnerable to extinction because of small population size despite an increasing population trend (Table 1). The lowland and lowland-Caucasian lines are listed as Vulnerable and Endangered respectively (Table 1). The bison is affected by a variety of different threats at the European and local level, including habitat loss and fragmentation, low genetic diversity, lack of connectivity between herds, hybridisation, disease, poaching and inappropriate management (Table 1).

Abundance and distribution: current status

In terms of population size (Table 2), an estimate from 2011 puts the total number of free-ranging European bison at 2,759 individuals. Of these, 61% are of the pure-bred lowland line, while the remainder are of mixed lowland-Caucasian descent. At the country level, strongholds for the species exist in Poland (36%), Belarus (34%) and Russia (17%), with smaller populations in Ukraine (9%), Lithuania (2%), Romania (2%) and Slovakia (<1%) (Table 2).

The largest surviving population of free-living bison of over 850 individuals or 31% of the European population occurs in the Białowieża Primeval Forest [2, 3, 16], which straddles both Poland and Belarus. There is, however, little opportunity for dispersal between the two countries due to existing physical barriers [3]. Poland is considered a particular stronghold for European bison: the Białowieża forest has long been part of the bison's core range in Europe and the first reintroduction of wild bison occurred here in 1952. There are also significant populations in the northwest and southeast of the country, of which all but Bieszczady, which accounts for around 31% of the country's bison, are descended from the lowland line [16].

A significant number of bison from the lowland line also occur in seven locations in Belarus, including the Białowieża Forest (Bielavezhskaya Pushcha in Belarusian) [16]. The third highest number of individuals can be found across 11 locations in European Russia; all of these are members of the lowland-Caucasian line, with populations in the northwestern Caucasus also containing some American bison genetic material [10]. Because the lowland-Caucasian line is based on a greater number of founder individuals, it contains some genetic material not present in pure-bred lowland line, however genetic variability is still very low and it is important not to further interbreed the lines [10].

The Carpathian Mountains are also an important area for the species. Populations have persisted here, but they are small and highly fragmented, and reintroductions are being carried out in Romania to remedy this [17]. These mountains have been identified as a key area for improving bison population viability, and ensuring its long-term survival [5], provided that suitable habitat and connectivity can be ensured.

Abundance and distribution: changes

Like many large mammals, the European bison has experienced a continuous and extensive reduction in its European range, particularly in central and western Europe (Figures 1A, B and C). By 1890, the species had retracted from over 99% of its Pleistocene distribution, which extended from the Spanish Pyrenees to southern European Russia, and included southern England, Sweden, Finland and the Mediterranean islands of Sardinia and Corsica (Figure 1A). As a result of this, the bovid existed in only two isolated populations in the Russian Caucasian Mountains and Białowieża forest in Poland and Belarus (Figure 1A). A slight expansion of 7% occurred between 1890 and 1971; while Caucasian territory was lost, reintroductions led to the colonisation of a number of additional areas in Poland, Estonia, Slovakia, Belarus and Romania (Figures 1A and B). Despite these conservation efforts, the bison's distribution appears to have reduced by another 69% by 2011, primarily around the core populations in Poland, Lithuania, Belarus and Ukraine, leaving it to occupy a mere 0.2% of its Pleistocene and 33% of its 1890s distribution respectively. However, these dramatic changes, especially in recent times, are very likely to be mostly attributable to the difference in spatial resolution between the maps for the two time periods in question. More specifically,

Table 2.
Latest population estimates for free-ranging European bison globally, in Europe and for European populations.

	Estimate	Year assessed	Reference
Global/Europe	**2,759**	**2011**	[16]
% of global population	**100%**		
Belarus (Lowland)	937	2011	[16]
Lithuania (Lowland)	61	2011	[16]
Poland (69% lowland)	991	2011	[16]
Romania (Lowland-Caucasian)	58	2011	[16]
Russia (Lowland-Caucasian)	461	2011	[16]
Slovakia (Lowland-Caucasian)	9	2011	[16]
Ukraine (Lowland-Caucasian)	242	2011	[16]

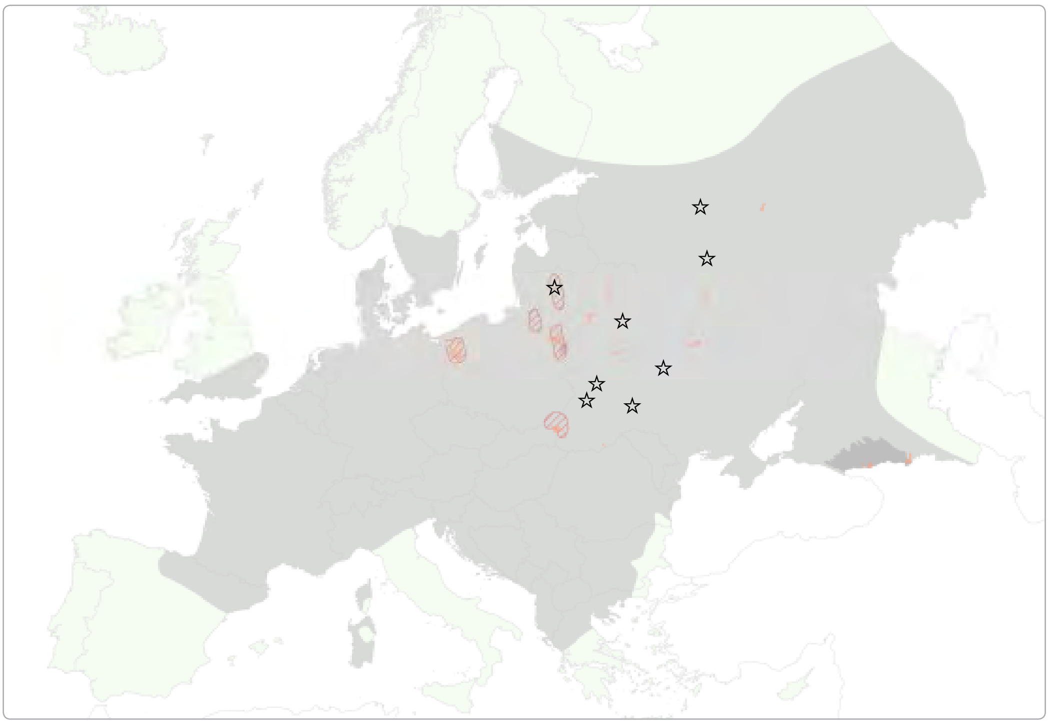


Figure 1A. Distribution of European bison in the **Pleistocene** [3, 18], **1890** [19], **1971** [20] and **2011** [6]. Stars denote smaller extant populations. Please note that only free-living populations are shown.

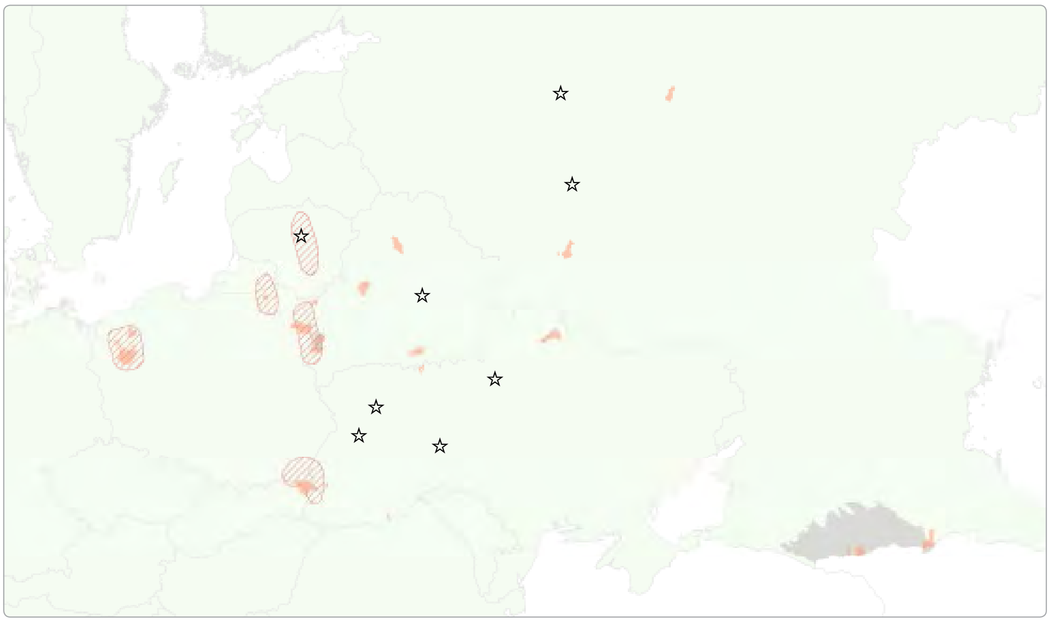
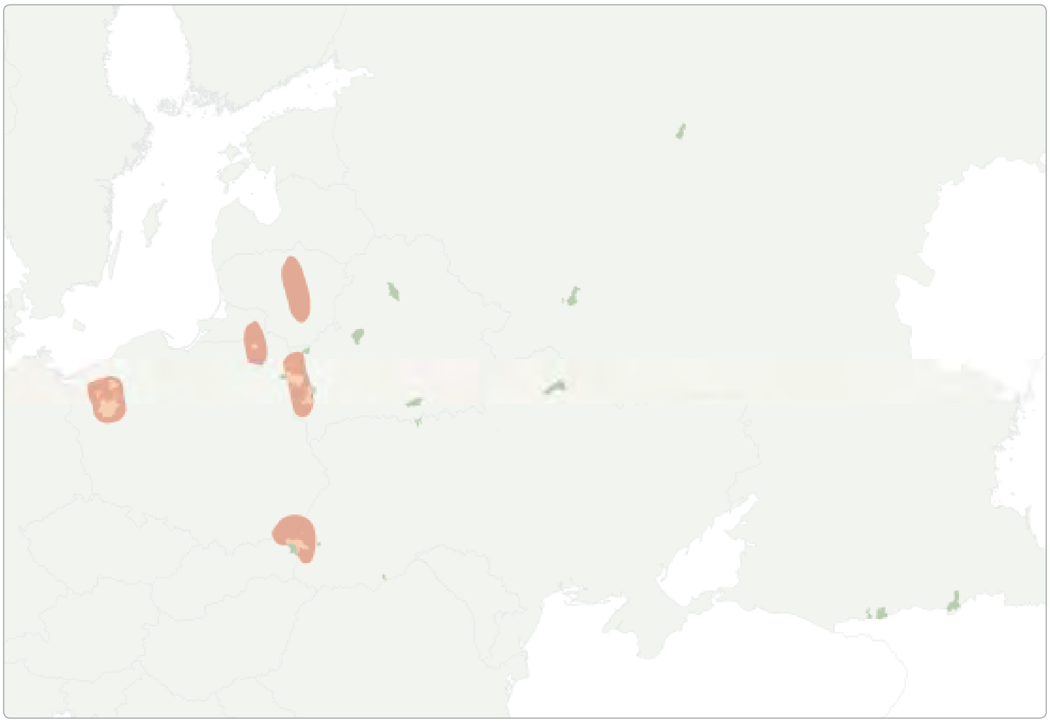


Figure 1B. Distribution of European bison in **1890** [19], **1971** [20] and **2011** [6]. Stars denote smaller extant populations.

the 1971 map is much coarser, and is therefore likely to lead to an over-estimation in the range reduction of the species by 2011. The fact that new territories, although small, were established as a result of reintroductions in Belarus, Ukraine and Russia gives further weight to the idea that range contraction was perhaps less pronounced than depicted in Figure (Figures 1A and 1B).

At the same time, European bison populations experienced an increase in abundance of over 3,000% (Figure 2). Most of this positive change appears to have occurred in the 1960s, with much smaller increases in the following two decades (Figure 2). This is in line with the literature, which quotes a doubling every 5–6 years in the 1950s and 1960s followed by a doubling every 11–12 years subsequently [3]. In our dataset, the increase slowed to 16% and 12% in the 1990s and 2000–2005; at this point in time, a significant decrease in numbers was observed, with birth rates becoming fixed in some herds at a lower level compared with the first few years after reintroduction [3]. In addition, some free-living populations became extirpated, while others suffered the impact of heavy poaching; for example, in Lithuania 20% of individuals were lost in the early 2000s [3]. However, the reduction in the rate of increase may also be due to a number of animals no longer being registered in the European Bison Pedigree Book as a result of lack of contact from particular breeders [3]. Overall, the bison's current situation can still be described as much more favourable than prior to its extinction

Figure 1c.
Map highlighting areas of range **expansion**, **persistence** and **contraction** of the European bison in Europe between 1971 and 2008.



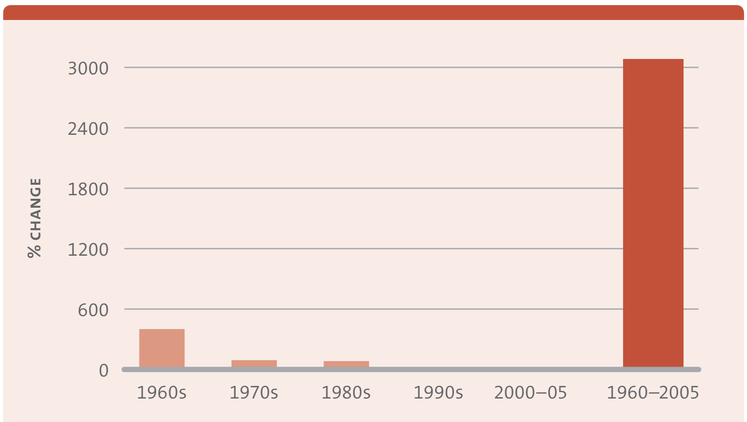
in the wild. The abundance trend is based on 10 populations from across the range, representing a minimum of 1,200 individuals, or 44% of the total European population of 2011, covering 71% of all countries of occurrence. Data were missing from only two of locations within the species' current range, namely Romania and Lithuania.

Drivers of recovery

While no overriding factors could be identified in our data set to explain the large increase in the European population of bison, it can undoubtedly be attributed to the large-scale breeding, reintroduction and translocation efforts that have taken place since its precipitous decline [1, 3, 4] and extirpation in the 20th century. The first reintroduction took place in 1952 in the Białowieża forest and this population first started reproducing in 1957 [3], which coincides with the upward trend depicted in Figure 2. Changes in population size as well as genetic integrity are recorded in detail in the annually updated European Bison Pedigree Book (EBPB) [3], which provides a central resource to guide reintroduction efforts. In addition to targeted management, environmental conditions such as winter snow cover and May temperature have been shown to affect the bison in Białowieża forest, with less snow and warmer temperatures resulting in higher recruitment rates [2]. The species also benefits from oak seed mast years, which provide an abundance of food, and the protection and management of oak forest should therefore be more heavily integrated into bison management [2].

However, while the bison may indeed have a more favourable conservation status at present, the exponential recovery in abundance observed must be considered in the context of the severely depleted state of the population in 1960. Interestingly, there has also not been a concomitant clear expansion in range. While new territories have been established across eastern Europe, the species' distribution has remained small and fragmented. In addition, reintroductions appear to have been losing their momentum [3], which could explain the larger increases in earlier decades. Overall, successive reintroductions have not yet resulted in an increase in the range of the species or the viability of existing herds [5]. Recommendations for future conservation efforts are to focus on creating suitable habitat in areas where farmland is being abandoned, such as in the Carpathians [5], as well as on establishing a metapopulation across eastern Europe, on which the long-term survival of the species depends [21].

Figure 2.
Change in European bison population **abundance by decade** and **overall change** between 1960 and 2005. Error bars have been removed for clarity. Please note that due to the way change was calculated, decadal change does not sum to overall change.



Rank	Reason for change	Description
1	**Species management — Conservation breeding, reintroductions and translocations**	First reintroduction in 1952 in the Białowieża forest, leading to successful reproduction in 1957 [3]. Changes in population size are recorded in detail in the annually updated European Bison Pedigree Book (EBPB) [3].
2	**Other — Environmental conditions**	Low snow cover, warmer winter and May temperatures, and oak seed mast years have a positive effect on bison recruitment [2].

Table 3. Major reasons for positive change in the status of the European bison in Europe.

Recent developments

While populations of European bison in core areas such as the Carpathians and Białowieża are stable, moves for further introductions are being made in various countries which were once part of the European range of the species (Figure 3). Most of these have involved the introduction of semi-free living individuals to areas throughout Europe, including eight in the Czech Republic [22, 23], 28 in France [6, 16], and a further seven have been released into a 20 hectare enclosure in Palencia in Spain as part of a long-term plan towards establishing the bovid in the region [24]. In Germany, eight individuals released from a fenced area in the Rothaar mountains in 2013 became the first free-living bison in Germany for 400 years [25]. The first calf to be born here in the wild was quickly followed by another, bringing the total group size up to 10 individuals [25]. While many of these herds may not be viable in the long-term without focused management intervention [5], they can contribute to the maintenance or increase of the species' gene pool, and allow for linkages between existing populations. Habitat connectivity is likely to be the most significant contributor to the survival of the species in the long term [5].

Indeed much recent research has focused on working towards the establishment of the eastern European metapopulation within the Carpathian mountain range [21], which is crucial for ensuring gene flow [3] in this species of low genetic variability [26]. A recent study has identified a number of suitable, uninhabited patches in the Gorgany and Czornohora mountains (Ukraine), and Făgăraş, Maramureş and Rodna mountains (Romania), which could act as high-quality dispersal corridors [27] and take advantage of farmland abandoned in the wake of the collapse of socialism. Provided that in the Ukraine the main threat of poaching can be successfully addressed and the public's attitude towards the species changed through education [28], a large, well-connected and demographically safe population – the main goal for the conservation of European bison [3] – could be realised.

Although the situation of the European bison has undoubtedly improved over the past 50 years, the species remains at risk from its low genetic diversity and numbers are continuing to fall in the Ukraine [26, 29]. Along with poaching, diseases and habitat defragmentation, the lack of cooperation between breeding centres leading to malpractice is believed to be a potential threat that will need to be addressed in the future [29]. More and more, however, countries are collaborating in their efforts to save this species from another extinction in the wild. For example, the 11th international conference on European bison, which is taking place in September 2013, will provide a forum within which to discuss all projects realised in Europe and to strengthen ties [8].

Figure 3. Map of recent developments recorded for the European bison in Europe.

Expansion
Persistence
Contraction
◊ Reintroduction
? Potential reintroduction

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3.2. Alpine ibex

Capra ibex

Summary

The Alpine ibex has been able to make a significant recovery over the last 45 years with the help of various types of conservation initiatives, including protection, captive breeding, reintroduction and translocation. The species has now reached high numbers in some areas, which is leading some managers to propose culling for the apparent prevention of damage to the environment.

Background

General description of the species

The Alpine ibex (*Capra ibex*), or Steinbock, is a large member of the *Caprinae* family, previously endemic to the European Alps [1]. As a social, diurnal species, the ibex is usually found in maternal herds or bachelor groups [2], feeding mostly on grasses and woody plants [2].

Distribution in Europe

The species is distributed throughout the European Alpine arc countries, including Switzerland, France, Austria, Germany, Italy and has also been recently introduced to Bulgaria and reintroduced to Slovenia [2]. During the last glaciations, the species ranged over much of Europe including lowland areas in France, Luxembourg, Slovenia, Croatia, the Czech Republic, Slovakia, Hungary and Romania [3]. The species began to decline in the 15th century [4] due to over-hunting [1, 4], which continued for 300 years [4]. Exploited for meat and horns, but also for parts and blood, to which medicinal qualities were ascribed, the ibex was easy prey both because of its nature and the introduction of guns [5]. Legal protection of the species started in Austria in 1523, and the first reintroduction was attempted here in 1699, although neither measure was able to curb the decline [5]. As a result, the ibex was close to extinction in the early 18th century, with a single population of less than 100 individuals remaining in the Gran Paradiso Massif of the Italian Alps [4]. Protection in Italy came with a total ban on hunting in 1821, which was re-enforced in 1826 [5], as well as the establishment of the Gran Paradiso National Park. Through translocation, this remnant population forms the basis for the entire European population of the species. The first successful reintroduction in Switzerland took place in 1911 [6]; and since then, reintroductions have been undertaken in 175 areas in the Alps [3].

Habitat preferences and general densities

The Alpine ibex occurs primarily in alpine, rocky and open habitats at high altitudes (800m–3,200m above sea level [7]), spending most of the year above the tree line [2]. The species does, however, migrate

Scale	Status	Population trend	Justification	Threats
Global / Europe	Least Concern	Increasing	Wide distribution Large population Increasing trend	1. Genetic diversity 2. Human disturbance 3. Natural system modification 4. Invasive species/genes

Table 1. Summary of Global and European Red List assessments and threats listed for the Alpine ibex [2, 11].

to lower altitudes in winter and spring [2, 3]. Steep, rocky topography is an important feature of ibex habitat, as it retreats to precipitous slopes when threatened.

Legal protection and conservation status

The Alpine ibex is protected by the Bern Convention (Appendix III) [8], the EU Habitats and Species Directive (Annex V) [9], and by national legislation in most countries within its range [2]. Threats include low genetic diversity (increasing the likelihood of disease, parasites and inbreeding depression), habitat fragmentation, and hybridisation with domestic sheep [2]. Legal protection [2], reintroductions [2], and the absence of natural predators has led to great increases in some areas, making culling sustainable [10]. At a global and European level, the Alpine ibex is classified as Least Concern due to its widespread distribution, presumed large population size, and an increasing population trend (Table 1).

Abundance and distribution: current status

In terms of population size, an estimate from 2007 puts the total number of individuals in Europe at over 36,500 (Table 2). The most significant populations occur in Italy and Switzerland, each containing approximately 41% and 37% of the European population respectively (Table 2). Further populations exist in Austria (11%) and France (8%), with smaller populations in Germany and Slovenia (Table 2). Outside of its natural Alpine range, the species was also introduced into Bulgaria in the 1980s.

In the early 19th century, the last surviving population of Alpine ibex could be found in Italy, and the country also holds the largest number of individuals at present [3]. Widespread reintroductions have taken place during the past 30–40 years, and signs of recovery started to show in the 1980s [3]. The species now occurs in disjunct units fragmented by glaciers and forests, which limit their movement [3]. In Switzerland, the ibex reportedly went extinct in 1840 [5]. Since then, the ibex has been subject to a number of reintroductions following the first success in the Swiss National Park in 1920 [14].

Abundance and distribution: changes

A prominent problem with historical maps is the fact that they are often of a lower resolution than their more recent counterparts, causing severe over- or under-estimations in range change over time. In the case of the Alpine ibex, the range depicted for 1967 in Figure 1A is the best available but also highly misleading, as much of it falls mostly or entirely outside suitable ibex habitat, especially in the southern and eastern part of the range [15]. As such, both the exponential increase in range (17,000%) since 1800, when the species occupied an area of just over 200 km² in the Gran Paradiso National Park in Italy, and the 56% contraction in area by 2008 (Figures 1A and B), must not be taken at face value and instead interpreted with extreme caution. The range contraction since the 1960s is likely an artefact of different map resolutions in time as opposed to a genuine decline in range size [15]. Discounting the 1967 distribution, the species presently occupies an area 7,500% the size of its supposed historical range. Although this upturn in trend is promising, the extremely restricted range of the species in historic times may point to this expansion perhaps representing a very modest recovery, especially considering the possibility that the 1800 range had come at the end of a period of contraction.

The recent positive change in distribution is also reflected in the abundance trends of Alpine ibex populations, which show a rapid increase from the mid-1980s onwards, leading to a recovery of around 500% overall (Figure 2). The trend is based on 10 populations from across the Alpine region but mainly from Switzerland, representing a minimum of 6,000 individuals, or 16% of the total European population, from 60% of its countries of occurrence (not including its '(re)-introduced' range in Slovenia and Bulgaria).

Table 2. Latest population estimates for the Alpine ibex globally, in Europe and for European populations. Please note that the reintroduced population in Bulgaria was not included.

	Estimate	Year assessed	Reference
Global / Europe	36,780	2004/5	[12, 13]
% of global population	100%		
Austria	4,000	2004/5	[13]
France	3,000	2004/5	[13]
Germany	845	2004	[12]
Italy	14,900	2004/5	[13]
Slovenia	250	1997	[12]
Switzerland	13,785	2004/5	[12]

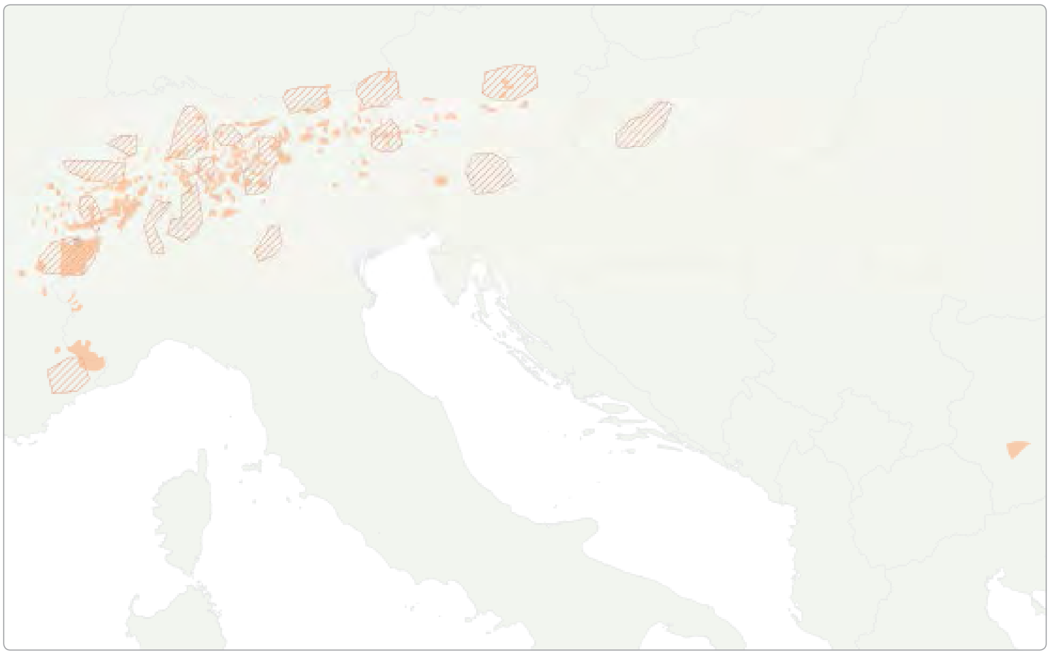

Figure 1a. Distribution of Alpine ibex in Europe in 1800 [4], 1967 [16] and 2008 [2]. Please note that the 1967 distribution represents an over-estimation of the species' actual range.

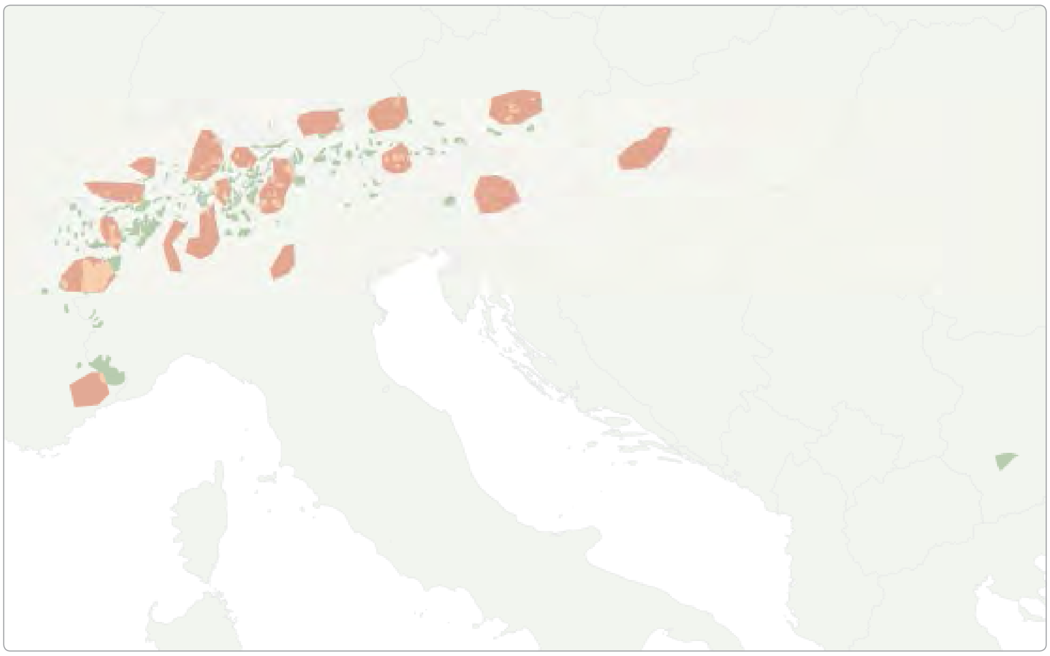

Figure 1b. Map highlighting areas of range expansion, persistence and contraction of the Alpine ibex in Europe between 1967 and 2008. Please note that contraction observed from 1967 to 2008 is likely to be an artefact of the difference in map resolution.

Drivers of recovery

There are several possible reasons for the increases in population size observed from our data set of Alpine ibex (Table 3). At a country level, populations from Italy and Switzerland, which have shown range change since the mid-20th century (Figure 1a), are increasing at a low rate at just above zero. In contrast, an ibex population from France was associated with the largest increase in abundance over the study period. This population resulted from a reintroduction to the Vercors area in the Western Alps [17], and its increase was considered in support of a reintroduction project of the Bearded vulture (*Gypaetus barbatus*) here. Unexpectedly, populations that were not threatened and did receive management intervention increased less than their counterparts. It is possible that the lack of information available from the French population skewed the results, and that this population may well have been managed in some way and not affected by any threats.

Other possible factors influencing the change in population of the Alpine ibex can be identified from the literature. For example, the Gran Paradiso population is strongly affected by winter conditions, with low snow depth in mild winters in the 1980s resulting in an increase due to adult survival, and this may have also positively affected recruitment [7]. In general, yearly fluctuations in numbers were negatively affected by population density, by winter snow depth, and by the inter-

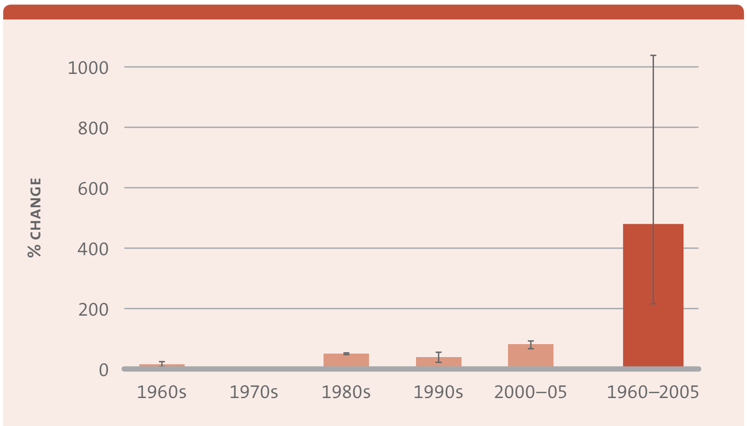

Figure 2. Change in Alpine ibex population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

action between the two variables [7]. Deeper snow is associated with a larger number of avalanches, which may bring with them a higher risk of mortality [4]. However, it is likely that animals are simply more likely to starve in deep snow due to lack of food [15].

While the historic decline of the species to one remnant population is thought to have been entirely down to over-exploitation and poaching [18], its recent recovery has been attributed to a four-stage conservation effort [4]: effective protection of the remaining population, captive breeding, reintroduction of captive-bred individuals, and translocation of animals from the reservoir populations to uninhabited sites. Perhaps as a result, some populations have reached high numbers so that culling initiatives are advocated by some managers to keep populations at what they perceive to be a sustainable size, thus resulting in little or no change in abundance [7]. Density-dependent regulation may also be taking place [7].

Recent Developments

Despite the positive change in population abundance and more recent expansion into new areas, there have also been a number of set-backs in the recovery of the Alpine ibex, most of which relate to disease (Table 3). After a number of keratoconjunctivitis outbreaks associated with *Mycoplasma conjunctivae* in Switzerland and other *Mycoplasma* species in Italy, a new, atypical strain (*Mycoplasma agalactiae*) of unknown origin has emerged and disseminated in the species in France, leading to large-scale mortality events [19]. The species has also been found to be susceptible to brucellosis transmitted by domestic sheep [20]. There have also been recurring outbreaks of sarcoptic mange, e.g. in the Marmolada massif in the eastern Italian Alps in 2003/4, when 3 out of 5 individuals died, and again from 2009/10 [21]. The disease caused a sharp decrease in the survival of both sexes and all age classes during the first outbreak, with a higher mortality rate for senescent males, while survival was high in the following years. Future management of the disease may indeed involve the use of detector dogs, which have been shown to identify successfully mange-infected animals to allow for the rapid removal and treatment of carcasses and sick animals [22]. While winter harshness did not contribute to explaining the high mortality observed in Marmolada [21], it is often assumed to be a factor in survival [15]. Conversely, however, low snow cover was associated with a decline in the Gran Paradiso National Park population of ibex [23]. This is because although rapid change in vegetation resulting from earlier, climate-induced green-up will translate into higher productivity, it also shortens the period in which high-quality forage is available over a large spatial scale [23], making climate change a serious future threat for this range-restricted species.

On the other hand, the species continues to be a great media focus. In 2011, Switzerland celebrated the centenary of the reintroduction of the species into the Weißtannen Valley using descendants of individuals that had been stolen from the King of Italy and smuggled over the Swiss border [24]. This celebration was marked by a range of events, as well as the release of more individuals into the reserve [25]. In France, a total of 30 individuals were released into the Hauts de Chartreuse National Nature reserve in 2010 and 2011 [26, 27]. Three kids were born following the 2010 release [27], and with ongoing reintroductions [27] and extensive management (a climbing route was created for individuals trapped on a ledge because these represented 18% of the local population [28]), the future is looking bright for this new population. Indeed, the Alpine ibex as a whole has been able to make a remarkable recovery throughout its distribution, and although it has not been able to recolonise all of its historical range, with further protection and intervention, there is no reason to assume that it will not continue to fare well in the future.

Table 3. Major reasons for positive change in the status of the Alpine ibex in Europe.

Rank	Reason for change	Description
1	Legislation	The Alpine ibex is listed on Appendix III of the Bern Convention [8], Annex V of the EU Habitats and Species Directive [9], and is protected by national legislation in most countries within its range [2].
2	Species management – Captive breeding, reintroduction and translocation	Switzerland: the ibex has experienced a number of reintroductions following the first success in the Swiss National Park in 1920 [14]. France: reintroduction to the Vercors area in the Western Alps [17], and translocation of animals from the reservoir population to uninhabited sites.
3	Other – Seasonal changes	Gran Paradiso: low snow depth in mild winters leads to increased adult survival as well as a possible positive affect on recruitment [7].

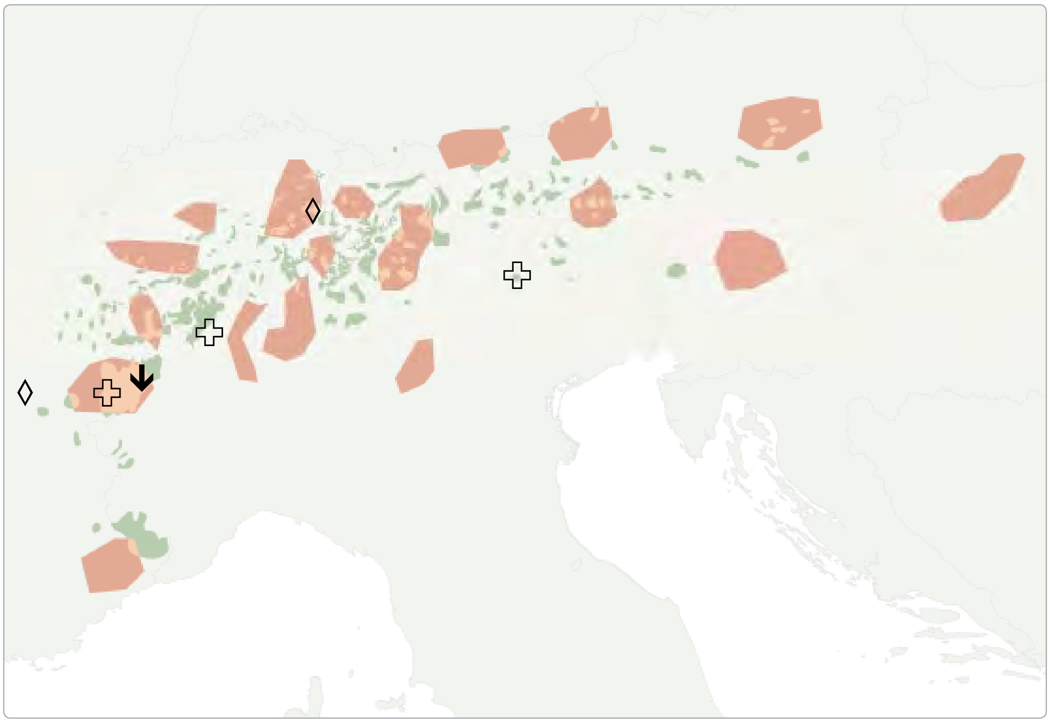

Figure 3. Map of recent developments recorded for the Alpine ibex in Europe.

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Reviewer:

- **Professor Marco Festa-Bianchet**

3.3. Iberian ibex

Capra pyrenaica

Summary

The Iberian ibex declined due to over-exploitation, poaching, infection and inter-species competition. In contrast, legal protection, translocations and reintroductions, and new habitat resulting from rural abandonment have had positive effects on the species' distribution and abundance. However, there are differences in ecology between the two remaining subspecies, and future management strategies will have to be devised accordingly.

Background

General description of the species

The Iberian ibex (*Capra pyrenaica*), a familiar and popular species due to its occurrence in close proximity to humans, is endemic to the Iberian peninsula [1]. As a mixed feeder, it browses or grazes depending on the availability of plants, and diet is influenced by altitude [2], geographic location [3] and season [4]. Based on the small genetic distance between Iberian and Alpine ibex (*Capra ibex*) [5] as well as paleontological descriptions found in Germany [6], the species are believed to have split following a wave of *Capra* immigration into Europe 300,000 years ago [5].

Distribution in Europe

Once widely distributed throughout southwest France, Spain, Andorra, and Portugal, the ibex decreased significantly over the past 200 years due to over-exploitation and habitat loss [7–9]. It formerly existed in four subspecies [1]. *C. p. lusitanica*, which inhabited northwest Portugal and Galicia in Spain, died out at the end of the 19th century [10]; and *C. p. pyrenaica*, which was abundant in the Pyrenees in the Middle Ages [11] and remained in the Spanish territory until its extinction in 2000 due to overhunting, agricultural development and expansion, and habitat deterioration [7, 12]. Today, two subspecies remain: *C. p. hispanica* in central and Mediterranean Spanish mountain ranges, and *C. p. victoriae* in the northwest Iberian Peninsula [13]. There is, however, some controversy about the subspecies classification, with some not being recognised [14–16]. Despite drastic reductions in the sizes of some populations [7], ibex in Spain have generally increased in both number and range over the last three decades [7]. The species is now widespread in the Iberian Peninsula [17], existing in over 50 localities [7, 18] and expanding its range into Portugal [1, 13].

Habitat preferences and general densities

The Iberian ibex prefers rocky habitats with bare, steep slopes [19]. Although it often colonises new areas rapidly through dispersal [17, 20], the species can become displaced to less optimal habitat such as pasture-scrub land due to competition with livestock [21].

Scale	Status	Population trend	Justification	Threats
Global [17]	Least Concern	Increasing	Abundant Increasing population Expanding range (due to rural abandonment)	No threats
Europe [20]	Least Concern	Increasing	Abundant Increasing population Expanding range (due to rural abandonment)	No threats
Europe – regional populations	Portugal: Critically Endangered [25] *C. p. victoriae*: Rare [18] *C. p. hispanica*: Not threatened [18]	N/A	Portugal: small population size [25]	Some populations are threatened by [20]: 1. Habitat alteration and fragmentation (through agriculture, forestry, fires, and infrastructure development) 2. Competition with introduced aoudad (*Ammotragus lervia*) may be threat in the future 3. Poaching of males may alter gene flow 4. Occasional mange outbreaks

Table 1. Summary of Global and European Red List assessments and threats listed for the Iberian ibex.

Legal protection and conservation status

The Iberian ibex is protected under the Bern Convention (Appendix III, except subspecies *pyrenaica*: II) [22] and the EU Habitats and Species Directive (Annex V, except subspecies *pyrenaica*: II, IV) [23]. Past conservation management included the establishment of the Sierra de Gredos National Refuge in 1905 [10, 18] to preserve the remaining 10 individuals of *C. p. victoriae* [7].

The first reserve in the Spanish Pyrenees was founded in 1918, and several more followed in the 1950s and 1960s [8]. *C. p. victoriae* has also been re-introduced into a number of sites in Spain and northern Portugal [24]. Although most of the current range is not protected, *C. p. victoriae* occurs in several Hunting Reserves and a Natural Park, and *C. p. hispanica* in a number of protected areas [17]. Both extant subspecies are hunting trophies [13], and an important source of income for some local communities in rural areas [17, 20]. The species is considered an agricultural pest in some parts of its range, as it causes damage to almond trees [24]. On both the Global and European Red List, the Iberian ibex is categorised as Least Concern with an increasing population trend (Table 1). The species is Critically Endangered in Portugal because of its very small population size, and different subspecies have been listed in various categories (Table 1).

Abundance and distribution: current status

In terms of population size, an estimate from 2002 puts the total number of individuals globally at over 50,000 (Table 2). These occur in the two subspecies (*C. p. hispanica* and *C. p. victoriae*) in over 50 localities in Spain and Portugal [7, 18]. The former is found in 46 sites and accounts for just over 40,000 or nearly 80% of the global population. The largest populations of *C. p. hispanica* are in the Sierra Nevada (30%), Maestrazgo (15%), Subbético jiennense (6%) and Sierra Madrona–Sierra Morena (6%) [7]. *C. p. victoriae* occurs in seven locations, which represent 9,600 or just under 20% of the total species population. Its most important populations are found in Gredos (83%), Batuecas (9%), Riaño (4%) and Pedriza/Soto del Real (3%) [7].

C. p. hispanica, the more abundant subspecies [7], occupies the arc of mountains along the Mediterranean coast from the Ebro river to the rock of Gibraltar (where it is extinct), as well as the Sierra Morena [24]. Andalusia Autonomous Community represents the stronghold, with nearly 32,000 individuals (64% of the global population) occurring here in 34 localities [7]. Populations are believed to be expanding [1, 26].

C. p. victoriae occurs in the central Spanish mountains (Sierra de Gredos), and has been re-introduced at a number of sites (Batuecas, La Pedriza, Riaño) [24]. It also made an unexpected return to Portugal in 1998, where *C. p. lusitanica* had become extinct at the end of the 19th century [10]. The population is believed to have been founded by translocated individuals escaping from a fenced area in Baixa Limia-Serra do Xurés Natural Park to the adjacent Peneda-Gerês National Park in Portugal [13]. As there are no limitations on resources in this area, numbers are increasing and geographical range is expanding [13]. By contrast, the main *C. p. victoriae* population in Gredos has been stable for the past 30 years [26] due to ecological peculiarities [1]. It has been suggested that *C. p. victoriae* is therefore particularly susceptible to quasi-extinction [26].

Table 2. Latest population estimates for the Iberian ibex globally, in Europe and for the two subspecies.

	Estimate	Year assessed	Reference
Global / Europe	**>50,000**	**2002**	[7]
% of global population	**100%**		
Capra pyrenaica hispanica	40,200	various	[1, 7]
Capra pyrenaica victoriae	9,600	various	[1, 7]

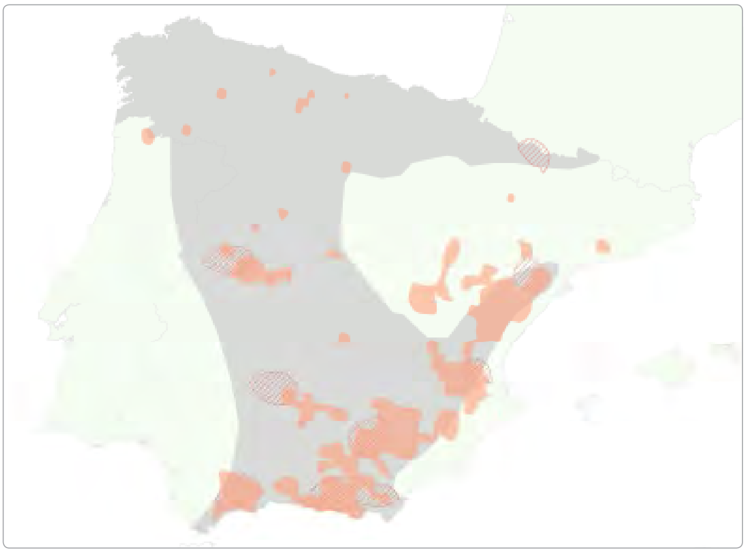


FIGURE 1A.
Distribution of Iberian ibex in **1900** [30], **1967** [31] and **2008** [17]. Please note that both the 1900 and 1967 distributions represent over-estimations of the species' actual range.

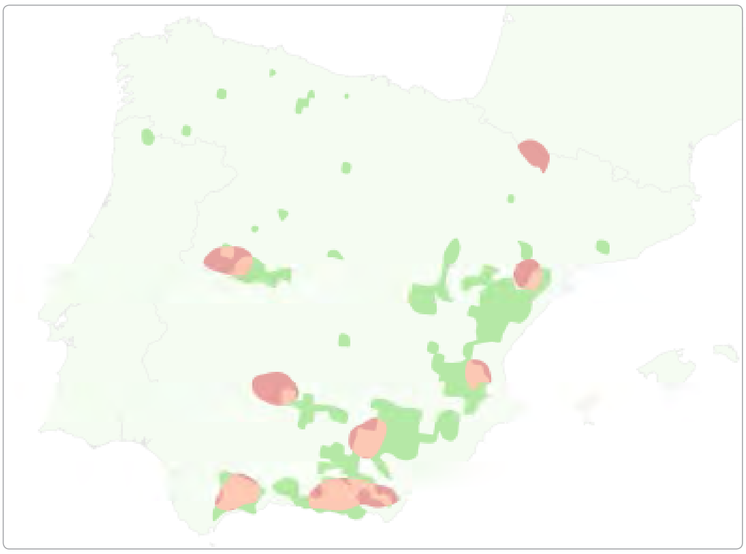


FIGURE 1B.
Map highlighting areas of range **EXPANSION**, **PERSISTENCE** and **CONTRACTION** of the Iberian ibex in Europe between 1967 and 2008. Please note that contraction observed from 1967 to 2008 is likely to be an artefact of the difference in map resolution.

ABUNDANCE AND DISTRIBUTION: CHANGES

A prominent problem with historical maps is their often lower resolution compared with more recent counterparts, which can cause severe over- or under-estimations in range change over time. In the case of the Iberian ibex, the distributions depicted for 1900 and 1967 in Figure 1A represent the best available but they are also gross approximations as much of the range falls outside suitable ibex habitat [27]. In addition, many of the localities for 1967 are likely to be larger than the actual distribution; for example, the population in the Pyrenees was already very restricted, with an estimated two dozen animals remaining at this point in time [27]. As such, both the decrease between 1800 and 1967, and the subsequent slight range expansion (Figures 1A and B) must not be taken at face value and instead interpreted with extreme caution. However, it is reasonable to assume that even if the ibex was distributed over a smaller area in 1900 and 1967 than depicted in Figure 1A, the decline to small, fragmented areas in the Sierra Nevada, Sierra Morena, Sierra Guadarama and the Valencia community is somewhat representative of the fate of the species during this time. Similarly, the subsequent range extension has been discussed in the literature, with expansion in the Sierra Morena and Sierra Nevada [28, 29], a northwards spread in central and northern Spain [1] and the return to Portugal [13] (Figures 1A and B). At the same time, the species became extinct in the Pyrenees due to overhunting, agricultural development and expansion, and habitat deterioration [7, 12]. Our results of a current distribution of nearly 60,000 km² are consistent with Figures reported in the literature [1].

In addition to the increase in range over the last three decades, an increase in number has also been reported [7]. This is reflected in our abundance trend of Iberian ibex populations, which shows a consistent increase from the 1960s onwards, with positive change in every decade, leading to a recovery of over 800% overall (Figure 2). This is broadly in line with the 10-fold increase reported for the species (an increase from 5,000 individuals in the 1960s to 50,000 at the end of the 20th century [7, 18]). Particularly large recoveries occurred in the 1970s (Figure 2). The trend is based on 7 populations from across the Iberian peninsula, representing a minimum of over 11,200 individuals, or 22% of the total European population.

DRIVERS OF RECOVERY

While no underlying reasons could be identified in our data set to explain the large increase in abundance and distribution of the Iberian ibex, a number of factors explaining both demise and recovery have been discussed in the literature (Table 3).

The extinction of *C. p. pyrenaica* has been attributed to overhunting, agricultural development and expansion, and habitat deterioration [7, 12, 32], but competition for food with chamois, parasite infections from domestic livestock, climatic conditions, poaching, low fertility due to plant secondary compounds and the resulting inbreeding depression have also been implicated [4, 18, 32]. Conservation efforts also simply came too late [1].

In terms of the recent expansion in range, current ibex distribution is likely the result of both natural and artificial expansion processes [1]. Legal protection of the species and its habitat [7, 10, 18, 22, 23], as well as translocations and reintroductions, probably played a role both in the recovery of range and numbers initially. Most of these were carried out after 1970, particularly

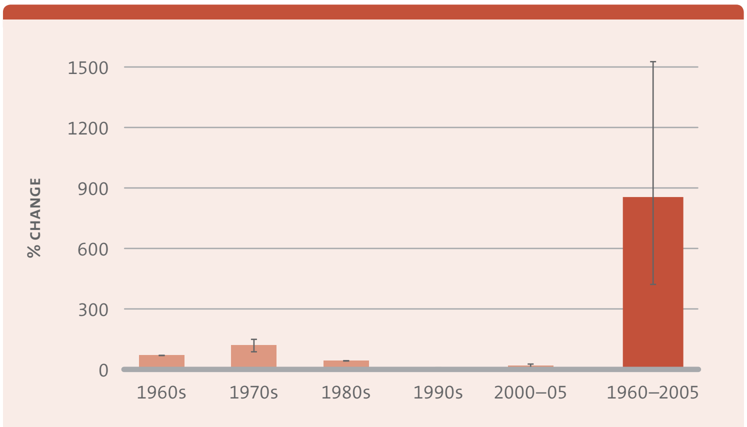
during the 1980s and 1990s, with the exception of Maestrazgo, where ibex were established in 1966 [1, 7]. Although recent range expansion has been described as primarily natural for both subspecies [7, 21], it is generally attributed to recovery from past mange outbreaks and game management translocations [33], but also habitat changes resulting from the abandonment of rural areas [17], and decreased hunting pressure. All of these measures will have resulted in population growth, which would, in turn, lead to the expansion of the geographical range [13].

The ibex's dispersive capacity is facilitated by an increase in density, loss of traditional agriculture and habitat improvement [29]. In addition, the distribution of *C. p. hispanica* has been shown to be influenced by competition with livestock [21] and invasive species [34], and human-induced translocation of ibex and other competing species such as Iberian red deer (*Cervus elaphus hispanicus*) [35]. In contrast, the distribution of *C. p. victoriae* is related to climatic conditions, and it has thus been suggested to be highly sensitive to variations in climate [36]. This is in line with the finding that in population viability analyses, the higher probability of quasi-extinction demonstrated for *C. p. victorae* was related to environmental stochasticity and possible variations [26]. This may become a particular worry for the species in the future, as climate change has already been shown to have an impact on the survival of other species of mountain ungulate [37].

Recent developments

The Iberian ibex has shown an impressive recovery in abundance and range over the past 45 years, and the population is now thought to be abundant, with its distribution range and population expanding

Figure 2. Change in Iberian ibex population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.



Rank	Reason for change	Description
1	**Species management – Reintroductions and translocations**	Translocations played a role both in the recovery of range and numbers initially, particularly during the 1980s and 1990s, with the exception of Maestrazgo, where ibex were established in 1966 [1, 7]. Reintroductions have taken place into a number of sites in Spain and northern Portugal [24].
2	**Legislation**	The Iberian ibex is protected under the Bern Convention (Appendix III) [22] and the EU Habitats and Species Directive (Annex V) [23]. Several parks and refuges have been set up for the protection of the species, e.g. the Sierra de Gredos National Refuge in 1905 [10, 18] to preserve the remaining individuals of C. p. victoriae [7].
3	**Land/water protection & management – Land use change**	New habitat becoming available as a result of rural abandonment has had positive effects on distribution and abundance [17].
4	**Species management – Reduction of threats**	Recovery from past mange outbreaks was attributed not only to game management translocations but also decreased hunting pressure [33].

Table 3. Major reasons for positive change in the status of the Iberian ibex in Europe.

and increasing [17]. All of the subspecies now occur in at least one protected area, and additional populations of *C. p. victoriae* have been established to protect them against detrimental stochastic events [17]. Efforts were recently made to revive the extinct *C. p. pyrenaica* through the cloning of cells obtained from the last living specimen and placement into Iberian ibex or hybrid recipients [38]. However, this approach proved unsuccessful, and most conservationists agree that it is not appropriate, practical or valuable to invest further in this process [27].

Despite the recovery of the Iberian ibex, a number of threats remain. Populations of wild *Caprinae* are particularly vulnerable to extinction because of genetic isolation, specialised habitat requirements, and low reproductive rate [39]. The increasing presence of domestic livestock in the ibex's range could, for example, lead to an increase in competition for resources [21]. In addition, livestock also transmit diseases to wild ungulates [7, 40], and in the ibex, sarcoptic mange outbreaks have been a problem in the past [7, 40], with 95% mortality occurring in some populations [41]. Pressure from tourism, which is currently being studied in the Sierra Nevada population, has also been suggested as a possible future threat [1]. Furthermore, hunting should be banned in areas where extensive exploitation cannot be sustained, and appropriate monitoring of Iberian ibex population numbers needs to be in place [17]. In addition, any management strategies need to be considered separately for each of the two subspecies [36].

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3.4. Southern chamois

Rupicapra pyrenaica

Summary

The Southern chamois is now increasing in distribution and abundance across its range after recovering from historical lows in population numbers caused by uncontrolled hunting. Management interventions have included a captive breeding and introduction programme implemented in Italy, translocations in France and establishing hunting reserves in Spain. Whilst the outlook for the species as a whole remains positive, continued monitoring of disease outbreaks in France and Spain and targeted conservation management in Italy are key to ensuring continued success for the Southern chamois.

Background

General description of the species

The Southern or Pyrenean chamois (*Rupicapra pyrenaica*) is a mountain ungulate which occurs as three subspecies in southwest Europe [1]. It is one of two species in the *Rupicapra* genus which spread to Europe from Asia in the middle Pleistocene, and it was during this period that the Southern chamois is thought to have diverged from older ancestors in western Europe to occupy its current distribution through adaptation to warmer climates [2].

Distribution in Europe

Since the last glaciation, the Southern chamois occupied a large part of the Iberian Peninsula [3]. During the Holocene, with a milder climate, presence became scarcer, and during the last 10,000 years further adaptation to mountainous environment, climate warming and hunting pressure reduced its range to today's extent [4]. In the Holocene the Apennine chamois was found throughout the central southern Apennines, its range was then reduced to just the Abruzzo region, where a population of less than 40 individuals survived in what is now the Abruzzo, Latium and Molise National Park [5].

The species is currently fragmented into three populations, which occur in the following mountainous regions: the Cantabrian mountains of northern Spain (Cantabrian chamois – subspecies *parva*); the Pyrenees in France, Spain and Andorra (Pyrenean chamois – subspecies *pyrenaica*); and three locations in the Apennine mountain chain in Italy (Apennine chamois – subspecies *ornata*) [1].

Habitat preferences and general densities

Adapted to high altitude, the Southern chamois is found in rocky areas, alpine meadows and forests according to the season. The species has adopted an altitudinal migration strategy in response

Scale	Status	Population trend	Justification	Threats
Global	Least Concern	Increasing	Increasing population Range expansion	N/A
Europe	Least Concern	Increasing	Increasing population Range expansion	N/A
Europe – regional populations	Least Concern: *R. p. pyrenaica*, *R. p. parva* Vulnerable: *R. p. ornata*	N/A	Very small population size Restricted area of occupancy	1. Disease (*R. p. pyrenaica* and *parva*) 2. Competition with livestock

Table 1. Summary of Global and European Red List assessments and threats listed for the Southern chamois [12, 13].

to seasonal changes and spends winter months in lowland forested areas followed by a move to supraforestal grasslands on higher ground as the snow recedes [6]. This is the general pattern for the species as a whole although some populations show slight variations in the extent of their altitudinal movement [6]. Densities have not been comprehensively recorded across the species' range but they are generally higher within protected areas [1]. For the Pyrenean chamois, a recent estimate gave a density of 21 individuals per km² in one hunting reserve in the Spanish Pyrenees [7]. The Cantabrian subspecies does not occur at such high densities, varying from 3 to 14 individuals per km² depending on the population, with the highest densities in the Picos de Europa [3]. For two of the populations of Apennine chamois in Italy, 14–20 individuals per km² have been recorded [8].

Legal protection and conservation status

The Apennine subspecies *R. p. ornata* is protected by the Bern Convention (Appendix II) [9] and the EU Habitats and Species Directive (Annexes II and IV) [10], and listed on CITES (Appendix II) [11]. *R. p. ornata* exists only in protected areas, while the other two subspecies occur largely in protected areas and hunting reserves in France, Spain and Andorra, where hunting is prohibited or managed [1]. The Southern chamois has been assessed as Least Concern by both the global and regional IUCN Red List; however the Apennine subspecies (*R. p. ornata*) has been given a status of Vulnerable due to its small population size and area of occupancy (Table 1).

Abundance and distribution: current status

The majority of Pyrenean chamois is found in the Pyrenees, where numbers of individuals are almost equally split between Spain and France, with a small number also found in Andorra (Table 2). The Cantabrian chamois population is about a third of the size of the Pyrenean subspecies and a quarter of the entire species population. The Italian subspecies has the smallest population with just 1,100 individuals, which equates to less than 2% of the global species estimate (Table 2).

Abundance and distribution: changes

Detailed range information was not available to calculate precise changes from historical distribution to the present day, but based on the literature the distribution of the Cantabrian subspecies in the 19th century does not differ much from the present except for some peripheral areas of the range where it has become extirpated [3]. Although our data suggest that there was a contraction in range for the whole species from 1955 to 2008 (Figures 1A and B), this is largely due to the difference in resolution of the maps between the two time periods [14]. The data from 1955 are quite coarse in resolution and some of the range shown actually falls partly or mostly outside of chamois habitat [14], so it is an over-estimation of the past range that is underlying the visible contraction in range which does not equate to an actual reduction in the area occupied by the Southern chamois. This is illustrated by the Apennine subspecies that appears to have fragmented into three populations whereas in reality, the number of populations and hence the range has increased due to recent introductions and reintroductions [14].

The range of the Southern chamois has not contracted since 1955 as suggested by Figure 1B, but expanded and this is mirrored in the abundance trend, which has increased overall since 1970 (Figure 2). This trend is based on 22 populations from the species current range and represents

Table 2. Latest population estimates for the Southern chamois globally, in Europe and for European populations.

	Estimate	Year assessed	Reference
Global / Europe	69,100	2008	[2]
% of global population	100%		
Andorra	600	2000	[4]
France	25,400	2000	[4]
Italy (*R. p. ornata*)	1,100	2008	[2]
Spain (*R. p. pyrenaica*)	27,200	2000	[4]
Spain (*R. p. parva*)	17,430	2008	[4]

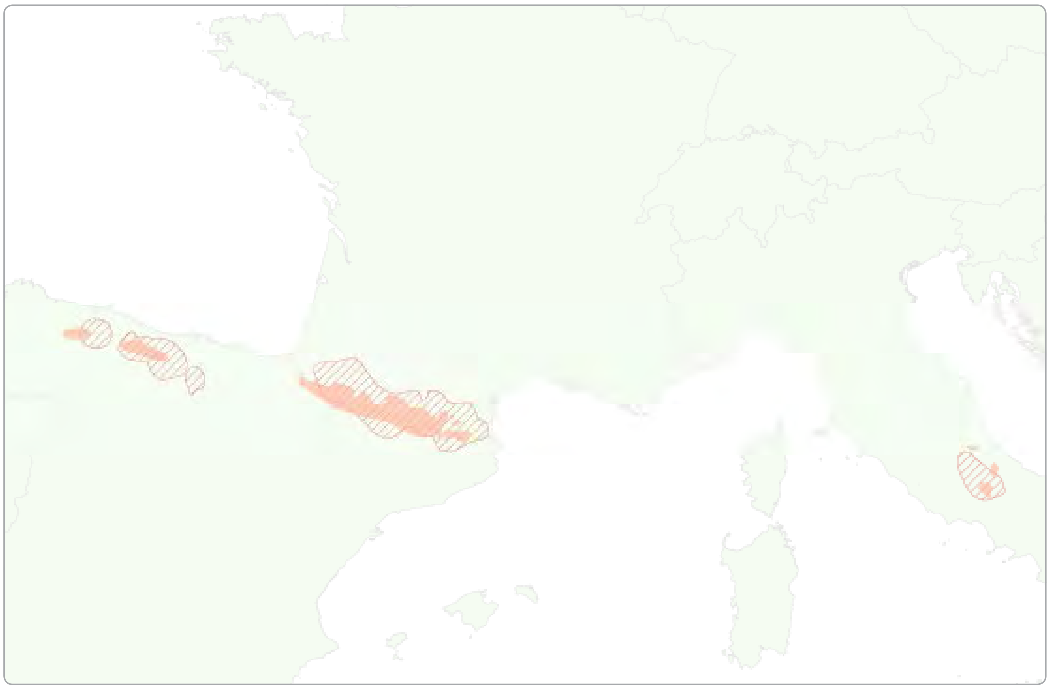

Figure 1a. Distribution of Southern chamois in **1955** [15] and **2008** [12]. Please note that the 1955 distribution represents an over-estimation of the species' actual range as the resolution is much coarser than that for 2008 and includes areas of unsuitable habitat for chamois.

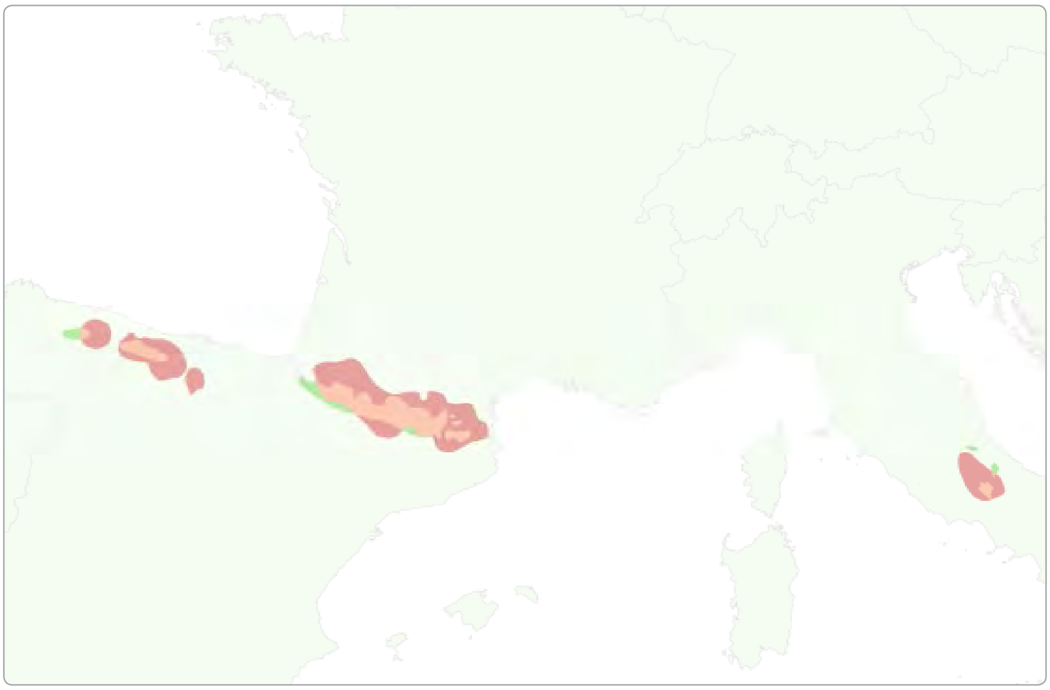

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Southern chamois in Europe between 1955 and 2008. Please note that contraction observed from 1955 to 2008 is likely to be an artefact of the difference in map resolution between the two time periods.

a minimum of 16,400 individuals, or 25% of the species' global population estimate. Figure 2 shows that there was an increase in overall abundance which became progressively greater throughout the first three decades. Between 2000 and 2005, there was still an increase but this was much less pronounced than between 1970 and 1999. In total there was an increase in species-wide abundance of over 500% from 1970 to 2005. The country coverage was comprehensive and population trend data were available from all three subspecies. The data set was missing information largely from populations in the French Pyrenees but also from some of the reserves in Spain.

Drivers of recovery

Our analysis revealed no significant factors for either positive or negative abundance change. The population trends shown in Figure 2 are reflective of the three subspecies, which have all recovered from historic low levels and are currently increasing in number [1]. The combination of uncontrolled hunting and the modernization of firearms had drastically reduced chamois numbers in the mid-20th century, so management interventions such as hunting legislation and the establishment of hunting reserves in Spain allowed populations to recover (Table 3). In France, translocations have been administered in order to bolster populations where the density was low [4]. The Apennine chamois reached critically low levels of less than 50 individuals in the 1940s and 50s persisting in the Abruzzo National Park [16]. Conservation efforts were implemented and the number of individuals gradually increased from 250–300 in the 1970s, to 400 in the 1980s and over 1,000 in 2006 [16]. A captive breeding programme was initiated and a reintroduction made into the Gran Sasso-Monti della Laga National Park and two introductions were made into Majella and Sibillini Mountains National Parks [16].

The lower rate of increase shown after 2000 is due to disease affecting some populations of both the Cantabrian and Pyrenean chamois. In 1993 Sarcoptic mange was detected amongst the Cantabrian chamois in Asturias and then in early 2000 further east in the Picos de Europa [3]. This disease is prevalent in 56% of the Cantabrian population and has had some noticeable effects on population size [3]. It continues to spread eastwards but the western populations have remained largely unaffected probably due to the lower densities preventing transmission. Antibodies to pestivirus have been detected in this subspecies, but this infection has not taken hold as readily as in the Pyrenees [4].

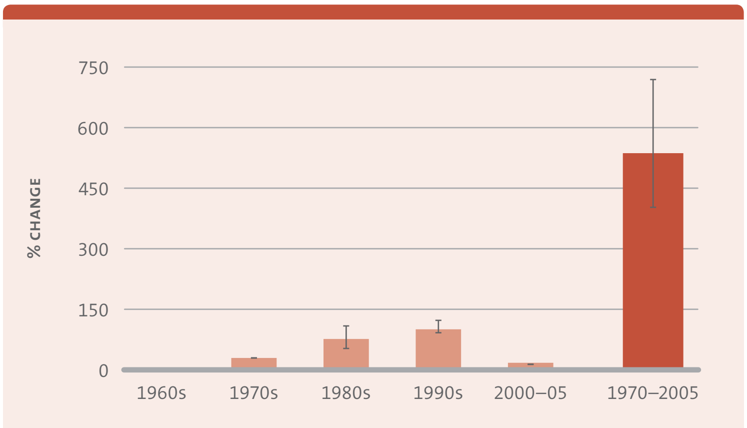

Figure 2. Change in Southern chamois population **abundance by decade** and **overall change** between 1970 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

Pestivirus was first detected among Pyrenean chamois in the Reserva de caza del Alt Pallars in 2001 and it has been suggested that it caused a reduction in numbers of up to 40% in some populations [4]. Routine samples collected between 2002 and 2006 revealed that this infection is endemic [4]. Hunting was suspended in 2006 due to the high mortality rates recorded, and in 2005 and 2007 hunting was much more strictly controlled. This was to avoid confounding the negative impact of pestivirus on chamois abundance with the added pressure of hunting [7].

Rank	Reason for change	Description
1	**Legislation**	National hunting law in Spain in 1970 [7]; given special protection status in Italy in 1992 [5]; listed on Appendix II of the Bern Convention; Annex II and V of the EU Habitats and Species Directive; CITES Appendix I for *R. p. ornata* [17].
2	**Species management – Reintroductions**	Reintroduction and translocation of the Cantabrian chamois in Spain to bolster low numbers and re-establish extirpated populations [4]; translocations of the Pyrenean chamois in France to increase population size where density was low [4]; reintroductions and introductions into protected areas in Italy in the 1990s [16].
3	**Land/water protection & management – Protected areas**	In Spain 18 national hunting reserves were created in 1966 [7].

Table 3. Major reasons for positive change in the status of the Southern chamois in Europe.

Recent Developments

A proposal was submitted to the CITES 16th Conference of the Parties to transfer the Apennine subspecies from Appendix I to Appendix II [16]. The reasons behind this are because the subspecies has national and international protection, the population trend is increasing, it does not appear to be in demand in international trade and the current listing is not in line with regulations regarding the split-listing of species. This news has provoked some debate in Italy; on the one hand there is concern that the risks to the populations are still there and that the Apennine chamois is still in need of the strictest protection [18] while others are hailing it as an illustration of a conservation success [19, 20]. The final decision was taken to downgrade the CITES listing to Appendix II [11].

Recent news on the Pyrenean chamois in France has come from the health monitoring program set up by the Parc National des Pyrénées [21]. It was revealed that pestivirus had returned to the chamois population in this park and although rates of mortality are not high, experts are alarmed by the virulence of the strain so the situation is being closely monitored. The disease was identified for the first time in chamois in the early 2000s in Catalonia and Ariège in 2003 and appears to be gaining ground to the west of the Pyrenees on both sides of the border.

The outlook for the Southern chamois is generally positive as all subspecies continue to increase in numbers. The concern over disease means that populations in Spain and France are being closely monitored and management interventions such as banning or reducing hunting can be put into effect if the threat level of disease is considered too high. Although populations are increasing, the Apennine chamois continues to be a cause for conservation concern as shown by the recent debate on downgrading the CITES listing. The release of more individuals into introduced populations is planned in the future to attain viable populations for this subspecies [16].

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Reviewer

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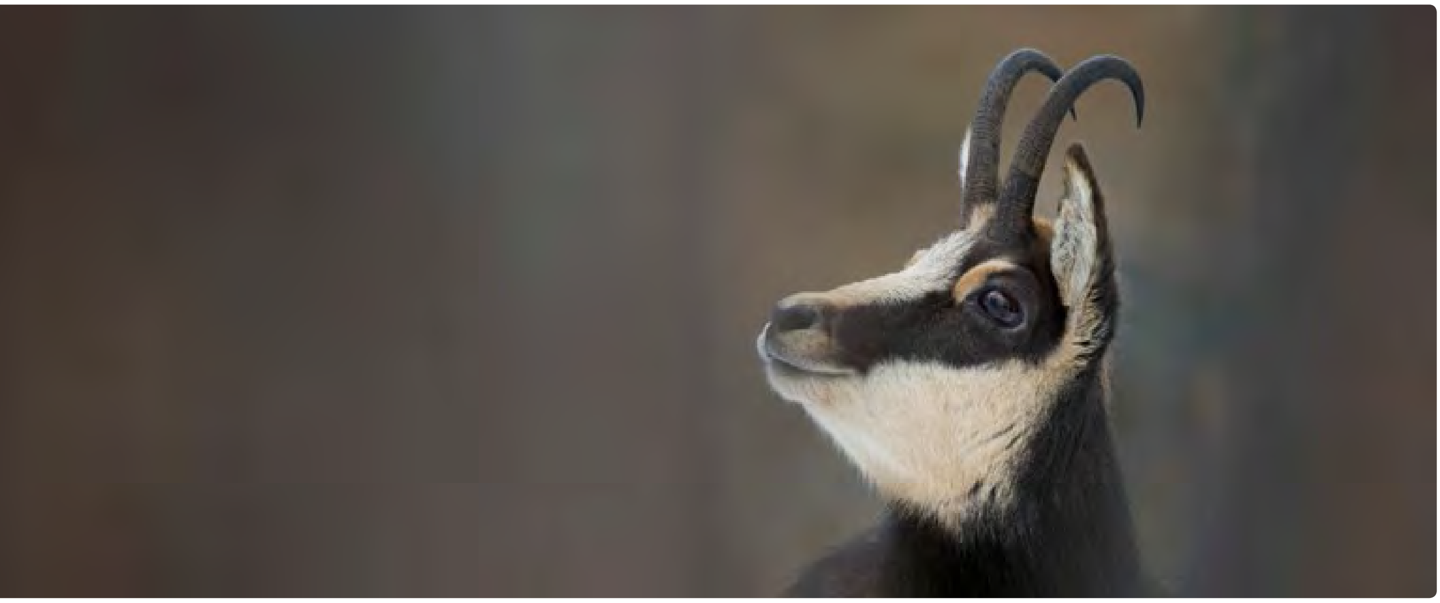

3.5. Northern chamois

Rupicapra rupicapra

Summary

The Northern chamois has increased in abundance and distribution as a result of targeted management including reintroductions, the establishment of protected areas, legal protection from over-exploitation, and the reduction of competition with other species. However, the different subspecies are still subject to a variety of different threats such as habitat loss, poaching and over-exploitation, human disturbance, competition with livestock and introduced species, hybridisation, disease, and stochastic demographic and environmental events. In addition, climate change is a particular concern for the future. Careful conservation management is required to ensure its continued survival in Europe.

Background

General description of the species

The Northern chamois (*Rupicapra rupicapra*) is native to central and southern Europe and Asia minor [1] and the most abundant mountain-dwelling ungulate in Europe [2]. Here, it is present in seven subspecies: *balcanica*, *carpatica*, *cartusiana*, *rupicapra*, *tatrica*, *asiatica* and *caucasica* [1] (Table 1). This report does not consider the subspecies *R. r. asiatica* (eastern and northeastern Turkey) or *R. r. caucasica* (Caucasus Mountains in southern Russia, Georgia and Azerbaijan) [1]. The chamois' diet consists of grasses, herbs, leaves, buds, shoots and fungi [1]. Females and young tend to live in groups of between 5 and 30 animals, while the males are solitary [3]. Females give birth to one offspring in May or June, and sexual maturity is reached at 2.5 years and 1–1.5 years for females and males respectively [3]. The species is long-lived, reaching a maximum age of 14 to 22 years [3].

Distribution in Europe

With its origin in Asia, the first species of *Rupicapra* is believed to have reached southwestern Europe by the end of the Mindel glaciations in the middle Pleistocene, i.e. between 350,000 and 400,000 years ago, with colonisation of the continent taking place during the Würm (50,000–10,000 BC) [4]. Mountain ranges were colonised after the retreat of the glaciers [4], and this colonisation may indeed explain the species' highly fragmented current distribution [2]. During the beginning of the Würm, both Northern and Southern chamois existed in Europe: the former from the Caucasus to the Alpine arc, and the latter on the Iberian Peninsula and in the Apennines [2]. The species is currently distributed primarily in the Alpine arc countries, with smaller, often more fragmented, populations in the Jura, Vosges, Black Forest, Swabian Jura, Dinaric Alps, Rhodopi mountains, Carpathians and the Caucasus.

Habitat preferences and general densities

The Northern chamois occurs in a number of habitats including alpine meadows, open rocky areas, mixed broadleaf woodland and coniferous woodland in steep, rocky, mountainous areas [5]. During winter, it moves from alpine meadows to lower-lying, forested areas [6]. When alarmed, chamois retreat to highly inaccessible places, making leaps of 2 m in height and 6 m in length [3].

Legal protection and conservation status

In Europe, the subspecies *R. r. balcanica* and *tatrica* are listed on Annexes II and IV of the EU Habitats Directive, while the whole species is included on Annex V of the Directive [7] and Appendix III of the Bern Convention [8]. Conservation actions for all subspecies include ensuring sustainable harvest, reducing poaching, reducing human disturbance, protecting the genetic integrity of populations, and monitoring, especially of vulnerable populations [9]. There have also been reintroductions of *R. r. cartusiana* [9] and in some areas protected areas have been set up. The hunting of the species is widespread and common, and culling is used to control population numbers, e.g. in France [4]. Both at a global and European level, the Northern chamois is classified as Least Concern with an unknown population trend (Table 2). However, a number of the subspecies are believed to be decreasing and are listed as Critically Endangered or Vulnerable due to various threats (Table 2).

Abundance and distribution: current status

In terms of population size, an estimate from 2004/5 puts the European population at 485,580 individuals, but as there are no reliable global estimates available, it is not possible to ascertain the proportion accounted for by this population (Table 3). Within Europe, the largest populations occur in the Alpine arc countries Austria (31%), Italy (28%), Switzerland (19%) and France (13%), and mostly as the subspecies *R. r. rupicapra*. The majority of extant populations in central Europe are reintroduced [6].

R. r. rupicapra represents the most numerous of the subspecies, occurring throughout the Austrian, Italian, Swiss and French Alps [6]. In Austria, the species is increasingly found in suboptimal habitat [6], which suggests that it is doing well here. Measures are in place to manage sarcoptic mange [6], and there are abundance-dependent hunting quotas [6]. The chamois is also hunted in Italy [6]. While present in almost all of Switzerland historically [13], the species now only occurs in the Alps and parts of the Jura mountains [6], where it was reintroduced between 1950 and 1962 [14]. The first federal hunting law was established in 1875 and as a result, populations recovered swiftly [15].

In France, *R. r. rupicapra* occurs in the Alpine region, the Jura and Vosges mountains and the Massif Central, but the country is also home to *R. r. cartusiana* in the Chartreuse limestone massif [6]. Hunting quotas have been in place since 1990 [4], with an initial reduction in culling leading to a recovery, which was followed by a subsequent higher culling quota [4]. The *cartusiana* subspecies recovered from food competition with other species from 250 individuals in 1972 to over 770 by 1997 [16]. However, food competition is still a major threat [16], as is hybridisation with the spreading Alpine chamois, which was introduced to the northern end of the massif [16].

R. r. tatrica is present in two locations: one in the High Tatra mountains in northern Slovakia and southern Poland, and a second, reintroduced population in the Low Tatra in Slovakia [11]. Declines after the first and second world wars to 300 and 132–230 individuals [11] were followed by initial recovery and then further declines, which continued steadily from the 1960s until today [11]. They are attributed to altered age structure and sex ratio induced by selective shooting, severe weather conditions, human disturbance through tourism and air traffic, predation and parasitism [11]. Censuses in 1999 counted 220 and 120–130 individuals in the two populations respectively [11]. Poaching and potential hybridisation with introduced Alpine chamois have been highlighted as the most urgent threats to address [11].

Subspecies	Distribution	Population size and trend
balcanica [9]	Mountain regions of Albania Bulgaria's four main massifs 6 populations on 11 mountains in Greece (Mount Rodopi in the northeast and the Epirus mountains in the northwest to Mount Giona in central Greece)	Thousands of individuals Declining in all subpopulations
carpatica [1, 9]	Transylvanian Alps Carpathians successful reintroductions	9,000 individuals in 1990 Increasing in Romania
cartusiana [1]	Chartreuse limestone massif around Grenoble in France Western edge of French Alps	300–400 individuals in 1970s 150 individuals in 1986–7 Recent estimate: 2,000 individuals
rupicapra [1, 10]	Alps (Austria, Germany, eastern France)	Comprises majority of global population Widespread and abundant Culling in Swiss Alps and Jura rose from 4,000 individuals (1950) to 17,000 (2000)
tatrica [1, 9, 11]	Tatra mountains of Poland and Slovakia Introduced into the low Tatras in Slovakia	Declining steadily since 1960 220 individuals in 1999 <200 individuals in 2002

Table 1. Subspecies of the Northern chamois in Europe, their distribution, and population size and trend. Please note that this report does not consider the subspecies *R. r. asiatica* (eastern and northeastern Turkey) or *R. r. caucasica* (Caucasus Mountains in southern Russia, Georgia and Azerbaijan) [1].

Scale	Status	Population trend	Justification	Threats
Global [1]	Least Concern	Unknown	Widespread Large population Largest population stable (Alps)	Development Agriculture Exploitation Human disturbance Invasive species/genes Problematic native species
Europe [12]	Least Concern	Unknown	Widespread Large population Largest population stable (Alps)	Human disturbance Invasive species
Europe – regional populations [1]	*tatrica*: Critically Endangered *cartusiana*: Vulnerable	*tatrica*: Decreasing *cartusiana*: Stable	*tatrica*: Very small population Projected continuing decline Interbreeding *cartusiana*: Confinement to single location	*tatrica*: Interbreeding

Table 2. Summary of Global and European Red List assessments and threats listed for the Northern chamois.

The Balkan chamois (*R. r. balcanica*) is stable in Bosnia-Herzegovina, Croatia, Macedonia, Slovenia and Serbia, vulnerable in Albania, rare in Bulgaria and endangered in Greece [17]. Here, it is listed in the Red Data Book of Threatened Vertebrates [18] and shooting has been banned since 1969 [17]. Poaching, which occurs both inside and outside protected areas, is considered the biggest threat but adventure tourism may be a growing problem in the future [17].

Abundance and distribution: changes

As with many of the historical and 1950s/60s maps collected for this report, the 1955 distribution for the Northern chamois shown in Figure 1a is much coarser in resolution than the present day map [20], making a comparison difficult. Although the best available, the 1955 distribution is misleading, as much of it falls mostly or entirely outside suitable chamois habitat, and populations which were isolated at the time appear to be connected, giving the false impression of a large area of occupancy [20]. As such, the apparent reduction in range of over 40% between 1955 and 2008 must not be taken at face value and instead interpreted with extreme caution, as it is likely an artefact of different map resolutions in time as opposed to a genuine decline in range size [20]. The Northern chamois was, however, able to persist in most of the larger mountain ranges, e.g. the central Alps, central Dinaric, Carpathians and Sudetes, and southern Russia, and was even able to expand into the Massif Central, Jura, Black Forest, parts of the Sudetes and very small populations in and around the Dinaric mountains and southern Bulgaria (Figures 1a and b).

In terms of abundance, Northern chamois populations in Europe have increased by around 90% over the period from 1960 and 2005, although this trend is not consistently positive in each decade (Figure 2). The trend is based on 10 populations from across Europe, representing a minimum of 98,400 individuals or 20% of the total European population of 2004/5 and the data were from 44% of the countries of occurrence. Trend information was missing from a number of locations within the species' current range, including the Massif Central in France, Germany, the Czech Republic, all of former Yugoslavia and Greece.

Table 3. Latest population estimates for the Northern chamois globally, in Europe and for European populations.

	Estimate	Year assessed	Reference
Global	Unknown	-	-
Europe (based on below)	485,580	2004/5	[19]
% of global population	-		
Austria	150,000	2004/5	[19]
Czech Republic	400	2004/5	[19]
Croatia	400	2004/5	[19]
France	62,500	2004/5	[19]
Germany	20,000	2004/5	[19]
Greece	800	2004/5	[19]
Italy	136,700	2004/5	[19]
Poland	80	2004/5	[19]
Romania	6,800	2004/5	[19]
Serbia	600	2004/5	[19]
Slovakia	600	2004/5	[19]
Switzerland	90,000	2004/5	[19]
Slovenia	15,600	1995	[19]

Drivers of recovery

Our analysis revealed no significant factors for either positive or negative abundance change. The decrease observed in the 1990s (Figure 2) can be attributed to populations from the Tatra

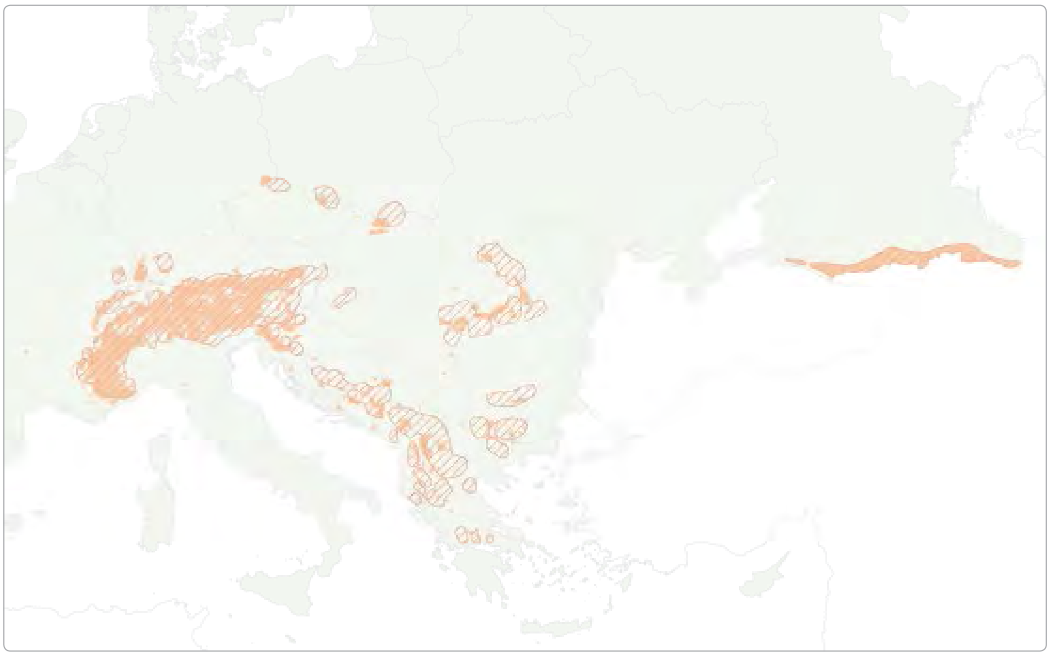

Figure 1a. Distribution of Northern chamois in **1955** [21] and **2008** [1]. Please note that the 1955 distribution represents an over-estimation of the species' actual range.

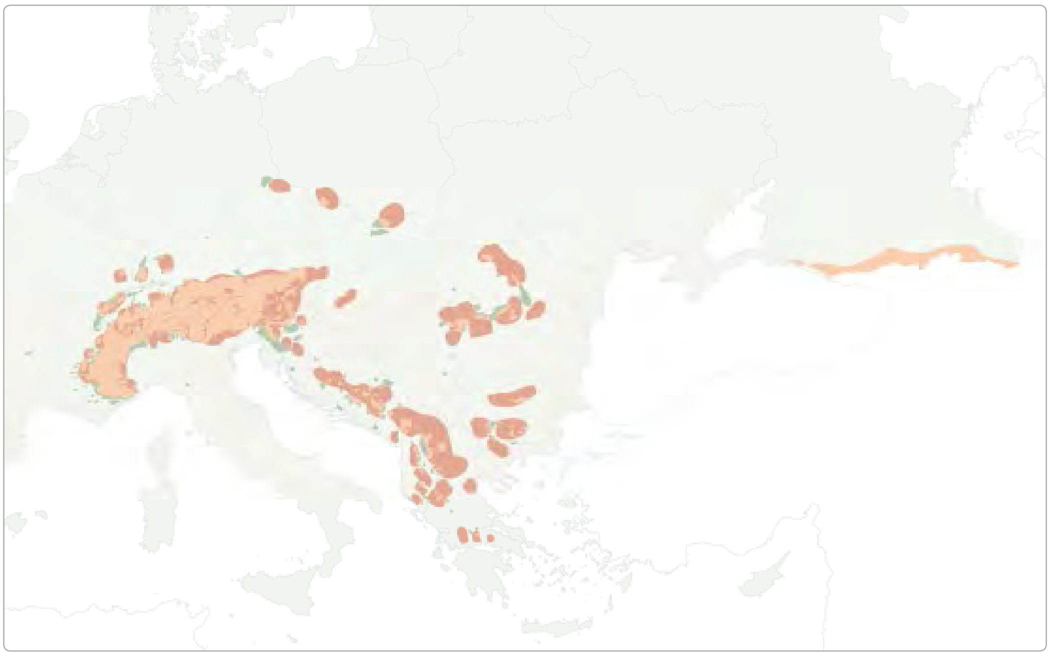

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Northern chamois in Europe between 1955 and 2008. Please note that contraction observed from 1955 to 2008 is likely to be an artefact of the difference in map resolution.

Mountains in Poland and Slovakia. As discussed in the literature, declines here are believed to be the result of altered age structure and sex ratio induced by selective shooting, severe weather conditions, human disturbance through tourism and air traffic, predation and parasitism [11]. The recovery in Northern chamois between 2000 and 2005 (Figure 2) can be attributed to change in management decisions in the Tatra population, specifically the adoption of strict anti-poaching measures [22] (Table 3). Despite this positive development, a further increase is not expected in Nítzke Tatry National Park, where the species was reintroduced between 1969 and 1976 [22], because of insufficient habitat and predation by Eurasian lynx (*Lynx lynx*), Grey wolf (*Canis lupus*) and Golden eagle (*Aquila chrysaetos*) [22].

In addition to the factors affecting population abundance change in our data set of Northern chamois discussed above, reintroductions have been key in the reestablishment of populations in Central Europe [6]. Other concerted conservation measures, including a shooting moratorium, the setting of strict harvest quota, removal and control of Red deer (*Cervus elaphus*) and Mouflon and limiting livestock grazing, have helped the Chartreuse chamois (*R. r. cartusiana*) recover to over 770 individuals by 1997 [16], although food competition remains an issue [16]. Research has also shown a higher population density of chamois in

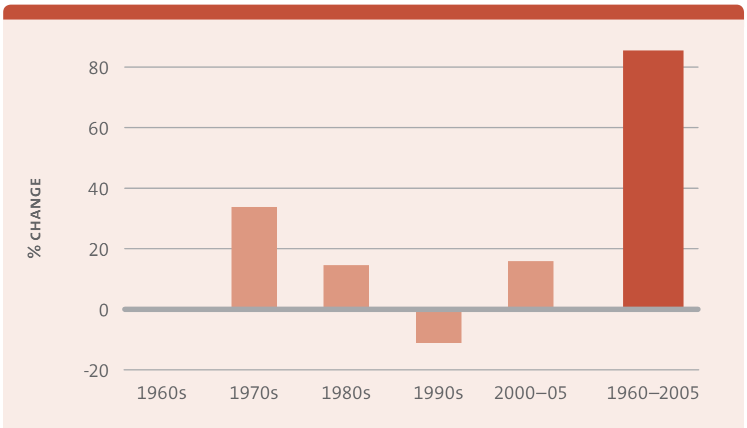

Figure 2.
Change in Northern chamois population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change. Error bars could not be calculated for this species.

areas of hunting prohibition compared to hunted areas, for example in the National Park of Ecrins in the French Alps, the National Park of Ordes in the Pyrenees and Grand Paradiso in Italy [17]. In addition, sarcoptic mange, a contagious infestation of the burrowing mite [2], which causes scabies in the Northern chamois and was first described in Bavaria and Styria at the beginning of the 19th century [2], is believed to be the one disease to have had the most severe impact on populations, thus presenting a threat to conservation [2]. It causes high mortality of up to 80% and is now most widespread in Austria, Slovenia and Italy [23]. Lastly, extreme weather can have a negative impact on chamois numbers [24].

Overall, both our analysis and the general literature suggest a beneficial effect of protection, conservation management measures such as the reduction of competition from other ungulates, and adequate hunting quota. On the other hand, over-exploitation and disease are associated with population decreases.

Recent developments

Although the Northern chamois has been able to recover both in terms of distribution and abundance, the species is still subject to a variety of threats throughout its range. These include poaching and over-exploitation [9, 11], human disturbance (for example through tourism) [9, 11], competition with livestock and introduced species (only applicable to vulnerable subspecies excluding *R. r. rupicapra*), habitat loss (mostly applicable to vulnerable subspecies) [9], hybridisation [9], disease [1, 9], and stochastic demographic and environmental events in subspecies with small populations [9]. The combination of threats is different for each of the European subspecies

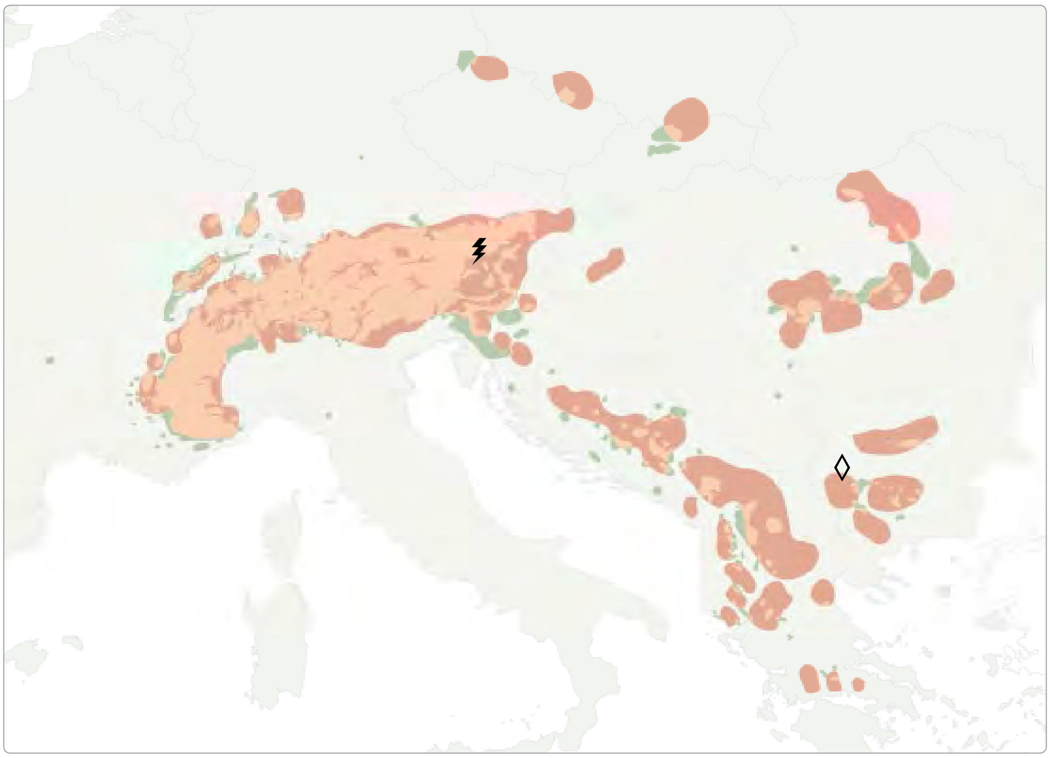

Figure 3. Map of recent developments recorded for the Northern chamois in Europe.

- Expansion
- Persistence
- Contraction
- Accidental mortality
- Reintroduction

(Table 4). In addition, extreme weather conditions can have catastrophic effects on chamois populations, as many individuals may not be hardy enough to survive harsh winters (particularly if this is combined with increased human disturbance). For example, in Upper Styria severe snowfall caused high mortality, primarily in young individuals, in 2009 and 2012, which led to a 50% reduction in culled individuals in 2010 [24]. In fact, there is increasing concern about the possible effects of future climate change on the species [20]. Yearling chamois showed decreases in body mass caused by additive negative effects of warm springs and summers over the first two years of life, but there was also a decrease in adult body mass over the same time period [25]. This suggests that ongoing warming in the Alps could potentially represent a considerable selective pressure on these ungulates [25].

A collaborative reintroduction programme between Frankfurt Zoological Society and the Balkani Wildlife Society is currently taking place for the Balkan chamois as part of a vulture conservation project [26] (Figure 3). Between 2003 and 2009, 27 individuals from the West Rhodope Mountains were released into a breeding enclosure in Vitosha Nature Park to increase productivity and ensure formation of a herd [27]. The first kids were born in 2004, and releases into the wild occurred in 2006. In 2009, 16–17 individuals were counted [28], while the number in 2010 was 16–19 in the wild and 13 in the enclosure [29].

Overall, the Northern chamois is showing some signs of recovery, although several of its subspecies are still under threat. Careful conservation management measures are required to ensure the continued survival of this ungulate in Europe.

Table 3. Major reasons for positive change in the status of the Northern chamois in Europe.

Rank	Reason for change	Description
1	**Species management – Reintroductions**	Most extant populations in Europe are the result of reintroductions [6].
2	**Species management – Reduced exploitation**	Recovery in the Tatra population is attributed to reduced hunting pressure through anti-poaching measures [22]. Reasons for the recovery of the Chartreuse chamois (*R. r. cartusiana*) include a shooting moratorium and strict harvest quota [16].
3	**Land/water protection & management – Protected areas**	Higher densities of chamois occur in areas of protection compared to hunted areas, e.g. the National Park of Ecrins in the French Alps, the National Park of Ordes in the Pyrenees, and Grand Paradiso in Italy [17].
4	**Land/water protection & management – Reduced competition**	The removal and control of Red deer (*Cervus elaphus) and* Mouflon as well as limiting livestock grazing have contributed to the recovery in Chartreuse chamois (*R. r. cartusiana*) [16].
5	**Legislation**	In Europe, the subspecies *balcanica* and *tatrica* are listed on Annexes II and IV, and II* and IV of the EU Habitats Directive [7] respectively, while the species as a whole is listed in Appendix III of the Bern Convention [8].

Subspecies	Exploitation	Hybridisation with Alpine chamois	Human disturbance	Competition (livestock or introduced species)	Disease	Habitat loss	Stochastic demographic and environmental events
balcanica	Balkans (poaching outside protected areas) Greece (poaching, predation by feral dogs)	Bulgaria (Rhodope almost complete, risk in Rila) Potentially Balkans	Greece	Greece		Albania Greece	
carpatica	Throughout range		Throughout range (livestock, recreation)	Throughout range			
cartusiana		Throughout range		Throughout range (livestock, Red deer, Mouflon)			
rupicapra	Austria (older males) Germany, especially Bavaria		Germany, especially Bavaria	Italy (Mouflon)	Austria (sarcoptic mange, pestivirus)		Germany
tatrica	Throughout range	Slovakia	Tatra National Park				Slovakia

Table 4. Threats to Northern chamois in Europe by subspecies [1].

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Reviewer

- **Professor Marco Festa-Bianchet**

3.6. Eurasian elk

Alces alces

Summary

The Eurasian elk occurs throughout the northern hemisphere in a number of subspecies, with the European subspecies *A. a. alces* occupying an almost continuous range from Scandinavia and eastern Europe eastwards through Siberia to the Yenisei River. Much of the decline, which occurred in three phases in the 19th and 20th centuries, was attributed to over-exploitation resulting from economic hardship and the concomitant destruction of the population structure, as well as political instability. Changes in forest management and hunting practices, as well as legal protection and the reduction of natural predators have contributed to the resurgence of the species across the continent. It continues to spread into areas of its former range, making particularly great advances at its western limit.

Background

General description of the species

The Eurasian elk (*Alces alces*) is the largest living deer [1] and exists as eight subspecies throughout the northern hemisphere [2]. The European subspecies *A. a. alces* has a distribution from Scandinavia, Poland, northern Austria and southern Czech Republic eastwards through Siberia to the Yenisei River [2]. The elk is active throughout the day, with peaks of activity occurring at dawn and dusk [2]. It is a browse feeder, consuming the vegetative parts of a variety of plants such as trees, shrubs, herbs and aquatic plants, although it shows a preference for birch, alder and willow [2]. Both genders become sexually mature at 16–17 months, however, males are usually excluded from reproduction by dominant rivals until the age of five [2]. Males and females only come together for mating during the rutting season in September or October, and the female gives birth to one or two calves in the following May or June after a gestation period of around 234 days [2]. The maximum longevity in the wild is 16–19 years, and natural predators include Grey wolf (*Canis lupus*) and Brown bear (*Ursus arctos*) [2].

Distribution in Europe

The Eurasian elk has a recent evolutionary history compared with some other large mammals [3, 4]. The modern elk appeared around 100,000 years ago in the late Pleistocene in central Asia [5], spreading into Europe over the Pleistocene and Holocene [6]. During the early Holocene, it was distributed across most of the European continent [7], with the species' southern range boundary reaching the northern Caucasus and Caspian Sea [8]. Population reductions caused an eastwards retreat [7] and the withdrawal from the southern limit [8]. By the mid-20th century strongholds of the Eurasian elk

Scale	Status	Population trend	Justification	Threats
Global [11]	Least Concern	Increasing	Very widespread Extremely abundant Expanding in some areas Tolerant of secondary habitat	No major threats
Europe [17]	Least Concern	Increasing	Very widespread Extremely abundant Expanding in some areas Tolerant of secondary habitat	No major threats
Europe – regional populations [18]	Vulnerable: Carpathians	N/A	N/A	N/A

Table 1. Summary of Global and European Red List assessments and threats listed for the Eurasian elk.

were in Scandinavia and Russia [7], but the species also survived in Białowieża Forest in Poland and Belarus [9]. Following initial recovery in Poland [10], Eurasian elk populations are reportedly making a comeback [11] and now occur in the majority of their former distribution [7]. For example, its range is extending southwards into the Caucasus lowlands [11] and the northern boundary is thought to be shifting to higher latitudes [8]. The subspecies *A. a. alces* now occurs throughout Norway, Sweden, Finland, Russia, the Baltic states, Belarus, Poland and northern Ukraine [2], but has been extirpated from the southern part of its range in Austria although infrequent sightings still occur [11]. Three isolated populations remain in the southern Czech Republic, with occasional occurrences in Germany, Croatia, Hungary and Romania [11].

Habitat preferences and general densities

The species inhabits boreal and mixed forests in the northern temperate zone, especially those that comprise damp, marshy areas [2]. The limiting factors are snow depth of more than 70 cm and a mean temperature of more than 14°C in summer [2]. There are differences in habitat choice between genders, with females preferring habitats with good cover, while males select areas providing abundant food [2]. Because the elk is largely solitary [2], densities tend to be low, ranging from 0.7 to 1.2 individuals per km² depending on the method used [12].

Legal protection and conservation status

The Eurasian elk is included on Appendix III of the Bern Convention [13] and legally protected in the Czech Republic [14] and Slovakia [15]. The species occurs in a large number of protected areas and is not affected by any major threat processes at the species level [11]. Hunting seasons and the use of specific hunting gear are legislated in most European countries [16]. Both the global and European IUCN Red Lists list the Eurasian elk as Least Concern due to an increasing population trend, a widespread and expanding distribution, high abundance and high tolerance of altered habitat (Table 1).

Abundance and distribution: current status

The IUCN estimates a global elk population of 1,500,000 individuals, with the European population accounting for around 720,000 of these (Table 2). The largest populations occur in Russia (39%), Sweden (28%), Norway (15%) and Finland (13%), with smaller populations in Germany, Austria, Czech Republic and Slovakia, the Baltic States, Poland and Ukraine.

The largest population of Eurasian elk with an estimated size of 278,000 individuals is found in European Russia (Table 2.). This population was very low at the beginning of 1900s, but increased to 266,000 individuals by the mid-20th century [8]. Trends fluctuated subsequently, and the maximum number for the entire country reached over 900,000 in 1991 [8]. With the collapse of the USSR, economic and social changes led to a considerable

Table 2. Latest population estimates for the Eurasian elk globally, in Europe and for European populations. No information was available on elk numbers in Belarus.

	Estimate	Year assessed	Reference
Global	1,500,000	Unknown	[11]
Europe (excluding Belarus)	719,810	2004–7	[19–21]
% of global population	48%		
Austria	10	2004/5	[19]
Czech Republic	30	2004/5	[19]
Estonia	11,900	2004/5	[19]
Finland	93,000	2004/5	[19]
Germany	50	2004/5	[19]
Latvia	14,500	2004/5	[19]
Lithuania	3,900	2004/5	[19]
Norway	110,000	2004/5	[19]
Poland	3,900	2004/5	[19]
Slovakia	10	2004/5	[19]
Sweden	200,000	2004/5	[19]
Belarus	No data	-	-
Russia (European)	278,000	2007	[20]
Ukraine	4,510	2005	[21]

Figure 1a. Distribution of Eurasian elk in **1810** [7], **1955** [25] and **2008** [11].

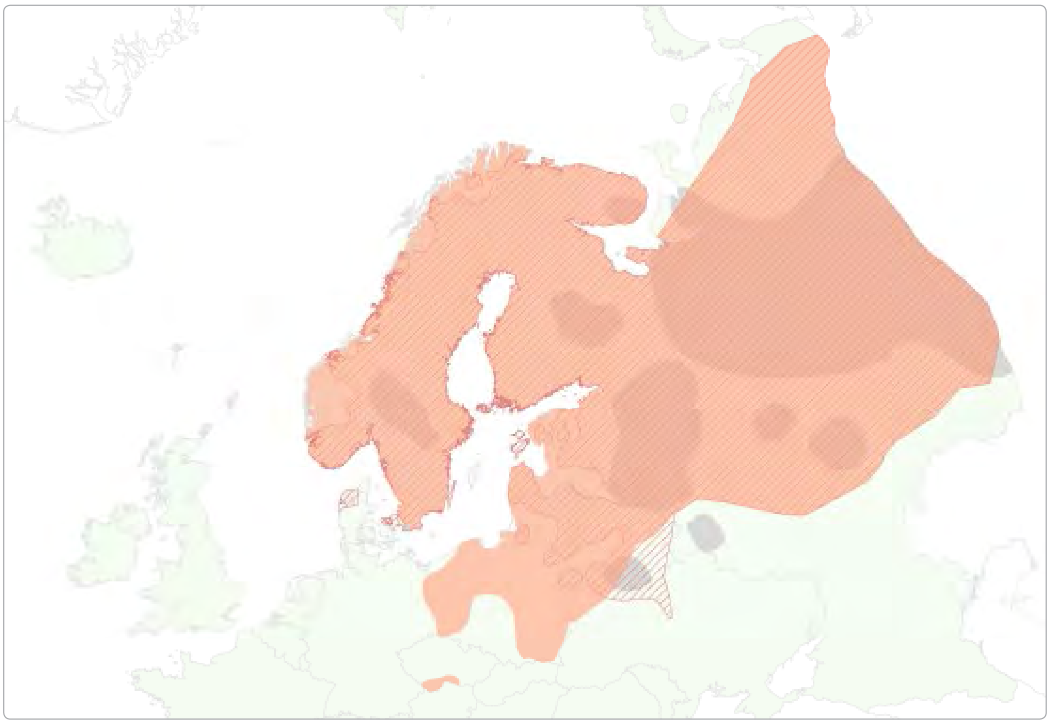
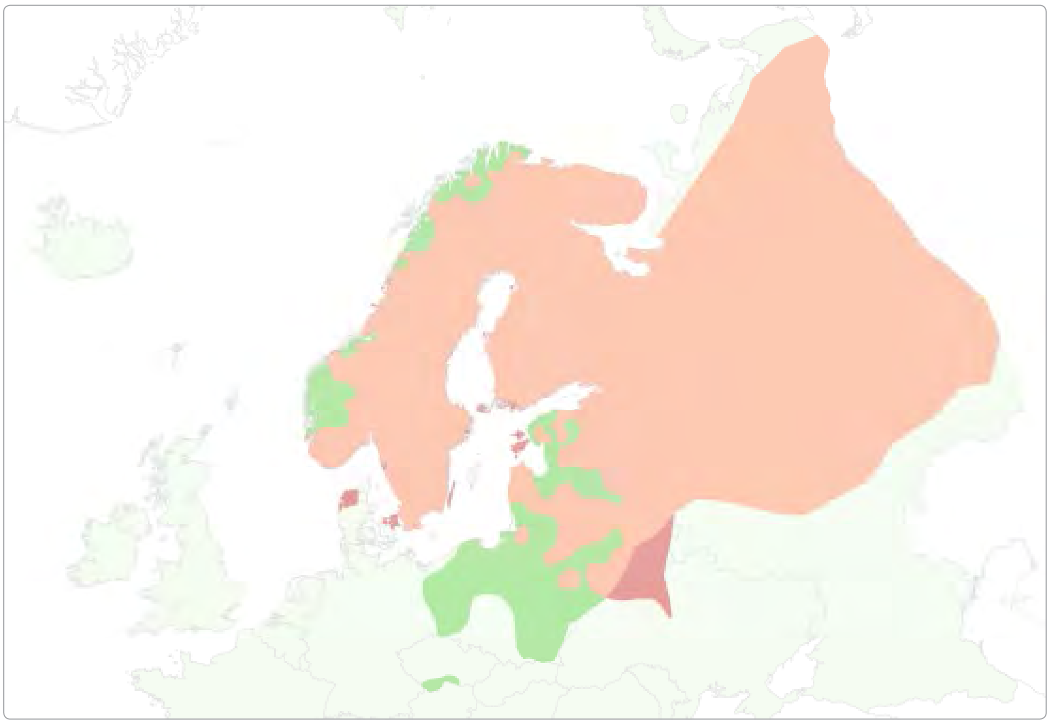


Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Eurasian elk in Europe between 1955 and 2008.



increase in poaching and a reduction in the elk population [8]. Numbers dropped to 526,000 by 2002, after which they stabilised and eventually began to increase [8]. At present, there are an estimated 600,000 individuals in all of Russia [8], with 278,000 occurring in the European part (Table 2).

At around 200,000 individuals, the second largest population of Eurasian elk occurs in Sweden (28%, Table 2), where it has been an important game species since the beginning of human settlement [22]. The hunting act of 1938 established larger game management areas with bag limits based on abundance, and most of the country was part of this system by 1970 [22]. The species benefitted from habitat changes, including the clear-cutting of forests and conversion of fields into forests and plantations, and increases were observed in range, abundance and hunting bag [22]. Exploitation levels peaked at 183,000 in 1982, which represents the largest harvest for the species in one year in any country on record [22]. Also an important game species in Norway and Finland, the elk has seen near extirpations in both countries [23]. Temporary hunting bans or legal protection provided opportunity for recovery, but with on-going exploitation populations continued to decline [23]. Although the species has not been formally protected since the Second World War, changes in hunting practices and forestry have allowed the species to become widespread and numerous [23].

Abundance and distribution: changes

In 1810, the Eurasian elk was distributed across an area of around 160,000 km² in a number of isolated populations. These ranged across south-central Sweden and Norway, Finnish and Russian Karelia, southeastern Murmansk, and some of European Russia. One continuous population ranged from Arkhangelsk to the Urals, another large population reached from the Moscow region into Belarus, and there were also five smaller satellite populations (Figure 1A). By 1955, the species' range had increased by around 150%, connecting formerly isolated areas (Figure 1A). Continued expansion resulted in an occupied area that was estimated to be 280% larger than the 1810 distribution in 2008 (Figures 1A and B). With significant spread into central Europe, the elk's current distribution encompasses Scandinavia, most of northern and central European Russia and two-thirds of Poland. It is also reaching into Germany, northern Austria, the southern Czech Republic, northern and western Belarus and north-western Ukraine (Figures 1A and B), as well as the northern Caucasus lowlands [11]. However, there have also been contractions in range in southern Belarus, Ukraine and Denmark (Figures 1A and B).

This overall positive trend in distribution is in line with change in population size. Monitored populations of the Eurasian elk in Europe appear to have increased in abundance by around 220% between 1964 and 2005 (Figure 2), although there is large regional variation underlying this average. The greatest recovery occurred in the 1960s, as has been reported in the literature [24], with population size increasing by 210%. The rate of growth then slowed, with a 25% increase in the 1970s, and stability or slight decline thereafter (Figure 2). It should be noted, however, that this overall trend may be masking differences at the regional level, as numbers have increased markedly in Scandinavia in recent decades [11]. The overall trend reported here is based on 18 populations from the species' current range, covering a minimum of 322,000 individuals. This therefore represents 45% of the total estimated European population from 2004–7, covering around 75% of the species' range countries. Population abundance data are missing from the western edge of the elk's range, namely western Poland, the Czech Republic and Germany.

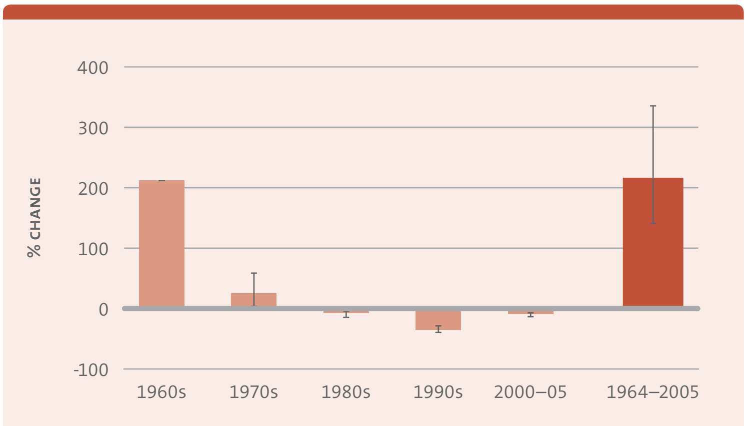


Figure 2. Change in Eurasian elk population **abundance by decade** and **overall change** between 1964 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

Drivers of recovery

A review of the literature suggests that while overall trends are positive, the European elk experienced three phases of decline in eastern Europe from which this resurgence has taken place [26]. The fragmented distribution of the species in the early 1800s (Figure 1A) was likely the result of the first phase of decline between 1800 and 1850 [26], which was marked by gradual change, local extirpation and range contraction followed by swift recovery [26]. The second phase in the 1920s, attributed to over-exploitation resulting from economic hardship and famine, led to smaller range decreases than previously, but recovery was delayed for unknown reasons [26]. Populations recovered with the reoccupation of the forest zone, although this process was slow due to the destruction of a formerly healthy population structure [26]. Our analysis showed a slight decrease from 1990 (Figure 2), which matches the third phase of decline normally attributed to political instability leading to inappropriate management decisions [26].

The variability in population change in the data set means that clear reasons for wildlife comeback are difficult to discern, but there are common themes (Table 3). Regional-level trends show that populations in eastern Europe have declined, while northern European elk (e.g. from Finland, Norway, Poland, and Sweden) have fared better. In addition, populations from boreal forest and taiga biomes showed increases in abundance, while temperate broad-leafed forest and temperate grasslands have decreased. Management was found to have a positive effect on European elk abundance in a range of locations, which included the adoption of new hunting principles in Russia and Finland, reforestation in Finland, and legal protection in Poland.

Historically, declines resulted from high levels of hunting and poaching, as well as predation by wolves and bears across Europe, e.g. Finland [27], Poland [10] and Estonia [28]. It is therefore unsurprising that the elimination of these predators has contributed to comeback, for example in Sweden [24] and Norway [23]. But it is changes in hunting practices, including the adoption of new hunting principles (such as age- and sex-specific harvesting) and hunting bans that are thought to be the main reasons for recovery over the past 50 years, e.g. in Finland [24, 27], Norway [23, 24], Sweden [24], Poland [10, 24] and Belarus [27]. Forest management practices increasing the amount of available browse have also played an important role in the resurgence of the species in Norway [23], Sweden [24], Finland [27] and Estonia [28]. In addition, both of these factors interact with local climatic conditions; for example in Latvia, fewer hunters entered the forests because of strong storms in 1967–68, which caused a rise in elk through a reduced level of exploitation and increase in available browse, although a concomitant growth in carnivore numbers also led to elevated predation [28]. To a smaller extent, population size has increased through natural expansion into suitable habitat. The species has, for example, spread into Finland from Russia [24], and small populations have formed in the Czech Republic, Slovakia and northern Romania through immigration from Poland and Ukraine [24]. In some areas, e.g. Sweden, land abandonment leading to higher availability of preferred browse has been beneficial [24].

Overall, a range of factors have been implicated in the recovery of the Eurasian elk. These include changes in forest management, the adjustment of hunting practices and legal protection, the reduction in natural predators, and, to some extent, land abandonment.

Recent developments

After a varied history in Europe, the Eurasian elk has been going from strength to strength in recent years. As numbers continue to increase, culling is employed in most countries where the species is abundant to control population numbers, e.g. in Sweden [29]. The elk is also spreading further into its historical range, especially at its western limit (Figure 3). In September 2009, a young male was observed in the northern part of the State of Hesse in Germany (it was, unfortunately, found dead following relocation to a suitable forested area), and there have also been increased sightings near the borders with Poland and the Czech Republic [33]. It is estimated that 50 elks now exist in Saxony alone,

and some individuals appear to have settled in the Oder-Spree area and Oberlausitz, where the species is reproducing [33]. Some states such as Bavaria, are starting to implement necessary management plans, as these populations are expected to spread further into the country, although this expansion may be somewhat restricted due to the small number of available unfragmented forests [33]. In addition to natural recolonisation, reintroductions have been carried out in some areas such as in Alladale Wilderness Reserve in Scotland, where two individuals were introduced in 2008 [30, 31]. This represented the first occurrence of the elk in the United Kingdom for 1,000 years [30, 31], and the species appears to be thriving, with the first calf born in the summer of 2011 [32].

Despite this, there have also been negative developments for the Eurasian elk in Europe. For example, traffic accidents are a major issue in Sweden, where 4,092 collisions were reported in 2005 [22]. Continuing infrastructure developments alongside the natural expansion of the elk into new areas could make this an increasing concern. In addition, natural predators of the species are making a comeback in many countries, for example in Sweden [22], and it remains to be seen how this will affect elk numbers in the long-term. There is also a fine balance to be struck between reducing the impact on forestry through population management, and maintaining both high genetic diversity and fitness, and continued hunting potential. In areas of large population size and high density, elk may need to be actively managed to prevent damage to crops and forests, whereas in areas of decline, threats need to be addressed through, for example, hunting bans, poaching control and monitoring [34]. Future conservation should also focus on maintaining viable metapopulations by preserving local populations to allow for sufficient exchange between them, particularly in forested zones which have served as important refugia in the past [26].

Overall, Eurasian elk is thriving in the European part of its range. It is considered Least Concern and is not believed to face any threats at the species level, despite intense hunting pressures in some countries. The species has more than doubled in abundance since the 1960s and continues to spread into areas of its former range.

Rank	Reason for change	Description
1	**Species management – Adjustment of hunting practices**	Positive management action included the adoption of new hunting principles, such as age- and sex-specific harvesting of populations in Finland [24, 27], Norway [23, 24], Sweden [24] and Poland [10, 24].
2	**Land/water protection and management – Forest management**	Elk number increased following changes in forestry practises (increasing clear cuts) in Norway [23], Sweden [24], Finland [27] and Estonia [28].
3	**Legislation**	A hunting ban in northeastern Belarus [27], and temporary legal protection in Finland [24] and Poland [24] were beneficial.
4	**Other – Natural expansion**	The species recolonised Finland from Russia [24], and small populations have formed in the Czech Republic, Slovakia and northern Romania through immigration from Poland and Ukraine [24].
5	**Other – Reduction of predators**	The elimination of the Grey wolf in Scandinavia [24] has reduced predation of the elk.
6	**Other – Land abandonment**	On a small scale, land abandonment leading to abundant preferred browse has been beneficial in Sweden [24].

Table 3. Major reasons for positive change in the status of the Eurasian elk in Europe.

Figure 3. Map of recent developments recorded for the Eurasian elk in Europe.

Expansion
Persistence
Contraction
New sighting
New management plan
Reintroduction
Accidental mortality
Direction of further range expansion

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Reviewer

- **Dr Robin M. A. Gill**

3.7. Roe deer

Capreolus capreolus

Summary

The Roe deer is the most abundant ungulate in Europe with an almost continuous distribution across the continent and Great Britain. It is absent only from the larger islands. The species declined in abundance and range and became locally extinct between the Middle Ages and early 20th century due to over-exploitation and habitat loss. Various factors contributed to its recovery, particularly a shift into open habitat, land use changes resulting in greater availability of food and habitat, and reintroductions and translocations.

Background

General information on the species

The Roe deer (*Capreolus capreolus*) is the most abundant wild ungulate in Europe [1] and Asia [2], with a near continuous distribution from the west of the continent to European Russia and the Caucasus [3]. It normally lives alone or in small groups [4], and herd size varies with habitat and season [5]. As an opportunistic and flexible but also selective feeder [4], the species' diet varies considerably with season and habitat [6]. However, herbaceous dicotyledons and deciduous browse as well as small amounts of grass and other plants are typically taken [6]. Although largely crepuscular in its behavior, the Roe deer can be more diurnal if undisturbed and during the rut when social behavior changes [5]. This is also the time when territoriality, which may be observed all year round, becomes particularly pronounced [6]. The Roe deer is the only artiodactyl to show delayed implantation, which occurs in late December after mating in July or August [5]. Twins are born after 150 days of gestation [4], and young reach sexual maturity at 14 months [5]. The species has a life expectancy of 7–8 years in the wild, but can live up to 20 years [5].

Distribution in Europe

First recorded from the Middle Pleistocene about 600,000 years ago, the Roe deer was present on most of the European continent during interglacial and mild glacial periods [4]. During the Last Glacial Maximum, however, it was forced into refugia in the Mediterranean and southeastern Europe [4], one of which provided the individuals for recolonisation of western, central and northern Europe around 9,600 years ago [4]. Roe deer was abundant throughout Europe and parts of western Asia historically [2], but declined in abundance and range between the 17th and early 20th century [7], mainly due to over-harvesting [4] and habitat loss, which led to near extinction in parts of southern Europe [3]. In some regions, declines occurred even earlier, such as during the Middle Ages in Great Britain [8], also the result of

Scale	Status	Population trend	Justification	Threats
Global [3]	Least Concern	Increasing	Widespread Common No major threats	1. Genetic mixing as a result of translocations 2. Poaching (*C. c italicus*) 3. Predation by feral dogs (*C. c. italicus*) 3. Habitat loss (Syria)
Europe (EU25) [15]	Least Concern	Increasing	Widespread Common No major threats	1. Genetic mixing as a result of translocations 2. Poaching (*C. c italicus*) 3. Predation by feral dogs (*C. c. italicus*)
Europe – regional populations [16]	Least Concern: France	N/A	N/A	N/A

habitat loss and hunting pressure. Management interventions started the recovery of the species during the 1800s, which accelerated in the subsequent century [9]. During the second half of the 20th century, European populations increased and stabilised in western and central Europe [2], while little distributional change occurred in other parts of eastern central Europe, e.g. Poland and the Czech Republic [10, 11]. In addition, numbers have been strongly controlled in areas with a high density of natural predators, e.g. Poland [10]. The deer is now present across all of mainland Europe, although its distribution is patchier in the far south, e.g. in Italy, Spain and Portugal. While it occurs in most of Great Britain (England, Scotland and Wales), it is absent from the other large islands of Europe, e.g. Ireland, Sardinia, Corsica, Sicily, Cyprus and Iceland [12].

Habitat preferences and general densities

Roe deer occurs in a wide variety of habitats [6], including forests, moorlands, pastures, arable land and suburban areas [3], although densities are highest in woodland-field mixtures or woodland with clearings [13] because these provide both food and cover in close proximity [5]. It is considered one of the best-adapted species for cultivated land [2, 7]. Population density is normally 15–25 individuals per km^2 in central Europe, but up to 60–70 deer have been recorded in good quality habitat [5].

Legal protection and conservation status

The Roe deer is listed on Appendix III of the Bern Convention [14], and many of its populations are found in protected areas [3]. The species is heavily managed through hunting, culling and supplementary winter feeding, although management plans differ considerably between countries [13]. Because it is widespread and common with an increasing population trend, the species is considered to be Least Concern on the IUCN Red List, both globally [3] and within Europe [15], as well as within France [16] (Table 1). Despite this, a number of threats remain: in Europe, this is primarily the mixing of genetically distinct sub-species due to translocations [3], but over-exploitation through hunting (specifically the small remaining population of *C. c. italicus*), and habitat degradation and loss (e.g. the remnant Syrian population [3]) also play a role.

Abundance and distribution: current status

While no reliable global estimate of Roe deer population size exists, the European population is believed to consist of at least 9.8 million individuals (Table 2). Around 47% of these occur in the countries situated in the centre of the species' range, namely Germany (24%), France (12%) and Austria (11%) (Table 2).

With an estimated size of around 2.4 million individuals, the largest population of Roe deer is found in Germany. Its history here has been varied, going from an abundant cervid when hunting rights were reserved for aristocrats and clergymen, to near extinction after farmers were given equal hunting rights in the wake of the 1848 revolution [20]. Following extensive recovery, the species is now abundant and present throughout the country up to the upper forest line at 1,800 m in the Alps [20], although the highest densities occur in areas comprising a mosaic of forest and meadows [20]. As one of the staple quarries for hunters [20], more than one million individuals have been shot annually in recent years [36]. Another major source of mortality are vehicle collisions, with an estimated 170,000 deer killed on German roads in 2011/2012, thus accounting for around 88% of reported collisions involving ungulates [37]. Fawn mortality is often high due to early mowing for silage and an increasing fox population [20].

As the most abundant ungulate in France, the Roe deer population is 1.2 million individuals strong and occurs in 90% of the country with the exception of the Mediterranean island

Table 1. Summary of Global and European Red List assessments and threats listed for the Roe deer.

	Estimate	Year assessed	Reference
Global	**No data**	**-**	**-**
Europe	**9,860,049**	**2005**	**[8, 10–12, 17–32]**
% of global population	**No data**		
Albania	No data	-	-
Austria	1,050,000	2005	[33]
Belarus	51,190	2003	[12]
Belgium	~60,000	2006	[34]
Bulgaria	71,000	2006	[12]
Croatia	41,500	2002	[35]
Czech Republic	292,800	2004	[11]
Denmark	200,000	2005	[17]
Estonia	~50,000	2005	[18]
France	1,200,000	2005	[19]
Germany	~2,400,000	2010	[20]
Greece	No data	-	-
Hungary	316,157	2005	[21]
Italy	426,000	2005	[22]
Latvia	~130,000	2005	[18]
Lithuania	~80,000	2005	[18]
Luxembourg	24,000	2003	[12]
Macedonia	5,000	2002	[12]
Moldova	2,300	2002	[12]
Montenegro	1,627	2005	[12]
Netherlands	~60,000	1992	[23]
Norway	90,000	2005	[24]
Poland	692,000	2005	[10]
Portugal	3,000–5,000	2010	[25]
Romania	159,000	2006	[26]
Serbia	120,000	2005	[27]
Slovakia	80,000–85,000	2010	[28]
Slovenia	150,000	2005	[29]
Spain	600,000	2005	[30]
Sweden	800,000	2010	[31]
Switzerland	133,575	2004	[32]
Ukraine	120,900	1999	[12]
United Kingdom	~450,000	2007	[8]

Table 2. Latest population estimates for the Roe deer globally, in Europe and for European populations. No information was available for Albania and Greece.

of Corsica [19]. While the species was formerly restricted to forest, colonisation of more open habitats started from the 1980s, leading to marked population recoveries in agrosystems [38], Mediterranean landscapes [39] and mountainous areas [19]. The hunting bag has steadily increased since the early 1970s, and although 500,000 individuals were culled in 2004, some argue that this Figure should be higher [19].

In Austria, the situation is comparable: as the most common ungulate, the Roe deer occurs in 90% of the country, with a maximum population density of about 40 per km² [33]. There has also been a linear increase in the hunting bag [33]. While culling intensity was already high in the early 1960s, particularly in the west of the country, it is now more than 2 per km² per year in most administrative districts, with the exception of parts of Tyrol, and the areas around Innsbruck and Vienna [33]. The other main source of mortality are vehicle collisions, which account for around 8% of individuals killed in 2005 [33].

Abundance and distribution: changes

According to available range data, the Roe deer was widely distributed in 1900 across an area of around 2,700,000 km² covering central Europe from eastern France to Russia (with the exception of Italy and the Balkan peninsula), Scotland, eastern Denmark, southern Sweden and the easternmost part of European Russia (Figure 1A). Phylogeographic analyses indicate that some populations persisted in some small patches in Iberia [40, 41]. This distribution was the result of increases in the latter half of the 19th century which followed declines up to around 1800 [9]. Since then, the species has gained ground, now occupying around 2.2 times its range in 1900 (Figure 1A). Most of this change occurred between 1900 and 1967, when deer distribution almost doubled, spreading outwards from its core central European range (Figure 1A). In Scandinavia, for example, the Roe deer was restricted to a population of around 200 individuals in the southernmost part of Sweden before 1850, but expanded its range after 1850 at a rate of around 12 km per year [24].

A further extension of 25% between 1967 and the present day resulted in the species now reaching across the European continent from Scandinavia into the South of Spain, France and Italy and as far as east of the Caucasus. However, rates of expansion over this time period have varied greatly, both across Europe and at sub-regional levels. In southern Scandinavia, it was of much slower pace despite the fact that habitat was deemed more optimal for the species [42]. Conversely, range expanded by 2.3% per annum between 1972 and 2002 in the United Kingdom, and the species was predicted to spread even further to cover around 79% of mainland Britain within ten years [43]. In addition, positive range change in Spain between the 1960s and the present day is likely to be an underestimation, as the Roe deer was less widespread around its glacial refuges in 1967 than depicted in Figure 1A [41]. The expansion of the species from these areas occurred primarily over the last 30–40 years, especially in the northwest of the country [41].

Range contraction has only occurred at a sub-regional level in the southern extreme of the species' range in Spain (due to habitat restrictions [41]) and Italy (Figure 1B). It is in these areas that populations are generally more disjunct than others (Figure 1B). This is a particular concern as populations here are believed to be distinct from the European clade since the last glaciation [22, 30] and may be seriously compromised from a genetic point of view [22].

The overall positive trend is also reflected in the change in population size. Monitored

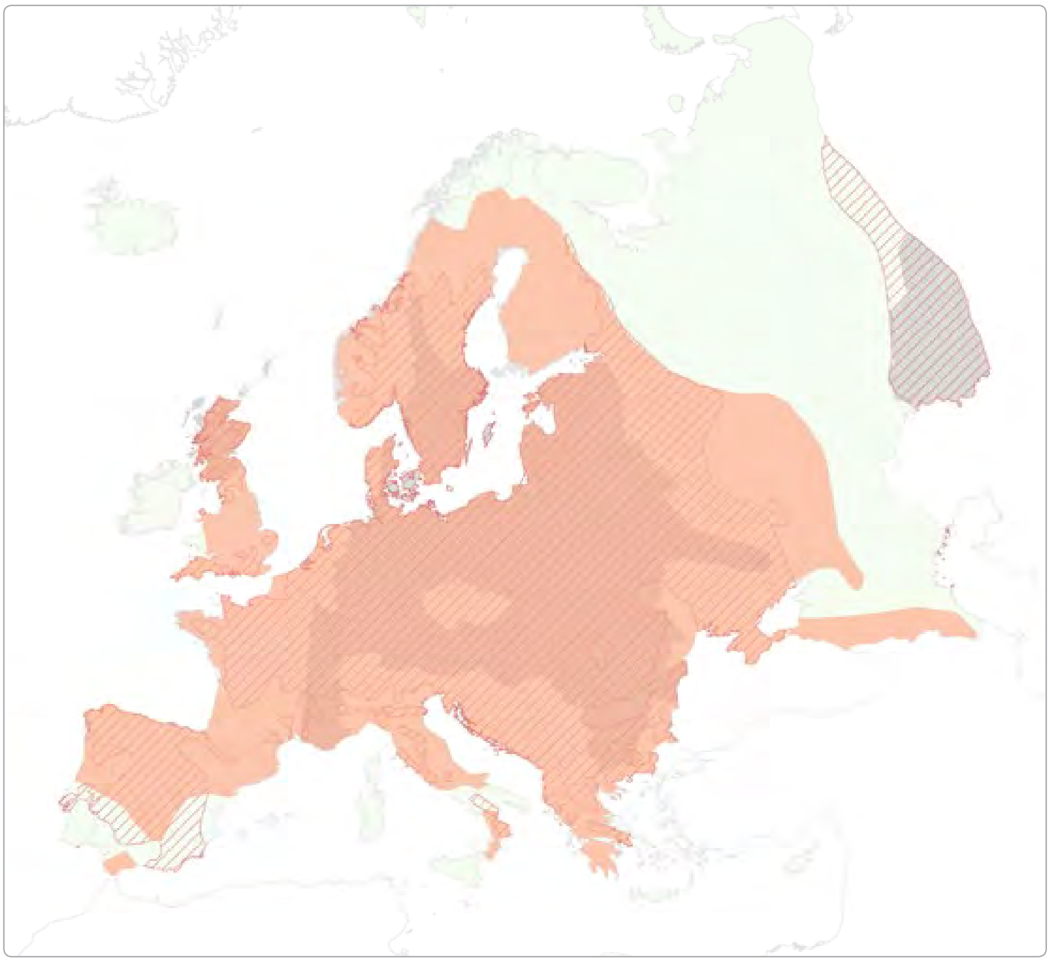


Figure 1a. Distribution of Roe deer in **1900** [2, 9], **1967** [46] and **2008** [3]. Question marks are areas where the species persisted into the 20th century after the last glacial maximum, and from which it recolonised the Iberian peninsula [40, 41]. Please note that the map for 1900 is at the country level and thus of lower resolution. By 1967, the deer was more widespread in Scotland and northern England [9] and present in smaller areas around the glacial refuges in Spain [41].

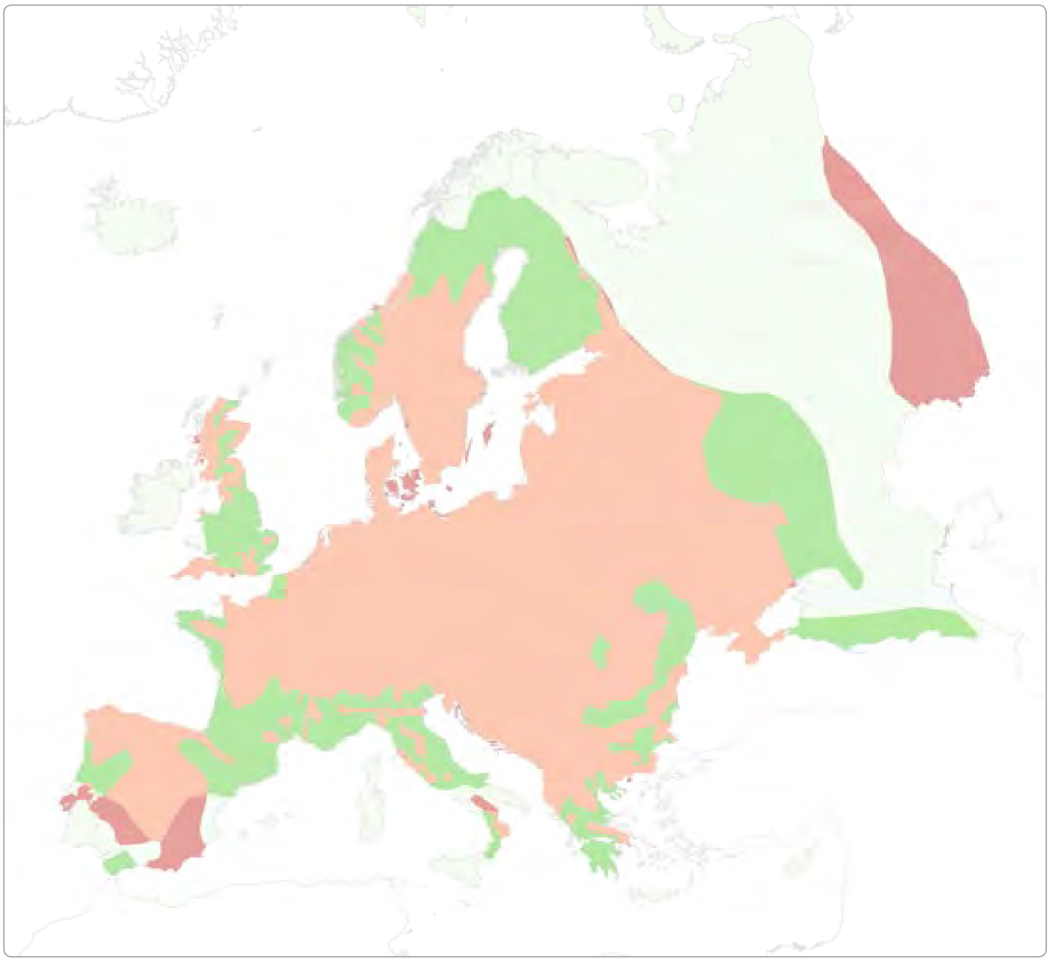
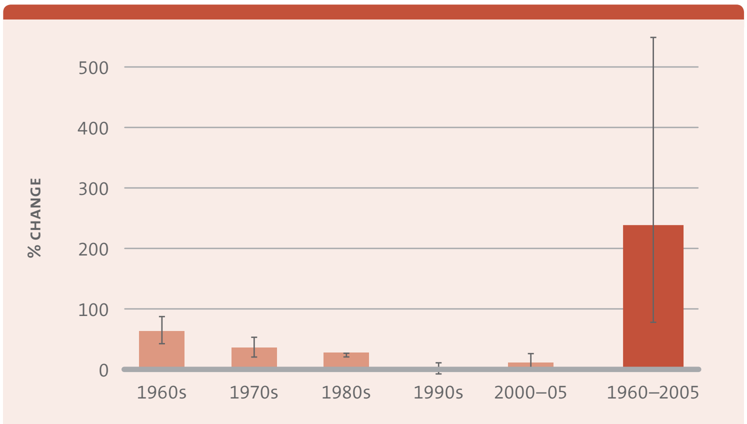


Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Roe deer in Europe between 1967 and 2008. Because the species was more widespread in Scotland and Northern England, the expansion depicted is likely to be an overestimation [9]. Range change in Spain is likely to be an underestimation as the deer was less widespread in 1967 than depicted [41].

Figure 2.
Change in Roe deer population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.



populations of the Roe deer have increased in abundance by around 240% between 1960 and 2005 (Figure 2). The greatest abundance change of over 60% occurred in the 1960s, which is in line with the reported increases between the 1950s and 1970s throughout the species' range, with the notable exception of Greece [44] and Serbia [27]. Thereafter, the rate of growth steadily declined, reaching a low of less than 1% in the 1990s, and rising to around 11% in the 2000s (Figure 2). Similarly large overall recoveries have been reported nationally: population increase has been estimated at 317% for the period between 1980 and 2005 in Italy [22], 500% over the same time period in Flanders (Belgium) [34], and a fivefold increase occurred in Roe deer populations between 1960 and 2005 in Hungary [21]. However, negative change has also been reported, such as in Greece, in Macedonia due to poaching [45], and in Serbia, where population numbers fell during the 1990s because of overhunting, poor harvest management and reduction in supplementary winter feeding [27]. It is believed that the Roe deer is faring less well in these regions because it has not expanded into available open habitat, being mostly restricted to forested areas. In other areas, increases in large predators, poaching and harsh winters have contributed to negative abundance change and range reductions, e.g. in the Baltic states [18].

Naturally, monitoring data are spatially and temporally sporadic for a wide-ranging and common species such as the Roe deer. The overall trend is based on 23 populations from the species' current range, covering a minimum of 327,700 individuals and therefore representing only 3.3% of the total estimated European population (Table 2). The dataset covers 27% of the countries of occurrence, including 11 which support more than 50,000 individuals (Table 2), e.g. France, Sweden and Poland. However, data were missing from the largest population in Germany, as well as other important countries numbering more than 200,000 individuals such as Austria, Spain and Denmark, and there were no data from medium-sized populations of between 80,000 and 200,000 individuals (Table 2).

Drivers of recovery

While no significant factors for recovery could be discerned from the data set, this is unsurprising, considering the fact that despite covering over a quarter of the countries of occurrence, only 3% of individuals were represented (Table 2). A review of the literature suggests that, at least initially, legal protection [13], reduced exploitation [13, 31] and reintroductions and translocations played an important role in the recovery of the Roe deer across Europe (Table 3). This is particularly true in Italy [13], where most of the current southern populations are the result of such management intervention [22], England where individuals from the continent and Scotland were reintroduced [8, 13], and in Switzerland [32], Portugal [25] and Finland [13]. Increasingly connected populations and local recoveries also led to natural recolonisation, for example in Switzerland [32], Portugal [25], Norway [13] and Finland [13]. The reduction in hunting (France, Germany, Switzerland and Sweden [13, 31]) and lower competition and predation (e.g. fox reduction resulting from sarcoptic mange in Denmark [17], and of various competitors and predators in Sweden [13, 31]) have also been beneficial.

Most importantly, however, sudden expansion into open agricultural landscapes in the 1960s (particularly in central European countries such as Hungary [21] and Slovakia [28]) has been implicated in the recovery of the species over the past 50 years. In other regions, this habitat shift did not occur until later, although the species is now present in over 90% of mainland France [19]. As a result, open mosaic habitat of forest, meadow and agricultural land now supports some of the highest densities of this formerly forest-restricted species in many countries [18, 20, 28]. Similarly, numbers are often much lower in areas traditionally thought of as ideal habitat, such as the Slovakian Carpathians [28]. While one reason for this habitat shift is undoubtedly the deer's great ecological flexibility and ability to exploit a variety of different resources, land use changes have also played a role. For example, the sowing of cereals in the autumn (eg. winter wheat) is a fairly new practice compared to sowing in spring, providing substantial additional food over the otherwise lean winter months [9]. An increase in available food can greatly reduce mortality in winter, as has been shown in Denmark [17] and Sweden [31]. In addition, the depopulation of rural areas, which has a profound effect on the level of disturbance and hunting, will also have been in the species' favour by providing more high-quality habitat [9]. Abandonment of marginal agricultural land have been particularly beneficial in Denmark [13], Sweden [31], Slovenia [29], Switzerland [13] and Spain [47], where amended forestry practices have also contributed to an increase in available habitat.

Overall, a range of factors have been implicated in the change in abundance of the Roe deer (Table 3). While it is likely that many have ceased to be important in the maintenance of high population densities across Europe, the recent comeback of large predators may impact deer numbers in the future.

Rank	Reason for change	Description
1	**Other – Habitat shift**	The expansion into open agricultural landscapes led to increases across the range, including Hungary [21], Slovakia [28] and France [19]. Densities are now highest in open mosaic habitat of forest and meadow, agricultural fields [18, 20, 28].
2	**Other – Species ecology**	The Roe deer is an opportunistic and flexible feeder [4], which can exploit a variety of resources. It is considered one of the best-adapted species for cultivated land [2, 7].
3	**Land/water protection & management – Land use changes**	Beneficial land use changes include change in agricultural practices, abandonment of agricultural land and changes in forestry practices, all of which are described in more detail below.
4	**Land/water protection & management – Increased food availability**	The sowing of cereals in the autumn rather than spring provides substantial additional food over the winter [9]. Access to winter green pasture in Denmark [17] and winter feed in Sweden [31] have resulted in decreased mortality.
5	**Other – Land abandonment**	Abandonment of marginal agricultural land has been particularly beneficial in Denmark [13], Sweden [31], Slovenia [29], Switzerland [13] and Spain [47]. This also has an effect on the level of disturbance and hunting.
6	**Land/water protection & management – Change in forestry practices**	Amended forestry practices have also contributed to an increase in available habitat in Denmark [13], Sweden [31], Slovenia [29], Switzerland [13] and Spain [13].
7	**Species management – Reintroductions and translocations**	Reintroductions and translocations have been important in Italy [13, 22], the UK [8, 13], Switzerland [32], Portugal [25] and Finland [13].
8	**Other – Natural recolonisation**	Natural recolonisations have occurred in many parts of the Roe deer's range, particularly in Switzerland [32], Portugal [25], Norway from Sweden [13], and Finland from Russia and Sweden [13].
9	**Other – Reduction in predators and competitors**	Roe deer increased as a result of the reduction of foxes due to sarcoptic mange in Denmark [17] and of competitors and large predators in Sweden [13, 31]
10	**Legislation**	Legal protection in Bulgaria [13].
11	**Species management – Reduced exploitation**	More restrictive hunting laws led to recoveries in France [13], Germany [13], Switzerland [13] and Sweden [31].

Table 3. Major reasons for positive change in the status of the Roe deer in Europe.

Recent developments

As discussed above, Roe deer account for a large proportion of vehicle collision accidents in many European countries, for example in Germany [37]. The number of individuals killed on roads is likely to rise in future, due both to increasing deer population density and continued fragmentation of the landscape through infrastructure development. In addition, Europe's large predators are making a comeback in many regions, which may have an impact on Roe deer population size in some areas. There is also growing evidence that the species can be outcompeted by the sympatric Red deer. For example, Roe deer numbers are suppressed in areas with high Red deer density in Scotland [48] and Portugal [49], while Roe fawns show lower body mass in areas where Red deer are present [50]. The maintenance of Roe deer populations may thus not be compatible with artificial restocking of areas with other ungulates or with the natural increase of wild and domestic ungulate species [41]. While this issue is unlikely to affect the species as a whole, it could be a concern at a local level, and should be taken into account when designing community composition in rewilding areas [41].

Overall, however, the Roe deer is not facing any major threats [3, 15] and increasing both globally [3] and in Europe [15]. Because the species has already made the successful shift from forest to more open landscapes, it has probably colonised all available habitat across Europe, and is therefore unlikely to show further range expansion in the future. In many countries, densities may still rise, but increases are not expected everywhere, e.g. in Slovenia [29] or at the southern edge of its range in Iberia [51].

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3.8. Red deer

Cervus elaphus

Summary

The Red deer has a wide distribution across most of the European continent, with the exception of northern Scandinavia, Finland and Iceland, where it is limited by severe climate. Declines and local extinctions occurred throughout the species' native range from the 16th century due to overexploitation, habitat loss and competition with livestock. Through changes in legislation, hunting, habitat, and predator and competitor levels, as well as translocations, reintroductions and recolonisation, the cervid has grown in abundance and range, and now represents the greatest biomass of any ungulate in Europe.

Background

General description of the species

The Red deer (*Cervus elaphus*) is the most widely distributed deer species in the world, with a large but patchy distribution across Eurasia and also reaching into northern Africa [1, 2], being limited only by severe winter climate [3]. It also occurs in introduced populations in parts of the southern hemisphere such as Chile, Argentina, Australia and New Zealand [4]. Once considered a single species, Red deer is now divided into six to ten subspecies globally [4]. It is the fourth largest ungulate [5] and second largest deer on the European continent [6]. Although active throughout day and night, peaks of activity occur at twilight due to human activity [6]. As an intermediate feeder with a large rumen, the Red deer consumes a variety of plants including grasses, sedges, browse, fruits and seeds; the exact composition differs between males and females, and habitats [4]. Females and young live in small matrilineal herds but gather into larger groups in winter, while stags live a solitary life, except in summer when they may occur in all-male herds, and during the rut in late summer when they gather harems [4]. One calf is usually born in May or June after a gestation period of around 8.5 months [4]. Young reach sexual maturity between 1.5 and 2.5 years depending on habitat quality [4]. The natural maximum lifespan of the species is 17–18 years, although individuals as old as 26 years have been recorded [4].

Distribution in Europe

The species appeared in Europe in the late Early Pleistocene around 900,000 years ago [4] and was able to persist in southern Europe (Iberia, south-western France, Italy, Balkans, Greece) and east of the Carpathians in Moldavia during the Last Glacial Maximum [7, 8]. The clades present today can be traced back to different refugia: the western and eastern European lineages (*scoticus*, *atlanticus*, *elaphus*, *hippelaphus* and *hispanicus*) stem from the Iberian and Balkan refugia, while the Mediterranean lineage (*C. e. corsicanus*) is descendent from Sardinia or Africa [7]. From the 16th to the 19th century, and in some places even earlier, populations declined throughout much of the native range [9, 10], mainly as a result of overhunting (e.g. Switzerland [3]), forest loss (e.g. southern France [11]) and competition with domestic livestock (e.g. Norway [12], Sweden [13] and the Czech Republic [14]). Native populations disappeared completely in the Baltic states [15], Switzerland [16], Slovenia [17] and Macedonia [18], while near extinctions occurred in Portugal [19] and Italy [20]. In other areas, the species became confined to remote forest or mountain areas, for example in Slovakia [21].

Habitat preferences and general densities

Red deer inhabits broadleaved and coniferous forest and woodland margins, although it is also found on mountain meadows (Alps and Norway) and in more open habitats (Scotland) [3]. Where populations have improved, this species is also increasingly found in agricultural areas near woodland, e.g. in central European countries [3]. It naturally occurs at a density of 1–5 up to 15 individuals per km^2, with an upper limit of 45 individuals depending on habitat and the presence of supplementary feeding [4, 6]. In many countries, densities correlate primarily with forest cover, for example in Poland [22] and Croatia [23]. In areas where hunting represents major revenue, artificially raised unnatural levels of up to 100 individuals per km^2 may be recorded [4].

Legal protection and conservation status

The subspecies *corsicanus* is included in Appendix II of the Bern Convention [24] and Annexes II and IV of the EU Habitats and Species Directive [25], whilst the remainder of the species is listed on Appendix III of the Bern Convention [26]. Because of its large distribution, the Red deer occurs in protected areas throughout Europe [26], and is heavily managed through hunting, culling and supplementary winter feeding, although management plans differ considerably between countries [3].

The IUCN Red List lists the cervid as Least Concern both globally and in Europe because it is widespread and abundant with an increasing population trend overall (Table 1), despite range contractions and population declines in some parts of Eurasia and North America [26]. In Europe, some subspecies and national populations are still in need of conservation intervention (e.g. *C. e corsicanus*, endemic to the islands of Sardinia and Corsica [27]). In addition, the genetic identity of the species is increasingly compromised, partly through hybridization with the non-native Sika deer (*Cervus nippon*) [28–30] due to an increasing range overlap, e.g. in the United Kingdom [10]. But it is the mixing of distinct subspecies that is of greatest concern, as farm-reared individuals which have experienced admixture of different lineages and artificial selection through domestication have been widely translocated and have bred with natural populations [31]. For example, *corsicanus*-type mitochondrial DNA haplotypes have been found on Rum in the UK [32] and in Spain [31]. In addition, genetic material of the subspecies *hippelaphus* is often found in western Red deer (*C. e. elaphus*, *scoticus* and *hispanicus*) [31]. This is the result of little control over past breeding and translocation, as well as a focus on the conservation of number as opposed to natural features [33]. Hunting, as well as management for hunting, is strictly regulated in most countries of occurrence and is not considered a major threat [26]. However, it can contribute to population fragmentation through fences, and to altered age structure, disequi-

Table 1. Summary of Global and European Red List assessments and threats listed for the Red deer.

Scale	Status	Population trend	Justification	Threats
Global [26]	Least Concern	Increasing	Wide distribution Large populations	1. Genetic mixing & hybridisation 2. Habitat loss (agricultural expansion) 3. Habitat loss (urban development) 4. Hunting
Europe (EU25) [27]	Least Concern	Increasing	Wide range Common	1. Genetic mixing & hybridisation 2. Habitat loss (agricultural expansion) 3. Habitat loss (urban development) 4. Hunting
Europe – regional populations [37]	Endangered: *C. e. corsicanus* France [37], Greece [38] Vulnerable: *C. e. elaphus* Sweden [37], Serbia [39] Least Concern: France, Ireland [37]	N/A	N/A	N/A

	Estimate	Year assessed	Reference
Global	**No data**	**-**	**-**
Europe	**2,443,035**	**2002–2010**	**[9]**
% of global population	**No data**		
Austria	140,000–190,000	2005	[40]
Belgium (Wallonia)	10,000	2006	[41]
Belarus	4,890	2003	[1]
Bosnia and Herzegovina	No data	-	-
Bulgaria	16,264	2002	[1]
Croatia	9,600	2002	[23]
Czech Republic	25,000	2004	[14]
Denmark	12,000–14,000	2002	[42]
Estonia	1,550	2005	[15]
France	35,000–45,000	2000	[11]
Germany	150,000–180,000	2006	[43]
Greece	130	2001	[1]
Hungary	74,130	2005	[44]
Ireland	3,000–4,000	2010	[45]
Italy	62,913	2005	[20]
Latvia	28,400	2005	[15]
Lithuania	12,600	2005	[15]
Luxembourg	3,192	2003	[1]
Macedonia	300	2002	[1]
Moldova	429	2003	[1]
Montenegro	No data	-	-
Netherlands	2,735	2010	[46]
Norway	130,000	2004	[12]
Poland	141,000	2005	[22]
Portugal	15,000–20,000	2010	[19]
Romania	36,100	2006	[47]
Russia (European)	17,630	2006	[1]
Serbia	5,000	2007	[48]
Slovakia	38,000	2004	[48]
Slovenia	10,000–14,000	2010	[17]
Spain	>800,000	2010	[49]
Sweden	>10,000	2010	[13]
Switzerland	25,647	2004	[16]
Ukraine	14,431	2006	[1]
United Kingdom	~400,000	2007	[50]

Table 2. Latest population estimates for the Red deer globally, in Europe and for European populations.

libria in the sex ratio and, ultimately, changes in the genetic structure through selective culling (male-biased hunting or culling of undesirable phenotypes) [34–36]. Growing habitat fragmentation caused by urban expansion and agricultural intensification also represents a problem in parts of the species' European range at present [7].

Abundance and distribution: current status

While no data are available for global population size, the IUCN estimates a total of almost 2.5 million individuals in Europe, with the majority of these occurring in Spain (32%), the UK (16%), Germany, Austria and Poland (6% each) and Norway (5%).

At present, the Red deer is widely distributed throughout most of the European continent, with the exception of northern Scandinavia, Finland and Iceland [2]. However, its range is likely to be patchier than indicated on available maps [1]. For example, in Germany, the species is restricted to specific areas and rarely occurs outside of these [43]. Additionally, there is increasing fragmentation of populations in central Europe [1]. Traditionally considered a woodland species, Red deer has expanded into a variety of habitats, including open moorland in the UK [45], with densities varying with habitat quality [51].

Based on population numbers, Red deer is the third most common ungulate in Europe, with particularly high numbers in Spain and the UK [9] (Table 2). However, in some parts of Europe, the species has not yet recovered from past population declines. For example, it is listed as Endangered in the Red Data Book of Threatened Vertebrates of Greece [38], Vulnerable in Serbia [39] and Sweden [52], and the subspecies *corsicanus* is considered Endangered on the French National Red List [53]. The species is thought to be Extinct in Albania [26], and estimated at only a few hundred individuals in Macedonia [1].

Abundance and distribution: changes

According to available range information, the Red deer has expanded its area of occurrence by 190% since 1955 , spreading into surrounding areas from refugia and now occupying nearly half of its historical range in the 1800s (Figure 1a). For example, the British Isles have seen range increases of between 0.3% (United Kingdom [10]) and 7% per year (Ireland [54]). However, the expansion depicted for the UK in Figure 1b is likely an exaggeration [55] resulting from differences in the resolution of the two maps. Similarly, the range depicted for the 1950s in Spain is larger than the actual distribution at this point in time, as the species was reduced to small patches in Extremadura, Sierra Morena and Montes de Toledo [31]. The majority of extant populations in the north of Spain, Portugal and some southernmost ranges have resulted from translocations from these remaining stocks [31]. In addition, current range may be overestimated in some countries, for example in Germany, where the species is legally confined to Red deer areas ("Rotwildgebiete"), outside of which individuals are generally shot [43]. Despite the overall positive developments, there has also been some contraction at a sub-regional level or national level, most notably in the already threatened population in Greece (Figure 1a).

The expansion in range is also reflected in the change in population size over a similar period. Overall, the species has experienced an increase

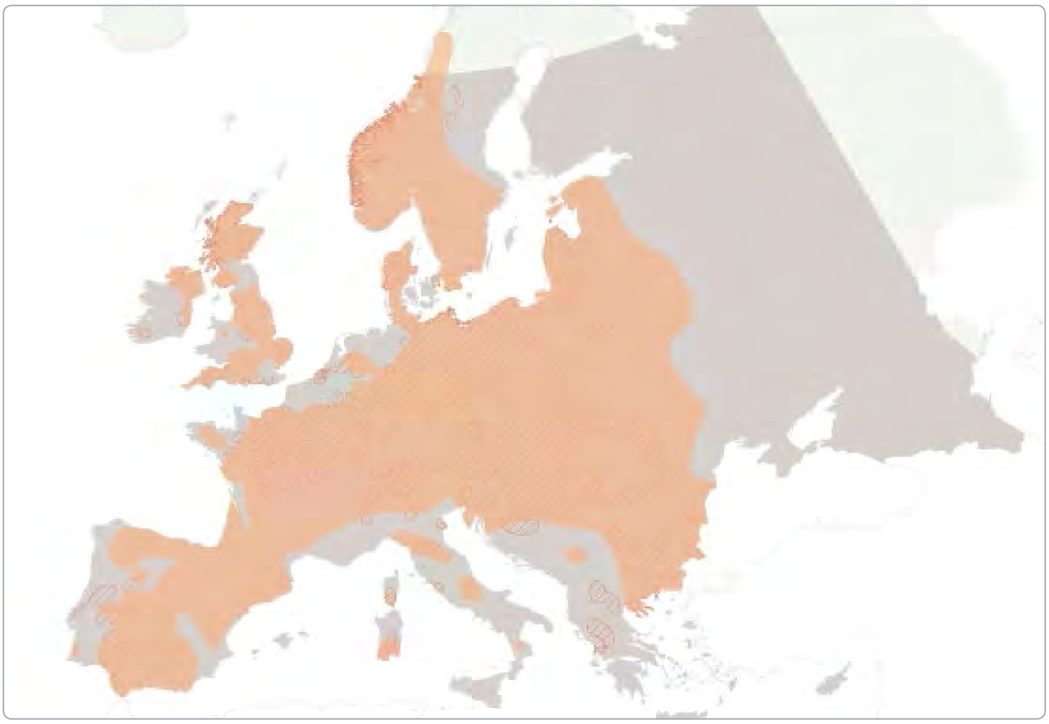

Figure 1a. Distribution of Red deer in the **1800s** [56], **1955** [57] and **2008** [26]. Please note that the range depicted for 1955 in Spain may be larger than the actual distribution of the species [31].

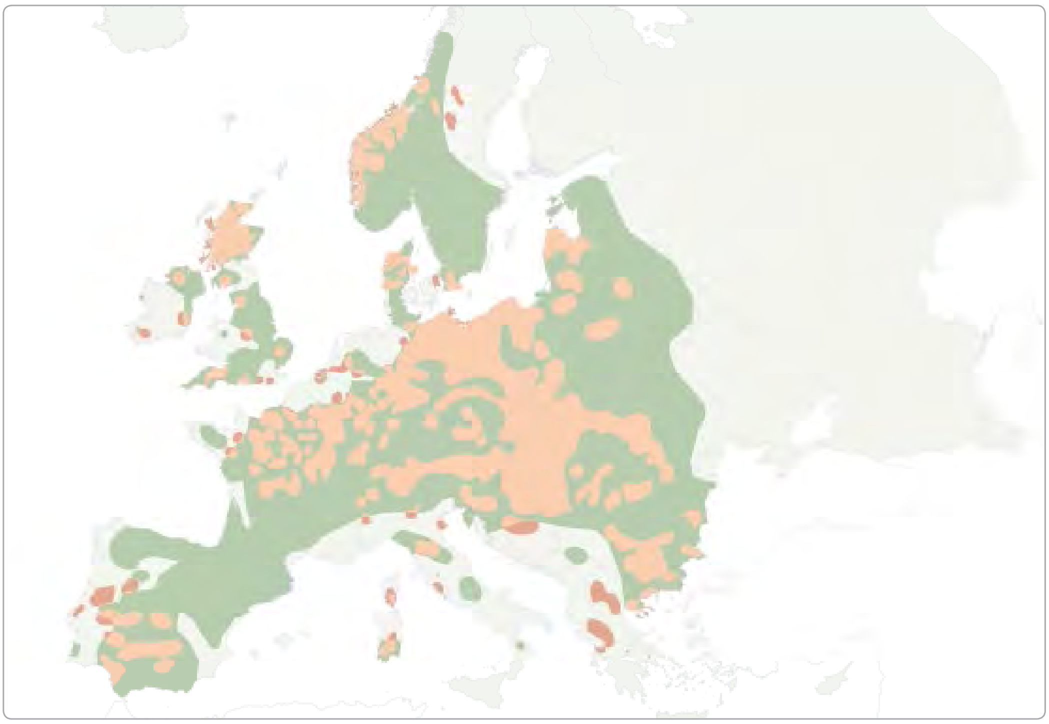

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** for Red deer in Europe between 1955 and 2008. Please note that some of the change observed from 1955 to 2008 is likely to be an artefact of the difference in map resolution, for example for the United Kingdom and Spain.

in abundance of just under 400% (Figure 2). Recovery was greatest in the 1960s (120%), after which the decadal growth dropped to around 30% for the following two decades, and around 5% thereafter (Figure 2). This is in line with the large-scale increases described throughout most of the deer's European range in the 1950s to 1970s [9], with the notable exception of Greece [38] and Serbia [48]. The abundance trend is based on 21 populations from the species' current range, representing a minimum of 512,000 individuals or 21% of the total estimated European population. Data were available from around half of all countries of occurrence, but lacking from those harbouring particularly large populations such as Germany and Austria (100,000+ individuals), as well as Denmark, Sweden and Latvia (10,000+ individuals).

Drivers of recovery

In our data set, recovery in protected populations correlated with the IUCN category of the protected area, with only category V areas showing

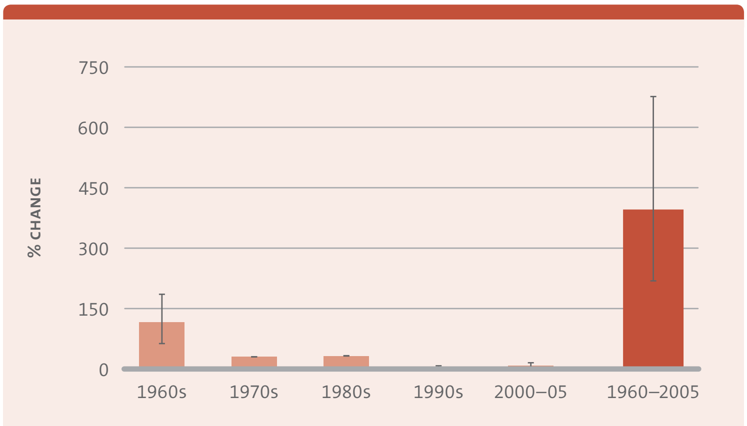

Figure 2. Change in Red deer population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

increases. These are managed mainly for landscape conservation and recreation, rather than stricter wilderness protection, and it is therefore likely that this effect reflects the absence of top level predators, which would keep populations in check naturally.

In areas where Red deer had previously been exterminated, natural recolonisation (e.g. former Yugoslavia [3], Switzerland [16], Portugal [19] and Italy [20]), reintroductions (e.g. Portugal [19], Spain [49], central Italy [3], Sweden [3], Slovenia [3] and the Baltic states [15]) and farm escapes (e.g. Denmark [42]) are considered to be the main reasons for the re-establishment of populations (Table 3). Other contributing factors include improved hunting regulations and protection (e.g. Norway [12], Romania [3], Bulgaria [3], Poland [3], Slovenia [17], Hungary [3], Italy [3], Austria [3]), and improvement of habitat quality and area (e.g. Norway [12], Denmark [3] and the UK [3]). For example, land use change, i.e. the reduction in sheep grazing and the subsequent reforestation, aided the expansion of the species in Scotland [55]. Land abandonment was also beneficial in Switzerland, northern Italy and Slovenia [3]). In addition, the reduction of predators and livestock competitors played a role [3]. In some areas, however, populations have not yet returned to their former extent, either due to population management for the purposes of reducing forestry damage from bark stripping (e.g. Sweden [13]), or confinement of the species to specific areas by law (e.g. Germany [43]).

Table 3. Major reasons for positive change in the status of the Red deer in Europe.

Rank	Reason for change	Description
1	**Other – Natural/artificial recolonisation**	Recolonisation of former Yugoslavia from Hungary through removal of fence [3].
		Recolonisation of Switzerland from Austria [3, 16].
		Recolonisation of Italian Alps from Austria, Switzerland and Slovenia [3, 5, 20].
		Recolonisation of Portugal from Spain [19, 26].
		Recolonisation from farm escapes in Denmark [42].
2	**Species management – Translocations and reintroductions**	Translocations and reintroductions because of importance of species as game [5], e.g. in Portugal [19], Spain [49], central Italy [3], Sweden [3], the Baltic states [15], Slovenia [3] and Bulgaria [3].
3	**Legislation**	Legal protection in Slovenia [17], Hungary [3], Italy [3] and Austria [3].
4	**Species management – Changes in hunting practice**	Permit system and selective culling in Norway [12], temporary suspension of hunting in Romania and Bulgaria [3] and hunting management in Poland [3].
5	**Land/water protection & management – Habitat provisioning**	Establishment of conifer plantations in western Norway [12], Denmark [3], Poland and the UK [3] and increased timber extraction in Poland [3].
		Land use change including a reduction in sheep grazing and reforestation was beneficial in Scotland [55].
		Land abandonment (primarily from marginal grazing land) in Switzerland, northern Italy and Slovenia [3].
6	**Other – Reduction of predators and competitors**	Reduction of natural predators such as the Grey wolf in Bulgaria [3].
		Reduction in sheep numbers in the UK [3] and alpine Italy [3].

Recent developments

A recent update of the Red List of Threatened Mammals in Greece lists the Red deer as Critically Endangered due to the prominent threat of illegal hunting [58], while in Sweden the resident subspecies *C. e. elaphus* is now considered Near Threatened [59].

Due to a large body weight of around 100 kg, Red deer represent the most important ungulate species in Europe in terms of biomass [9], and are therefore an important resource for humans. Harvest levels, much like abundance, have been on the increase [60], and because of the species' cultural and economic importance, it is unlikely that this trend will be reversed in the near future. However, overabundance of the cervid in parts of its range may require stricter population management due to increases in deer-forestry conflict, its negative effect on the re-establishment of native woodland [61, 62] and the resulting conflict between stakeholders [63, 64]. Significant management is already in place in many countries, for example Sweden, where the species has not yet recovered to its historic range [13]. From a wildlife conservation perspective, however, the increase in Red deer and other ungulates has facilitated the comeback of top-level predators in Europe [65], and reintroductions of carnivores are usually only considered in areas where these prey are particularly abundant, e.g. Scotland [66].

Our knowledge about the distribution of natural lineages of the Red deer have improved noticeably over the past decade, and the conservation of the genetic identity of the species in Europe is likely to become an important issue in the future, both because of mixing of distinct sub-species [31, 32] and hybridization with the non-native Sika deer [28–30]. Projects re-establishing Red deer across Europe need to take into consideration the known genetic

lineages for the local area and minimise interbreeding where possible. Further restocking from farms must be avoided even if the correct lineages are present, as the artificial selection process may have important effects on the species that cannot be easily detected in many genetic analyses [31, 67]. In addition, management should be designed in such a way that it maintains the natural composition and behaviour of populations (e.g. sex and age structure, food habits) and does not alter the transmission and conservation of genetic features, which in turn allows for the preservation of a natural selection process [31, 67]. Furthermore, some management practices, such as maintenance of high population density and local aggregation of animals around watering holes or feeding stations, and the resulting contact between species increases the prevalence and transmission of tuberculosis [68]. However, the Wild boar *Sus scrofa* is considered the main reservoir of tuberculosis in Spain and is thus much more relevant for transmission to livestock than Red deer [69].

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3.9. Wild boar

Sus scrofa

Summary

The Wild boar has experienced a large increase in abundance and distribution since the mid-20th century, which can be attributed to a variety of factors, including deliberate and accidental reintroductions, favourable environmental conditions, hunting control, lack of management, improved food availability and land abandonment. It is now widespread and abundant across Europe and faces no major threats. As a resilient and adaptable species, further growth is expected, with climate change and land abandonment probably playing an increasingly beneficial role. Future management will to a large part have to focus on the mitigation of problems associated with greater abundance of this ungulate.

Background

General description of the species

The Wild boar, also known as the Eurasian wild pig, is present in its wild or feral form in every continent except Antarctica, in a range that has been greatly expanded by humans [1]. A large number of subspecies has been proposed based on significant levels of naturally occurring geographic and genetic variation, which has been compounded by widespread anthropogenic releases, but there is still some debate about the precise number [2]. The species is highly sexually dimorphic, and there are size differences between genders and regions, with males and animals in temperate zones being larger [2]. The Wild boar lives in maternal families of around 20 individuals, although adult males tend to be solitary outside the breeding season [2]. In Europe, litters of 5–9 are generally born in spring after 112–130 days of gestation, and young reach sexual maturity at 18 months [2]. Wild boar can live up to 20 years in the wild, although younger animals tend to be more common in populations [2]. Activity levels vary between regions, but are usually highest around dawn and dusk except in areas with high hunting pressure, where exclusively nocturnal activity is common [2]. As an omnivore, the boar eats almost anything from grass, nuts, berries and roots to invertebrates and small reptiles [2], and also frequently damages agricultural crops [2]. Predators include Grey wolf (*Canis lupus*) and Eurasian lynx (*Lynx lynx*) [2].

Distribution in Europe

Molecular analysis suggests that the Wild boar originated from islands in southeast Asia (Phillippines, Indonesia) from where it dispersed across Eurasia [3]. The species was widely distributed throughout Europe during the early and mid-Holocene [4], with domestic

Scale	Status	Population trend	Justification	Threats
Global	Least Concern	N/A	Very widespread Extremely abundant Expanding range in some areas Tolerant of secondary habitat	No major threats
Europe	Least Concern	N/A	Very widespread Extremely abundant Expanding range in some areas Tolerant of secondary habitat	No major threats

Table 1.
Summary of Global and European Red List assessments and threats listed for the Wild boar [1, 10].

stock thought to have been bred from these wild relatives around 9,000 years ago [3]. The species arrived in Britain and Ireland in the early Mesolithic [5], but were extirpated here in the 17th century [2]. The range of the species contracted in several locations between the 17th and 19th centuries (e.g. in the Baltic states, Hungary, Czech Republic), due to a combination of changes in land use practices and overhunting, with climate cooling and high wolf densities implicated in some regions [6]. It was extirpated from Denmark in the 19th century [2] and Switzerland by the turn of the 20th century. Following this severe reduction in number and range, slight recoveries occurred in Russia, Italy, Spain and Germany in the mid-20th century, as well as reintroductions in Sweden and Denmark [2], and populations established from escaped animals in Britain [7]. The Wild boar is now distributed across almost all of mainland Europe, with the exception of the northern reaches of Scandinavia and European Russia, and the southernmost parts of Greece [2]. It is abundant throughout, although populations can be reduced and fragmented in areas of high hunting intensity [2].

Habitat preferences and general densities

As an ecologically adaptable species, the Wild boar is found in a wide variety of habitats from closed natural and planted forest to open

	Estimate	Year assessed	Reference
Global	Unknown	-	-
Europe (based on below)	3,994,133	2004–2012	[8, 11–31]
% of global population	Unknown		
Austria	60,000	2004/2005	[11]
Belgium	21,000	2004/2005	[12]
Croatia	18,200	2004/2005	[13]
Czech Republic	48,000	2004/2005	[14]
Denmark	100	2004/2005	[15]
Estonia	22,500	2012	[16]
Finland	400	2004/2005	[17]
France	1,000,000	2004/2005	[18]
Germany	1,000,000	2004/2005	[19]
Greece	19,033	2004	[20]
Hungary	78,100	2004/2005	[21]
Italy	600,000	2004/2005	[22]
Latvia	46,800	2004/2005	[23]
Lithuania	29,500	2004/2005	[23]
Netherlands	2,300	2004/2005	[24]
Norway	Unknown	2004/2005	[32]
Poland	173,000	2004/2005	[8]
Portugal	Unknown	2004/2005	[33]
Romania	56,700	2004/2005	[25]
Serbia	30,000	2004/2005	[26]
Slovakia	28,000	2004/2005	[27]
Slovenia	10,000	1995	[28]
Spain	600,000	2004/2005	[29]
Sweden	150,000	2010	[30]
Switzerland	Unknown	2004/2005	[34]
UK & Ireland	<500	2004/2005	[31]

Table 2. Latest population estimates for the Wild boar in Europe and for European populations. Please note that estimation techniques vary between countries, as do their precision and accuracy. Figures are therefore approximations, frequently derived indirectly from hunting bags. Information is missing for Norway, Portugal and Switzerland.

scrubland with some cover [2]. In Europe, it is also present in agricultural landscapes, and riverine and mountainous forests, with highest densities in oak-dominated forests [2]. Density varies depending on habitat quality (vegetative productivity), temperature and level of mortality, and there is also a weak limiting effect of predators such as Grey wolf (*Canis lupus*) [2]. Studies have established a density of 3–5 individuals per 100 km^2 in Italy, 0.7–16.3 individuals/100 km^2 in Spain, 10 individuals/100km^2 in Switzerland [2], as well as 0.1–17.9 individuals/km^2 in Poland [8].

Legal protection and conservation status

Wild boar is listed as Least Concern both globally and in Europe because it is widespread, abundant, tolerant of secondary habitat, and even expanding in some areas (Table 1). While not affected by any major threats at a larger scale (Table 1), the species can be threatened at a more local level, e.g. the highly threatened *S. s. riukiuanus* in Japan [2].[2]. In Europe, the species occurs in a large number of protected areas [1]. The subspecies *S. s. meridionalis* (located in Sardinia) is listed on the Bern convention under Appendix III [9].

Abundance and distribution: current status

While there are no global Figures available, a conservative estimate for the European population is 3.99 million individuals, with the largest populations occurring in France and Germany (25% each), Italy and Spain (15% each), and Poland and Sweden (4% each) (Table 2), which together account for almost 90% of the estimated European population. All other countries support populations of 2% or less.

The Wild boar has shown the same pattern of population growth throughout France, which came in two phases: a slow increase from 1973 to 1989 followed by an accelerated increase since 1990, which may be related to releases from game parks, reserves and high density populations in the 1980s [18]. While no hunting quotas are required by law, many departments set their own, and kills have increased from 36,500 in 1970 to 443,500 in 2004, suggesting a yearly growth rate of 5.1% [18]. The species is now widespread including in mountainous areas, with highest densities in north-eastern and southwestern areas, and on the island of Corsica [18]. In Germany, the boar was initially restricted to large deciduous forests, and hunted as a pest species with bounties in agricultural areas in the 1950s [19]. Following rapid population increase, it spread into lower quality habitat such as spruce forest and into higher altitudes, and now occurs all over Germany except in the Alpine region [19]. The recovery has been attributed to a combination of factors, including mild winters, an increase in the number of corn fields and mast years, lack of hunting and management, and artificial feeding [19]. Although there is great variation in the annual hunting bag, harvest rates have increased from 23,000 in the 1960s to 500,000 at present [19].

The Wild boar's current distribution in Italy has been described as the result of incorrect and inconsistent management decisions, and the species' genetic integrity is severely compromised [22]. Progressive expansion began at the start of the last century, when two subspecies were present: one on the mainland, which was restricted to a number of coastal areas at the beginning of the 20th century, and one on Sardinia (*S. s. meridionalis*) [22]. Reintroductions occurred after the 1950s, and included the introduction of the mainland subspecies to Sardinia, which represents a threat [22]. The boar can be hunted from October to January, and is responsible for around 90% of the damage caused by ungulates, estimated at more than 10 million euros [22].

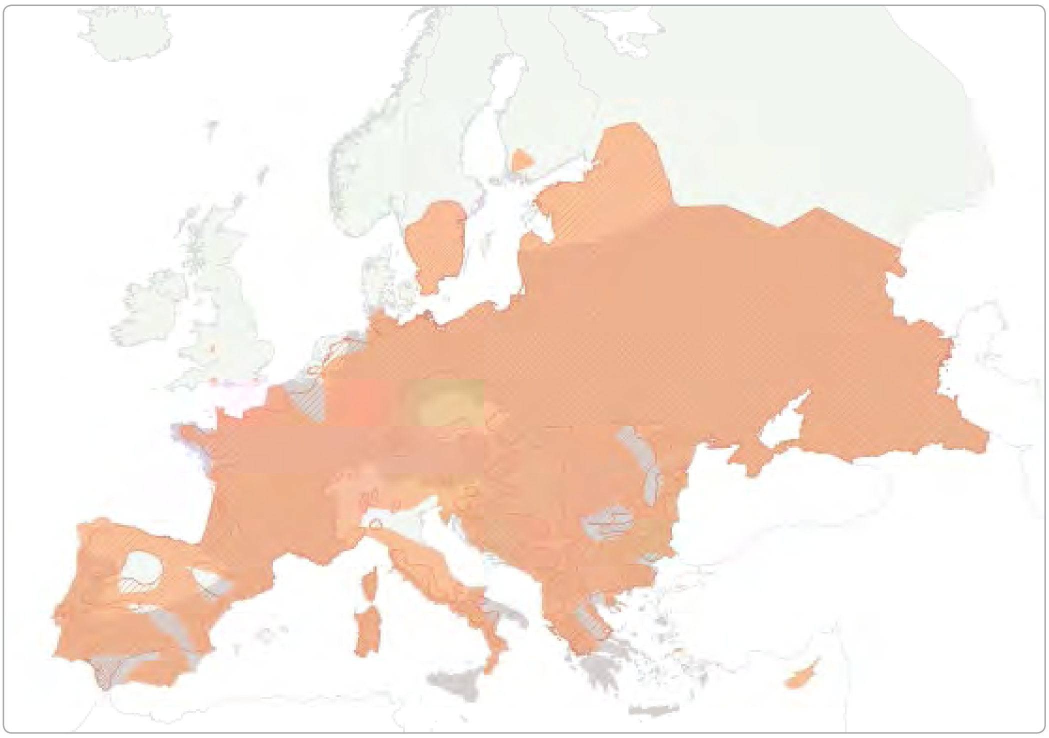

Figure 1a. Distribution of Wild boar in **1890** [6], **1955** [38] and **2008** [1]. Black stars denote countries where the species occurs in low numbers [39–41]. In Cyprus, the species was reintroduced in the 1990s, and subsequently eradicated with government backing [42].

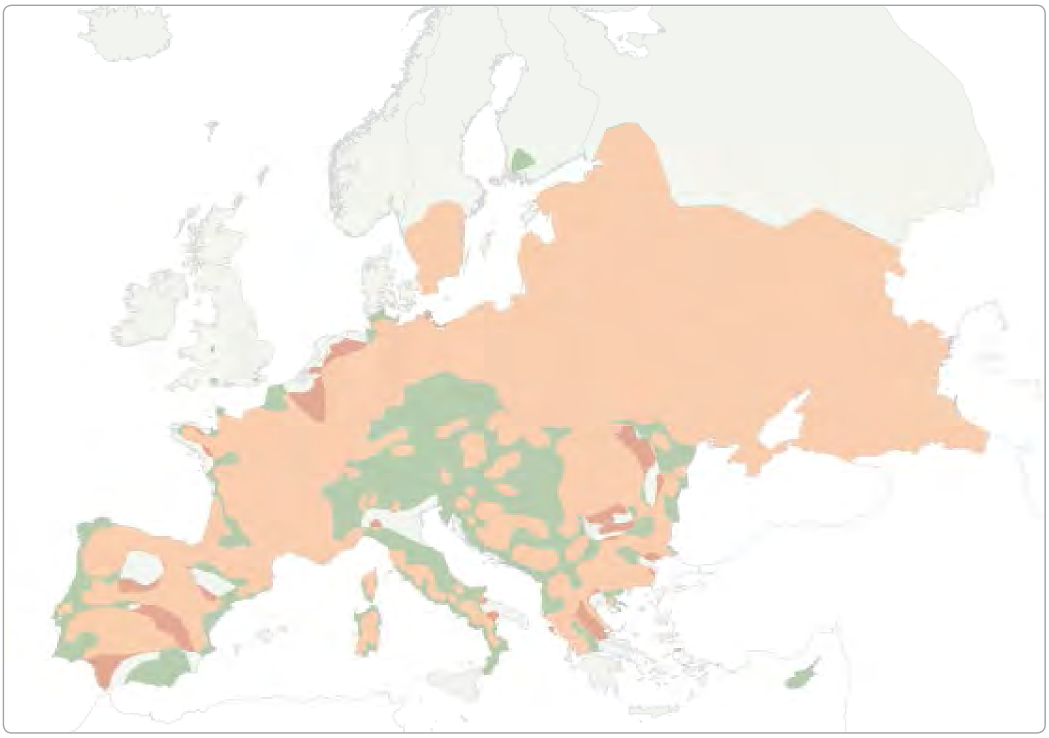

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Wild boar in Europe between 1955 and 2008.

Abundant and widely distributed in Spain, the Wild boar expanded its range throughout the Iberian peninsula from occupying half of the country in the early 20th century [29]. This development was most likely driven by the abandonment of rural areas by humans, and the associated increase in scrubland habitat [35]. Management of the species is aimed at reducing the impact on small game breeding, crop damage and road accidents [29].

The species is present throughout Poland except at higher altitudes, although it is more abundant in the west where winters are milder [8]. Thought to be steadily increasing, official Figures on population size are very likely underestimations [8].

The history of Wild boar in Sweden is an eventful one: it disappeared in the 17th century due to hunting and hybridisation with free-ranging domestic pigs, but was re-established through reintroductions and escapes [36]. Following its

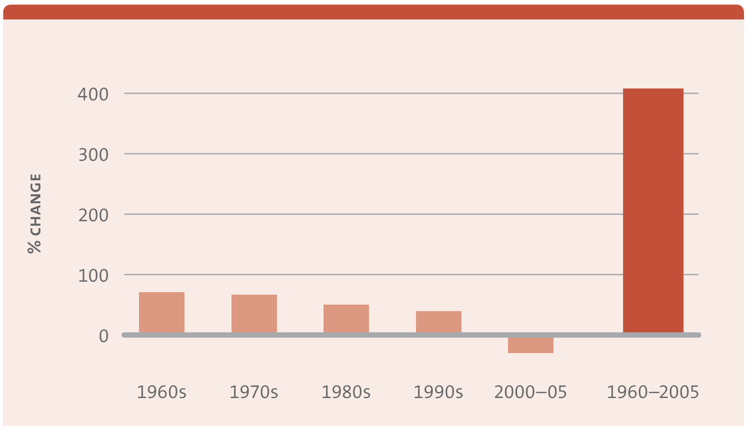

Figure 2. Change in Wild boar population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change. Error bars have been removed for clarity.

listing as an undesirable exotic in 1980, hunters did not follow the government recommendation of shooting all but one population, and having been re-declared a natural member of Swedish fauna in 1988, the species is now distributed over a large part of southern Sweden [8]. Expansion continues at an estimated rate of 3–4 km/year [37], and climate change is likely to support further expansion in the future [8]. Hunting is regulated with an increasing annual bag, but there are concerns about the potential impact of this species on crops, as well as the rise in road accidents [8].

Abundance and distribution: changes

In the late 19th and early 20th century, Wild boar distribution was significantly smaller than it is today. Between 1900 and the 1950s, the range contracted, particularly in central Europe, with over-exploitation and persecution suggested as the primary reasons for change (Figure 1A). Since that time the species has undergone a quite dramatic range expansion, in many places past that of its extent at the end of the 19th century (Figure 1B).

As can be the case with common species, monitoring of the Wild boar is infrequent. The majority of studies of change in abundance are drawn from hunting data, whereby assumptions are made about the size and change in abundance of the population from indirect evidence from harvest statistics. Nevertheless, of the populations being monitored, an average increase of 350% was observed between 1960 and 2005 (Figure 2). Abundance change across those decades appeared to be fairly consistent, with a constant increase in abundance apparent between 1960 and 2000. That rate appears to have slowed since the year 2000, though a time lag in reporting may be in part responsible, and updated monitoring data for the period 2005-present are needed. The abundance

trend for Wild boar is based on 10 populations, representing a minimum of 142,000 individuals or 4% of the total European population from 2004–2012.

Wild boar are clearly able to sustain these increasing numbers even in the face of what appears to be high rates of harvest or exploitation. For example, populations have been able to sustain their numbers despite annual kill rates of about 50%, such as in the broadleaved woodlands around Monticiano in Italy [1], and in Germany [19]. At face value, some reported off-take rates appear to be even higher.

Drivers of recovery

While no factors explained the increase in our data set, several reasons for resurgence of the Wild boar in the latter half of the previous century have been cited in the literature (Table 3). Among them are deliberate and accidental reintroductions, warmer winters with less snow leading to greater survival and reproductive success, hunting control and lack of management, as well as improved access to forage earlier in the spring season through more frequent mast years in their preferred forest and woodland habitats and an increasing number and size of arable fields, particularly with crops such as corn (Table 3). In addition, land abandonment in some countries has led to larger areas of scrubland, which the species is able to disperse into. Clearly these factors are not mutually exclusive, and a detailed analysis has yet to be compiled across a representative part of the Wild boar range. The species is both highly adaptable and highly resistant to a variety of processes causing degradation of habitat, which affect other European species, and appears to thrive under certain forms of habitat modification.

Rank	Reason for change	Description
1	**Species management – Deliberate and accidental reintroductions**	France: accelerated growth from 1990 due to releases from game parks, reserves and high density populations in the 1980s [18]. Denmark: populations are the result of reintroductions [2]. United Kingdom/Ireland: populations formed from escaped animals [7]. Italy: reintroductions after the 1950s contributed to expansion [22]. Sweden: species was re-established through reintroductions and escapes [36].
2	**Other – Environmental conditions and change**	Warmer winters and less frequent snow lead to greater survival rates and increased reproductive success [6], for example in Germany [19] and Poland [8]. Climate change is likely to be beneficial in the future in Sweden [8].
3	**Other – Land abandonment**	Spain: expansion and increase were driven by the abandonment of rural areas, and the associated increase in scrubland habitat [35].
4	**Species management – Hunting control and lack of direct management**	Firmer control of hunting now exists throughout many national range states, with upper limits set [6]. Lack of management has contributed to growth in Germany [19].
5	**Other – Increase in food availability**	Germany: increase in corn fields, and artificial feeding [19]. Food availability is increased by more and larger arable fields, and more frequent mast years of native trees such as oak and beech [6].

Table 3. Major reasons for positive change in the status of the Wild boar in Europe.

Recent developments

The Wild boar's high adaptability and resilience has enabled it not only to persist but to increase in the face of a variety of anthropogenic processes leading to habitat degradation and modification, and continuing high levels of exploitation. As a result, it is now a highly common and widespread species across the whole European continent, and faces no major threats [1]. Perhaps because of its impressive range and abundance change history, data on recent developments relating to the species are scarce.

Wild boar are by the second most common ungulates to die in vehicle collisions in many countries, for example in Germany, where they accounted for 9% of all accidents involving ungulates [43]. The large number of individuals killed on European roads is likely to increase in future, due both to increasing boar population density and continued fragmentation of landscape through infrastructure. In addition, Europe's large predators are making a comeback in many regions, which may have an impact on Wild boar population size in some areas. However, it is unlikely that either of these developments will have a noticeable effect on the species.

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Reviewer

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3.10. Golden jackal

Canis aureus

Summary

The Golden jackal is a resilient, adaptable and opportunistic species with a varied history in Europe. Pronounced declines occurred in the first half of the 20th century due to habitat change and human persecution. Over the last century, however, local colonisations and extinctions have led to changes in distribution and abundance. Factors that have been particularly beneficial in the recovery of the jackal are legal protection, decreased hunting pressure due to the prohibition of poisoning and leg hold traps, increase in food availability, habitat change, competitor reduction and favourable climate change and species characteristics.

Background

General description of the species

The Golden jackal (*Canis aureus*) is a territorial canid of medium size [1], which may be nocturnal to avoid humans [2, 3], although it is now often seen in inhabited areas, e.g. in Greece and Hungary [4]. Despite showing a preference for small mammals, the jackal is an omnivorous, generalist and opportunistic forager [1], and diet varies with location depending on available food items and human presence [5]. Near human habitation, the species feeds almost exclusively on rubbish and human waste [2]. The basic social unit is the monogamous pair but social organisation is flexible [1] and cooperative hunting and care of young has been observed [2]. The maximum group size is around 30, but families of five are more common [2]. One to nine pups are born after a two month gestation period, reaching sexual maturity at 11 months. The jackal can live up to eight years in the wild [2].

Distribution in Europe

With a distribution from Cambodia across southern Asia to the outer Arabic peninsula, Turkey to Greece, the Balkans and Romania, and Africa as far south as Senegal and Tanzania [6], the jackal is the most widespread of the carnivores. Within Europe, its distribution is patchy and fragmented with the highest concentration in the Balkan Peninsula [7]. It is also present in southern eastern Europe and Greece to the Black Sea coast, with a northern boundary in Hungary [8], and along the Danube, Romania and former Yugoslavia [7], and vagrant individuals occur in Austria and Slovakia [4].

The species is believed to have appeared in Europe in the Upper Holocene (Greek Neolithic) [9, 10]. Because Balkan jackals differ from their African counterparts, the species may have come from the East, possibly from the Caucasus via a land bridge between the Balkans and Anatolia during the Würm [11]. Pronounced declines occurred in the first half of the 20th century due to habitat alteration and change as well as human persecution [12], but over the last century, its distribution has changed as a result of local colonisations and extinctions [13].

Habitat preferences and general densities

As a highly adaptable species tolerant of arid conditions, the jackal occurs in a variety of habitats including desert, grassland, wetland, forest, and agricultural and semi-urban areas, although it is most common in dry, open country [1]. In Europe, it shows a preference for agricultural areas and wetlands with adequate cover in lower elevations [12]. Intensively cultivated areas without cover are not suitable, although human activity often increases food availability [14]. While subpopulations comprise fewer than 1,000 adults [12], the species is common and numerous where food and cover are abundant [1]. Viable populations can exist in small areas because the species tolerates living at high densities [14]. In terms of competition with other carnivores, the jackal is mutually exclusive with the Grey wolf (*Canis lupus*) [14–16], dominates over the Red fox (*Vulpes vulpes*) [14], and may impact negatively on the Wild cat (*Felis silvestris*) [14].

Legal protection and conservation status

The species is included in Annex V of the Habitats Directive in the EU [17] and has been protected in Bulgaria since 1962 [18], Italy since 1997 [19] and Slovenia since 2004 [16]. In Bulgaria, Croatia and Hungary, it is actually managed as a game species [12]. In Greece, a government-led poisoning campaign (with bounty payments until 1981) was discontinued in 1990 [14]. Although there is a national action plan [14], the species is neither officially a game species nor protected [15]. The jackal is listed as Least Concern both globally and in Europe because it is widespread, locally common, found at high densities where food and cover are abundant, and highly adaptable and opportunistic (Table 1). Within the EU, it is Near Threatened because of its small, patchily distributed and fragmented subpopulations (Table 1). In Greece, it is listed as Vulnerable.

Abundance and distribution: current status

The IUCN estimates a global population of over 130,000 individuals, with a maximum of 42% occurring in Europe (Table 2). The largest populations are found in Bulgaria (72%), Hungary (13%), Serbia (9%), Romania (4%) and Greece (2–3%).

In Bulgaria, the Golden jackal is present in 72% of the country [24], with the highest densities in the southeast, northeast and central-north [18]. A 33-fold expansion in range between 1962 and 1985 [7] has been attributed to increased food availability, and legal protection since 1962 [25]. Concurrently, the colonisation rate increased from 1,150 km^2 to 9,650 km^2 per year [7]. At risk of extinction before the 1970s [23], the population in Serbia is now the third largest in Europe (Table 2), and jackals are locally common near the Bulgarian border and in Srem [23].

The Serbian population originated from a small number of Bulgarian founders and therefore shows a strong founder effect [26]. It has since colonised Hungary [23], where it became extinct in the 1940s [18]. Natural recolonisation started with a few vagrant animals here in 1979 [27], and a viable population was established in 1991–2 [8]. It is now said to be spreading "like an invasive species" [8] and numbers over 7,200 individuals in three regions in the

Table 1. Summary of Global and European Red List assessments and threats listed for the Golden jackal.

Scale	Status	Population trend	Justification	Threats
Global [6]	Least Concern	Increasing	Widespread and common High density where food and cover abundant Highly adaptable (omnivorous, opportunistic, tolerant of dryness)	1. Industrialisation and agricultural intensification 2. Urbanisation of wilderness areas and rural landscapes 3. Local extirpation 4. Poisoning
Europe [12]	Least Concern	Stable to Increasing	Patchily distributed over wide area Locally common	No threats
EU 25 [12]	Near Threatened	N/A	Patchy and fragmented distribution Subpopulations <1,000 adults >50% reduction in 20 years (Greece) Decreasing net population trend Readily colonises new areas (changes status from Vulnerable)	1. Habitat loss due to changes in agricultural practices (Greece) 2. Possible reduction in food base due to animal husbandry changes (fewer carcasses) 3. Hunted as pest species
Europe — regional populations [15]	Greece: Vulnerable	N/A	N/A	N/A

	Estimate	Year assessed	Reference
Global	**>130,000**	**2008**	[6]
Europe	**54,350–55,271**	**2004–2012**	[14, 18, 20–23]
% of global population	**<43%**		
Albania	Extinct?	2004	[14]
Austria	Established	2012	[18]
Bosnia and Herzegovina	Vagrant	2012	[18]
Bulgaria	39,343	2012	[20]
Croatia	No data	2012	[18]
Czech Republic	Vagrant	2012	[18]
Germany	Vagrant	2012	[18]
Greece	1,100–1,500	2010–2011	[21]
Hungary	7,274	2012	[22]
Italy	3–7 / 15–35	2012	[23]
Macedonia	Vagrant	2012	[18]
Montenegro	Vagrant	2012	[18]
Romania	2,045	2008	[23]
Russia (European)	No data	-	-
Serbia	4,500–5,000	2011	[21]
Slovakia	Vagrant	-	[18]
Slovenia	3–4	2012	[23]
Ukraine	70	2004–2005	[18]

Table 2. Latest population estimates for the Golden jackal globally, in Europe and for European populations. No information was available for Croatia and European Russia.

south [22]. The jackal first arrived in Romania from Bulgaria in 1929 [28], where it is currently increasing in six regions in the southeast, central and west of the country [23].

The fifth largest population in Greece exists in a fragmented range [14] confined to seven subpopulations [14]. The largest occurs in the Vistonida-Nestos wetlands in the northeast, while others are found in Evros, Serres and Haldiki in the north, and Fokida, the Peloponnese and Samos Island in the south [14]. Declines from the 1970s, which accelerated in the 1980s [14], led to a 50% reduction over the past 20 years [12]. This is attributed to agricultural intensification, abandonment of small cultivations, changes in animal husbandry practices, urbanisation, forest fires, and persecution and intensive hunting [15] acting on populations that were already vulnerable because of isolation due to terrain [14]. Although there are signs of comeback in the northeast (except Serres), the Peloponnese and Samos Island [14], expansion is impossible in Fokida because of natural and man-made barriers and the spread of wolves [14]. Overall, the jackal is believed to be decreasing [12, 23].

Along with the countries above, Croatia is considered an important population [23]. Although little is known about its size, it is thought to be the source for the now established Slovenian and Italian populations [23]. The species is extending its range and breeding in both countries [16, 18, 19, 23, 29, 30]. The Golden jackal is described as vagrant in Slovakia (from 1989 [31]), Germany (from 1996 [31]) and the Czech Republic (from 2006 [31]).

Abundance and distribution: changes

Because historical range information was not available for the Golden jackal, precise changes to the present day could not be calculated. However, there is evidence that the species was already rare in Hungary in the 19th and early 20th century [32]. While data were available for the 1950s and the present day, it is important to highlight the difference in map resolution and level of species knowledge between these two time periods. These differences make accurate comparisons difficult, causing severe over- or under-estimations in range change over time. In the case of the Golden jackal, the range depicted for 1955 is extremely coarse compared to that for 2011, so the halving in range size observed is likely to be an artefact of the map resolution and should be interpreted with extreme caution. While the species may have indeed lost some ground in Greece and across the Balkan region, the contraction is unlikely to be as widespread as depicted in Figure 1B [33].

However, it is generally accepted that in Europe jackal populations have undergone significant changes in the past decades [7], including changes in distribution and abundance. For example, the species expanded into Slovenia and northeastern Italy, the Istrian peninsula, southern Hungary, northeast Serbia and further into Romania, with vagrant animals reported from further into Italy, Austria, Germany, the Czech Republic, northern Hungary and the southern Ukraine (Figures 1A and B). Overall, the jackal's distribution in Europe has been dynamic, being characterised by dramatic declines (until 1960s), recovery (1960s and 1970s) and expansion (early 1980s onwards) [18]. While no exact Figures on population change over time are available, European populations are believed to be stable to increasing [12]. Nevertheless, there are regional differences, with positive trends in Bulgaria [20], Serbia [23], Hungary [8] and Romania [23], and decreases in Greece [12, 23] and Albania [14].

Drivers of recovery

A review of the literature suggests that a number of reasons have contributed to the success of the Golden jackal in Europe over the last few decades. In Bulgaria, significant range expansion occurred between 1962 and 1985 [7] because of increased food availability and legal protection [25], and this is believed to have started the first expansion of the species in Europe. A concurrent reduction in Balkan wolves [35] resulted in the spread of Croatian

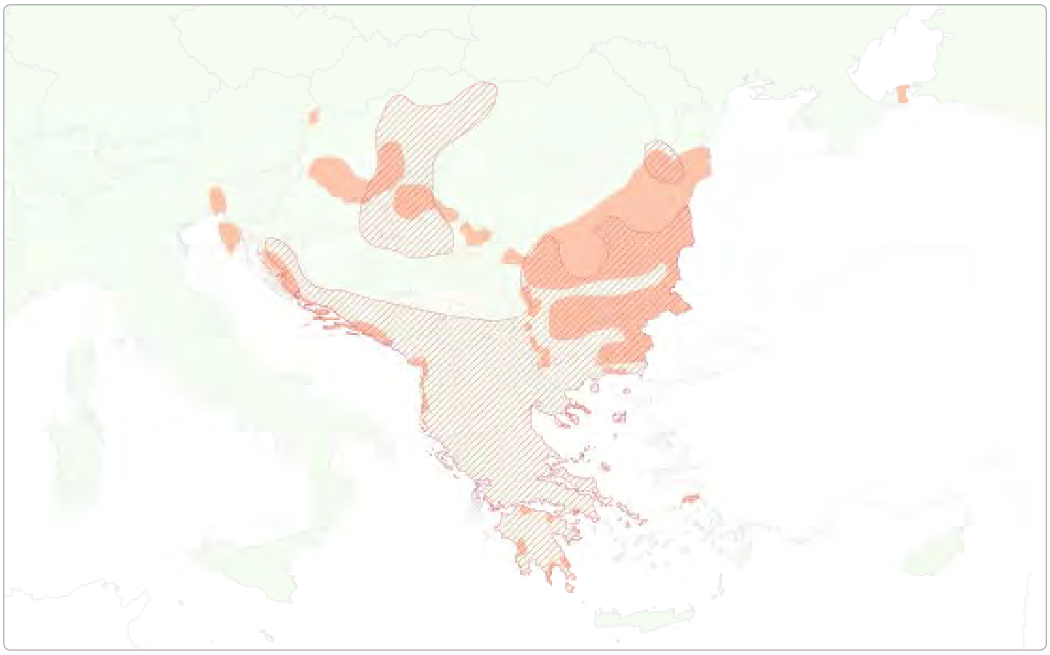

Figure 1a. Distribution of Golden jackal in **1955** [34] and **2011** [18].

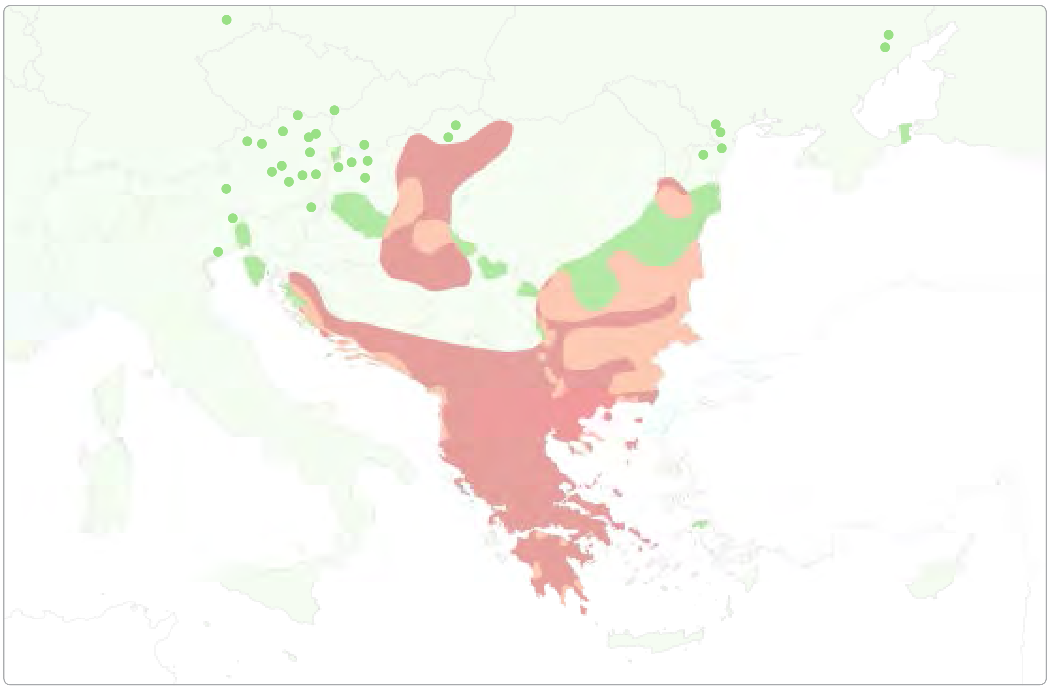

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Golden jackal in Europe between 1955 and 2011. Please note that contraction observed from 1955 to 2011 is likely to be an artefact of the difference in map resolution.

populations into northwestern Slovenia [30], and in the 1980s into Italy, Austria, and Hungary, likely with the help of the Bulgarian population [7, 19]. Other major reasons for expansion include habitat change, such as the felling of forest [14], planting of scrub [14] and abandonment of landscape [18]; and legal developments, such as the introduction of the EU directive on carnivore reduction methods (relating to the use of poisons, leg hold traps, and non-selective killing methods) and the EC Birds Directive and EC Habitats Directive [8]. A third range expansion is believed to have occurred in the 2000s [7, 8, 19], and this is generally attributed to the high adaptability of the jackal [18], as well as the increasing availability and accessibility of food resources [24]. Particularly favourable mild winters are believed to have contributed to population increases in the Balkans [8].

Overall, current changes in distribution and population sizes are most likely due to protection and reduced persecution [18] and the species' ability to adapt to human-managed areas [4] (Table 3). In future, however, climatic changes due to global warming may reduce barriers to the dispersal of the Golden jackal, such as long winters with severe snow cover [14].

Recent developments

Having established stable source populations in Bulgaria, Serbia, Hungary and Romania, the Golden jackal is continuing its conquest of the European mainland. As part of the recolonisation of areas from which it had gone extinct [18], the species is expected soon to be resident in all of Hungary [8] and spread to Moldova from Romania [18]. However, the most interesting developments are believed to be occurring in the western portions of the range. Permanent territories have now been described in Slovenia in areas where the wolf is absent [16], and the presence of territorial groups in Ljubljansko barje were confirmed in 2009 [38], with the second region with reproduction confirmed in the Slovenian Julian pre-Alps in 2012 [29]. The first evidence of the occurrence of jackal in Switzerland was recorded from five camera traps between 27th November and 12th December 2011 [39]. In addition, the Italian population is believed to play a central role in the continuing expansion westwards. In April 2012, a male jackal hit by a car was the first evidence of the species in the Trentino [40]. Further expansion of the northern limit of the species is also expected, following unconfirmed sightings from central Slovakia in 2008 [18], as well as breeding evidence in the Neusiedler See region of Austria from 2007 [41]. Although the presence of adults was confirmed with camera traps in spring 2009, the fate of the 2007 offspring is unknown and there is no evidence of further reproduction so far [18]. However, a jackal has now been recorded with camera traps for lynx in Nationalpark Bayerischer Wald (26th April 2012) after first spreading to the Lausitz in 1998 [42].

Because of the species' high adaptability, the conservation of the jackal in Europe is first and foremost a political and sociological problem [23]. Hunters in Slovenia and Hungary have a negative attitude towards the canid, and are of the opinion that jackals are responsible for the decline in Roe deer (*Capreolus capreolus*) populations [4, 29]. Wolves, which have a far greater effect, are viewed as less negative, perhaps because they have been present in the landscape for longer [29]. Public awareness also needs to be raised [16, 19], especially in Italy, where many deaths are caused by accidental shooting or poisoning, poaching and collisions [23]. Misidentification and confusion with the Grey wolf and Red fox are common, and the main problem for the species' conservation in the Adriatic hinterland [19]. In addition, the species' legal position needs to be strengthened through both national (e.g. Italy [30]) and regional (e.g. Europe) action plans. Potential conflict with humans as well as increasing contact with the wolf [23] (for example in Italy [30]) should be of particular concern. Elsewhere, there have been recommendations to include the jackal in hunting regulations to exert greater control over illegal hunting (e.g. in Slovenia [16]), while population control measures have been put forward for countries with large and increasing populations in which these have been proven to affect game and domestic animals, e.g. in Bulgaria [25].

Although a carnivore and despite its recent recolonisation success, the Golden jackal has been somewhat neglected by the scientific community, and there is a definite need to encourage research and monitoring [18]. A particular focus should be on improving current monitoring methods, as these are unlikely to record all individuals [30]. Overall, however, the Golden jackal is a resilient, adaptable and opportunistic species, able to recover quickly [18] if necessary, and its continued existence and spread in Europe is to be expected.

Table 3. Major reasons for positive change in the status of the Golden jackal.

Rank	Reason for change	Description
1	**Legislation**	Legal protection resulted in marked abundance increases and range expansions in Bulgaria [25]. The introduction of EU directives on carnivore reduction methods, and the EC Bird Directive and EC Habitat Directive) resulted in recoveries in the Balkans [8]. Legal protection also resulted in reduced persecution [18].
2	**Other — Increase in food availability**	Game farming developments led to the increase of animal carcasses and supported the comeback in Bulgaria [25]. The species is opportunistic and can exist on human waste alone [15]. In Greece, jackal populations are found near human settlements [15]. However, this may also indicate an overdependence on human food [15].
3	**Land/water protection & management — Habitat change**	Felling of forest and planting of scattered coniferous trees led to the creation of more suitable habitat (open areas with some cover) [14]. The depopulation of rural areas is believed to be one of the main factors in the maintenance of high densities of jackals in Bulgaria [18].
4	**Other — Competitor reduction**	A reduction in wolf facilitated expansion in Bulgaria [35].
5	**Other — Climate change**	Particularly favourable mild winters are believed to have contributed to population increases in the Balkans [8].
6	**Other — Species ecology**	The species is highly adaptable [24], opportunistic [1] and mobile [24], all attributes which contribute to its ability to expand its range quickly [18]. High reproductive output [24] means it can bounce back easily, e.g. in Bulgaria [7], Hungary [36, 37], and Samos Island [15].

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Reviewer

- **Dr Miklós Heltai**

3.11. Grey wolf

Canis lupus

Summary

Once the world's most widely distributed mammal, the Grey wolf declined in Europe as a result of severe persecution, which confined it to areas in the south and northeast by the 1970s. However, with increasing public acceptance and legal protection, increase in wild ungulate numbers, and subsequent natural dispersal, the canid has been able to regain much of its former territory. The species is highly adaptable, and with the recent spread into western Europe, continuing range expansion is extremely likely. Management should therefore focus on mitigating the inevitable rise in conflict between wolves and humans.

Background

General description of the species

The Grey wolf (*Canis lupus*) is the largest wild canid with a near continuous distribution throughout the Northern hemisphere [1]. It is found north of 15°N latitude in North America and 12°N in India [1]. The species has become extinct in much of western Europe, in Mexico and the southern USA, and now occurs in five subspecies in North America [1] and a further six in Europe, where it is the second largest predator after the Brown bear (*Ursus arctos*) [2]. The wolf is mainly carnivorous, relying primarily on large wild ungulates, but it also consumes smaller vertebrates, invertebrates, fruits, carrion, livestock and food waste [3]. The majority of individuals are social and live in often familial packs in distinct territories [4], which are between 100 and 500 km^2 large in Europe [2]. At varying size, packs have a dynamic hierarchy with higher ranked individuals participating in reproduction [2]. Wolves become sexually mature at two years, when they either leave the pack and disperse into new, often distant, territories, or attempt to increase their ranking within their group [2].

Distribution in Europe

While the wolf was historically the world's most widely distributed mammal [5], its current range is much more restricted as a result of severe persecution by humans due to predation of livestock and fear of attack [6]. Towards the end of the 18th century, wolves were still found in most areas of Europe, but due to the rise in human population during the 19th century, wolf abundance decreased considerably [7]. The species continued to decline throughout the 20th century, particularly during the Second World War. By the 1970s, it was only present in parts of southern and northeastern Europe [7]. With increasing public acceptance and legal protection, and natural dispersal, the canid has been able to recolonise the continent naturally [1]. It now occurs in ten populations in a near continuous distribution from Finland to northern Ukraine, throughout the Balkan countries, around the Carpathians in eastern Europe, in central Scandinavia, along the Alps and the Italian peninsula, and northern Spain and Portugal, with smaller populations in south-central Spain, and across Germany and Poland [8].

Habitat preferences and general densities

Dependent on prey density and the level of human disturbance, the Grey wolf is found in a wide variety of habitats within the Northern hemisphere [6], where suitable food is abundant [1]. This includes dense forest, open grasslands, mountain ranges and the Arctic tundra [5], as well as in highly human-modified habitats such as agricultural areas [9]. Wolf densities vary from 0.1 to 1 individual per 12 km², with the greatest numbers being recorded in areas where prey biomass is highest [1].

Legal protection and conservation status

The Grey wolf has been protected in most of Europe since 1979, when it was included in Appendix II of the Bern Convention [10]. The species is now recolonising areas in central and western Europe such as the Western Alps [6, 11] and Scandinavia [12]. In addition, it is listed on Appendix II of CITES [13] and protected by the EC Habitat Directive [14], with the exception of some populations in Spain, Greece and Finland. Many countries do not enforce this level of protection and there are still significant illegal killings [2]. While many wolf populations occur in protected areas [1], these are usually too small to be of benefit to the species [12]. In many European countries compensation schemes exist for loss of livestock due to wolf predation [15].

Abundance and distribution: current status

The Grey wolf's global Red List category is Least Concern [6] due to its large range and stable global population trend [6]. However, threats to the species remain: hunting and poaching are widespread and likely the most significant threat in Europe [2]. Where human and wolf distributions overlap, livestock depredation leads to the killing of wolves, particularly in developing countries [6]. The low densities at which wolves exist make them particularly vulnerable to hunting as well as stochastic events [2]. In addition, habitat fragmentation is a significant threat through the isolation of small populations and the chance of dispersal to unsuitable habitats [2]. In Europe, the species is also listed as Least Concern [15], although the majority of regional populations are threatened due to their small size. Only the Central European and Sierra Morena populations are considered to be Critically Endangered (Table 1). In terms of population size, the current global estimate is around 200,000 individuals (Table 1). Europe comprises only a fraction of the species' global distribution and accounts for a minimum of 7% or 11,500 individuals. Around 82% of European wolves (not including Belarus, Ukraine and European Russia) are found in the Dinaric-Balkan, Carpathian, Baltic and Iberian populations (Table 2).

The Dinaric-Balkan population accounts for around one-third of Europe's wolves and covers a large area from Slovenia to northcentral Greece [15], including Bulgaria, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, FYR Macedonia and Albania [17]. Its conservation status is favourable due

Table 1. Summary of Global and European Red List assessments and threats listed for the Grey wolf.

Scale	Status	Population trend	Justification	Threats
Global [6]	Least Concern	Stable	Wide range Stable population	1. Competition with humans for livestock and wild ungulates (especially in developing countries) 2. Poisoning and persecution 3. Low human tolerance 4. Habitat fragmentation (resulting in non-viable pops)
Europe [15]	Least Concern	Increasing	Large size Increasing	As above
Europe – regional populations [15]	Critically Endangered: Central Europe, Sierra Morena Endangered: Western-central Alps, Scandinavia Vulnerable: Italian peninsula Near Threatened: Iberia, Karelia Least Concern: Dinaric-Balkan, Carpathian, Baltic	Increasing: Iberia, Western-central Alps, Italian peninsula Decreasing: Karelia	Small size	1. Human persecution 2. Lack/fragmentation of management regimes 3. Small population size 4. Habitat fragmentation 5. Low genetic variability

	Estimate	Year assessed	Reference
Global	**200,000**	**Unknown**	[12]
Europe	**11,533–12,358**	**2009–13**	[16]
% of global population	**7%**		
Iberia	2,450	2013	[16]
Western Alps	>160	2009–11	[8]
Italian Peninsula	600–800	2012	[8]
Dinaric-Balkan	3,900	2009–11	[8]
Carpathian (not including southwestern Ukraine)	3,000	2009–12	[8]
Baltic (not including Belarus, northern Ukraine and Russia)	870–1400	2010–11	[8]
Karelian (not including Russian oblasts of Karelia and Murmansk)	150–165	2012	[8]
Scandinavian	260–330	2012	[8]
Central Europe	143–153	2012	[8]

Table 2.
Latest population estimates for the Grey wolf globally, in Europe and for European populations. Please note that the European estimate excludes Belarus, Ukraine and European Russia, and the number of European wolves is likely to be higher than indicated, as Russia is believed to support the largest population.

to limited management resulting from political instability, but areas of human pressure remain, e.g. Slovenia and northern Greece [15]. Threats include legal hunting and illegal killing, poisoning, habitat fragmentation due to construction of roads and shortage of wild prey [15, 18].

The near quarter of European wolves in the Carpathian population (excluding the Ukraine) occur in several countries from northern Bulgaria to eastern Serbia [15], including Slovakia, Poland and Romania [17], with limited reports from the Czech Republic [15]. It is thought to be the only link between the northern and southern European populations [19]. Despite conservation efforts in Romania, pressures exist in the marginal areas of the range, e.g. southern Poland and Slovakia [15], where management regimes need to be applied across borders. In addition, poison baits and illegal killing are widespread [15], and habitat fragmentation is a problem [19].

Iberian wolves account for around 20% of the European population and are found in the northwest of the peninsula [15]. Although a game species in Spain, the wolf is protected in the south, and compensation schemes are in place which vary by region [17]. Compensation for livestock damage is also paid in Portugal, where the species is fully protected and the trend is stable [17]. The Iberian wolf is classified as Near Threatened due to fragmentation in management regimes, the lack of a management plan at the population level, and the occurrence of unpredictable human persecution at a local level, such as poisoning and shooting [15]. The small population in the Sierra Morena mountains in southern Spain is Critically Endangered due to its genetic isolation [15].

The Baltic population of wolves, which accounts for 7–12% of European individuals (not including Belarus, northern Ukraine and Russia), covers eastern Poland, Lithuania, Latvia and Estonia [15]. Due to its large size and unfragmented range, the

trend is very stable [15]. It should be noted, however, that this population is likely to be much larger than indicated, as Russia is believed to support a significant number of wolves [12]. The Baltic wolves thus play an important role in connecting with the Karelian population, and dispersing into the Carpathian and Dinaric-Balkan populations and towards Germany [15]. In terms of threats, there are indications that the Latvian population may be divided if no action is taken, thus risking isolating individuals in the west of the country [15].

Abundance and distribution: changes

Once widespread across the continent [5], the range of the Grey wolf has severely contracted over the last few centuries [7], with a 49% reduction taking place between 1800 and 1950–60 (Figures 1A and B) due to the increase in the human population [7]. This undoubtedly represented a continuation of a historical Europe-wide decrease in the species prior to this, as has been observed in mainland France (Figure 2). Here, the distribution contracted by over 70% for each interval between 1793 and 1918, reaching 7% of its 1792 distribution at the end of the first World War (Figure 2). In Scandinavia, declines started in the 19th century, which left only a small remnant in the north by the beginning of the 1900s [20]. Between the 1930s and 1960s, populations were at their lowest throughout Eurasia [21], and the species was indeed extirpated from France by 1960 [12]. Bounties were paid for killed wolves in Scandinavia as late as the mid-1960s, and when the wolf was finally protected in 1966 in Sweden, it was already functionally extinct in the region [22]. In Spain, the wolf was known to occur in only 50% of its 1840 range by 1950 [23]. Since then, recoveries have been observed in many European countries and regions resulting from legal protection, e.g. in Scandinavia, eastern Europe, the western Balkans, the Alps, Italy and Iberia (Figure 1B). In northern Spain, the range of the species doubled between 1970 and 2008 [12, 23]. In France, wolves first re-entered from Italy without human assistance in the early 1990s [24] and with natural recolonisation both in the southeast of the country and, more recently, in the southwest along the border with Spain [24], the wolf has been able to recover to 4% of its 1792 distribution (Figure 2). Populations have also reappeared in Sweden, Germany and Switzerland (where the wolf had been absent since the 1800s), and vagrant animals occur in Austria. While territory has been lost in areas of Spain, Italy, the Balkans, Greece, Eastern Europe and Scandinavia, these are balanced by the observed expansions, leading to a 1% increase in range since 1960 and

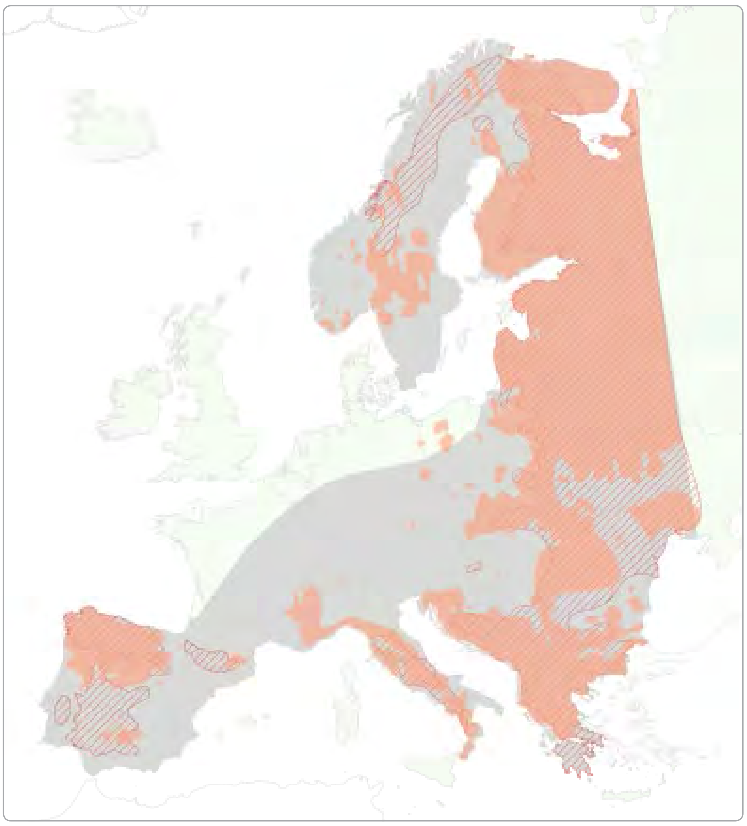


Figure 1A. Distribution of European Grey wolf in **1800** [25], **1950–60** [12, 23, 25] and **2008** [15]. Please note that areas further east were omitted due to limited data availability. Dotted range in Scandinavia indicates unlikely presence, as the species was presumed functionally extinct by the mid-1960s [22].

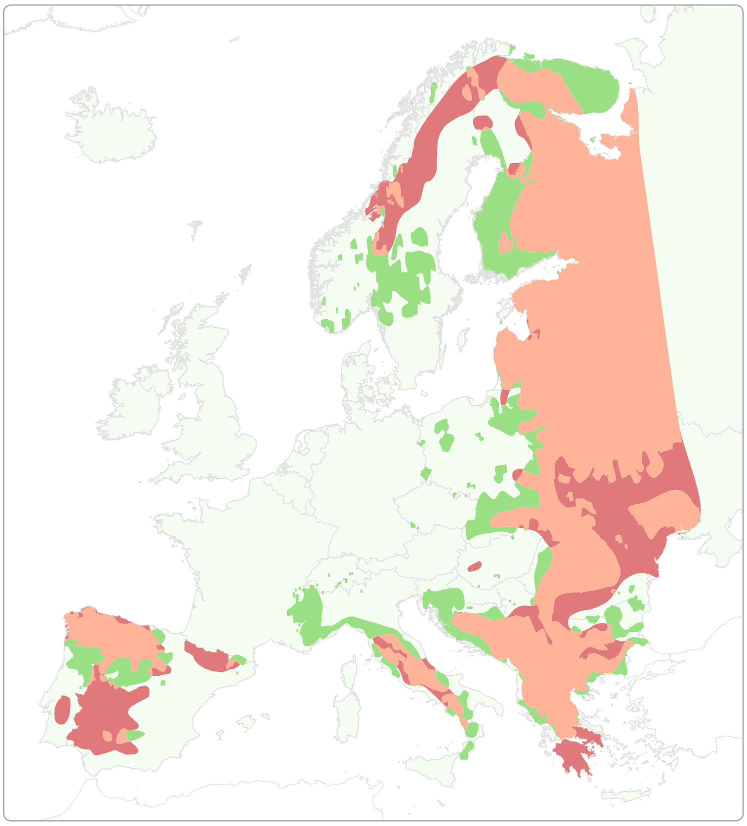


Figure 1B. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Grey wolf in Europe between 1960 and 2008. Please note that some of the contraction observed may be due to differences in the resolution of the maps.

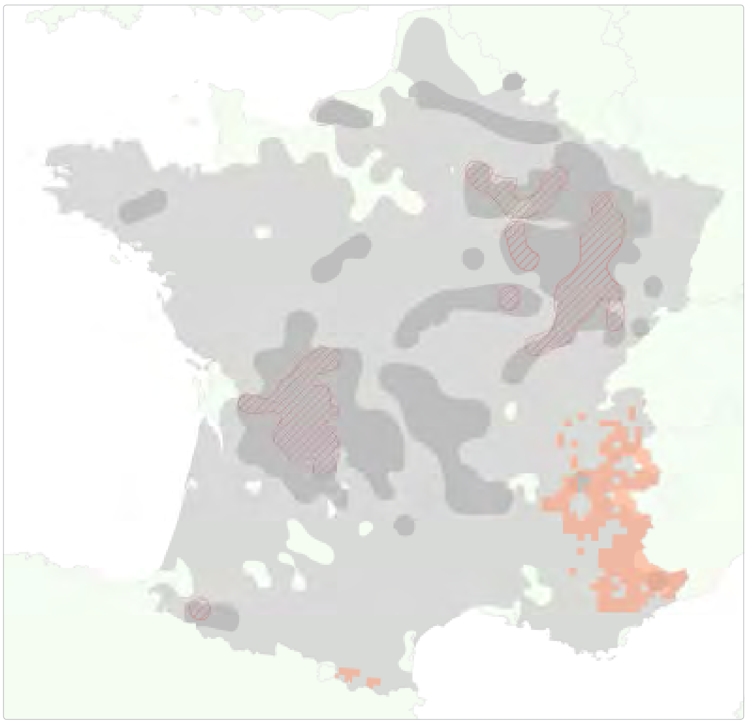
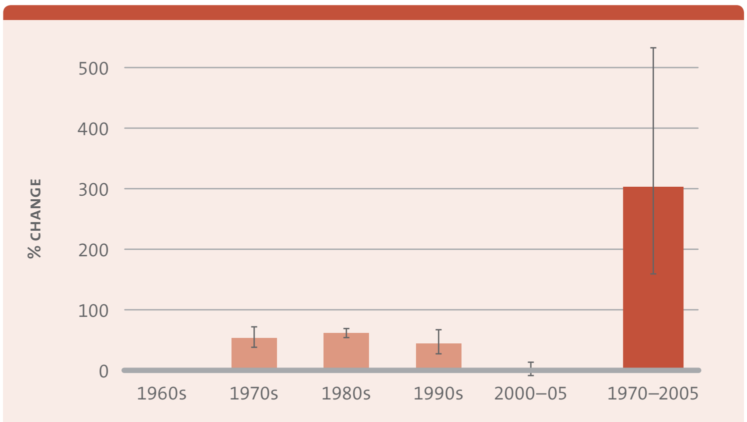


Figure 2. Distribution of European Grey wolf in France in **1792** [25], **1898** [25], **1918** [25] and **2008** [15]. The species was extinct in the country by 1960 [12].

a 50% reduction compared to 1800. It is possible, however, that the contractions observed are the result of low spatial resolution in the 1950–60 map.

In line with changes in range, European wolf populations have quadrupled in abundance between 1970 and 2005 (Figure 3). This represents an increase of 300% over the study period, with consistently positive change occurring in each decade, although growth was minimal between 2000 and 2005 (Figure 3). This is in line with the literature, which for example quotes a quadrupling of wolf numbers in Spain between 1970 and the present [12]. Abundance trends for Grey wolf were based on 31 populations from most of the species' current range, covering 65% of all countries of occurrence, and accounting for a minimum of 64% or 7,850 individuals of the European estimate from 2009–13. While all of the species populations listed in Table 2 were covered by the data set, information was missing from Ukraine and a number of the Balkan countries, Estonia, Lithuania, and Sweden.

Figure 3. Change in Grey wolf population **abundance by decade** and **overall change** between 1970 and 2005. There are no data available for 1960. Please note that due to the way change was calculated, decadal change does not sum to overall change.



Drivers of recovery

For our data set on Grey wolf in Europe, positive abundance change was associated with the Western European regions, specifically France and Germany. Both of these countries have experienced sudden reappearances of extant populations relatively recently. In France, recolonisation from Italy started in the early 1990s [24], while wolves were first discovered near the German-Polish border in 1998 [26]. Examination of ancillary information for the time series in the data set reveals that reasons for population increase (given for 60% of the populations) include legal protection and natural recolonisation, and it is perhaps these interventions that underlie the large increase seen in European wolf populations in this study (Table 3). More specifically, these two factors are interlinked and also interact with public acceptance. A recent study has found that the affective component in the local human population acts as a stronger predictor of accepted management options than beliefs about the impact or knowledge of the species [27]. As such, the gradual rise in public acceptance of the species since its widespread decline in the mid-20th century has been instrumental in the implementation of legal protection across the wolf's range [12, 27]. Because of its resilience and ability to disperse and adapt, the wolf was able to exploit the concurrent decrease in persecution and consequently spread into suitable habitat from its remaining range over long distances [12]. Secondly, it has also benefitted from the increase in available food resulting from the recoveries observed in wild ungulate populations such as Roe deer (*Capreolus capreolus*) (see section 3.7) and Red deer (*Cervus elaphus*) (see section 3.8) [12]. Changes in land use and the rise in land abandonment have also been cited as reasons for comeback [1], although they will have played a much smaller role.

Recent developments

Populations of the Grey wolf have been recovering in many of the core areas across the species' European range, but of particular importance are the recent increases at the limits of its current distribution (Figure 4). New packs and territorial pairs have, for example, been discovered in Poland and Germany [28]. In the German Lausitz region, there were nine confirmed packs and one territorial pair in 2011, up from six pairs in 2010 [26]. In addition, there have been first sightings of wolves for around 150 years in the centre of the country, for example in the states of Hessen [29] and Rheinland-Pfalz [30]. This central European population will undoubtedly play a pivotal role in the further expansion of the species into western parts of the continent: there have already been sightings of wolves in the Netherlands close to the border with Germany [31], representing the first occurrence here in more than a century [31] and further spread into Belgium [32], and into Denmark, where the last wolf was shot in 1813 [33]. The wolf has also been able to reclaim territory in the French Alps by crossing over from Italy [24, 34], and it has now spread as far as the Lozère region in central France [35]. In 2012, individuals from the Alpine population formed the first pack in 150 years in the Calanda mountains of Switzerland and four cubs were confirmed to have been born in 2013 [36]. Wolves from the Alpine region are also moving into southern Germany (Bavaria) [37] and have been detected in the French Pyrenees and in Catalonia (Spain) [38]. In the eastern part of its range, the existence of wolves in the Shebenik Mountains near the border to Macedonia was proven for the first time using camera traps [39]. As many of the smaller subpopulations are considered endangered due to low genetic variability [15], one important development is the increasing exchange between formerly isolated populations. For example, in October 2010, genetic analysis confirmed that a wolf from the Baltic population had found its way into the Alps [40, 41].

Despite the positive developments described above, the wolf is still affected by various threats throughout its range. In late 2010, the Swiss national assembly formulated a request for a loosening of the protection of the Swiss wolf from the Bern Convention [42]. In February 2011, a controversial hunt in Sweden, which has drawn legal proceedings from the European Commission, ended one individual short of the set quota [43].

Rank	Reason for change	Description
1	Other — Increased public acceptance	Efforts made to raise the wolf's image, and the subsequent rise in public acceptance, have contributed to comeback [27] by enabling the implementation of legal protection of the species [12].
2	Legislation — Legal protection	As well as European legislation [10, 13, 14], the wolf is also nationally protected in most countries of its range [8].
3	Other — Natural recolonisation	France was recolonised from Italy in the early 1990s [24]. Polish wolves spread into Germany from 1998 [26]. The northernmost part of Sweden was probably recolonised by individuals of the Finnish-Russian population from the late 1970s [22].
4	Other — Increase in wild ungulate populations	The wolf has benefitted from the increase in Roe deer (*Capreolus capreolus*) and Red deer (*Cervus elaphus*) [12].
5	Other — Species ecology	The species is resilient, adaptable and able to disperse over large distances, which has facilitated natural recolonisation.
6	Other — Land use change and land abandonment	These factors have played a smaller role in the comeback of the Grey wolf [1].

Table 3. Major reasons for positive change in the status of the Grey wolf in Europe.

Recent research also suggests that illegal poaching is a real threat in Sweden, where it accounts for over half of killed individuals [44]. In other populations, illegal shootings represent a much smaller proportion of unnatural deaths, for example in the Lausitz region in Germany a much greater threat comes from car collisions, which accounted for two-thirds of mortalities [45].

The wolf is a highly adaptable and opportunistic species, and many areas of Europe offer suitable habitat including sufficient ungulate prey and seclusion to make a continuing range expansion extremely likely. Action plans are needed to design successful livestock depredation prevention methods, to implement compensation schemes and monitoring programmes, and to further improve the species' public image. All of these will be vital in managing the comeback of the species in Europe.

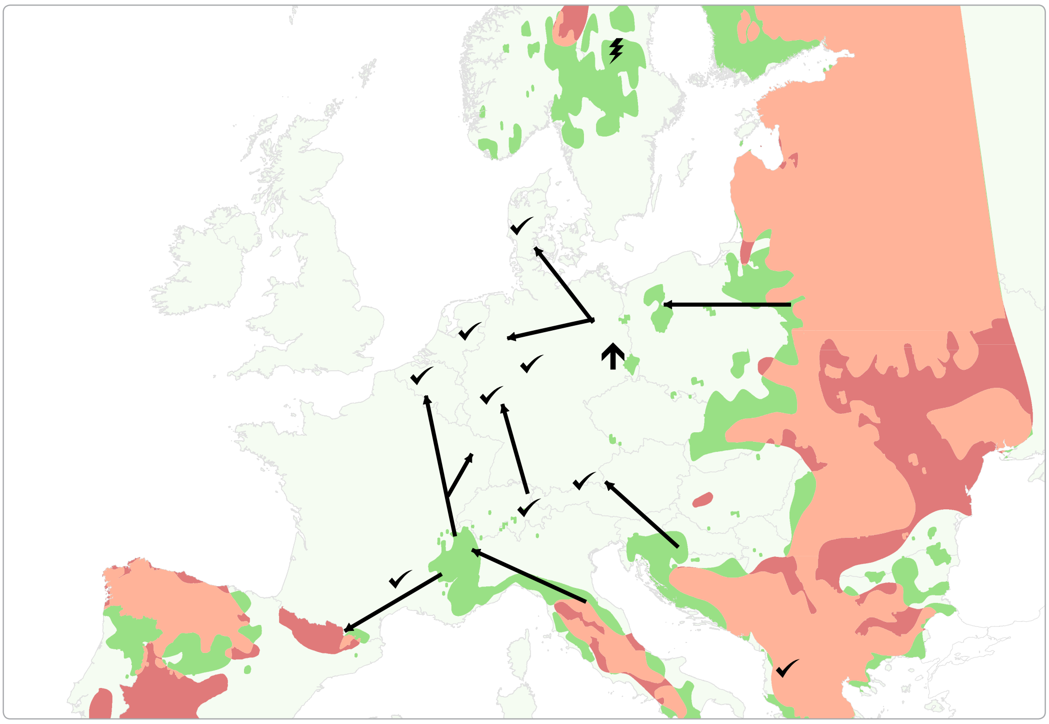


Figure 4. Map of recent developments recorded for the Grey wolf in Europe.

Expansion
Persistence
Contraction
Population increase
Intentional mortality
Range expansion
New sighting

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Reviewer

- **Dr Juan Carlos Blanco**

3.12. Eurasian lynx

Lynx lynx

Summary

The Eurasian lynx experienced a contraction in range during the 19th and first half of the 20th century due to hunting pressure and deforestation, but has since been subject to significant conservation effort across most of its former range. As a result populations have more than quadrupled in abundance over the past 50 years, an increase attributed to legal protection, reintroductions and translocations and natural recolonisation. The Eurasian lynx is, however, still under threat, especially in its isolated populations which are often fragmented and subject to continued hunting.

Background

General description of the species

The Eurasian lynx *(Lynx lynx)* is the largest European felid and the furthest ranging species of the *Lynx* genera [1]. It is a territorial species where the female establishes a home range based on prey and habitat availability and the males choose areas in close proximity to females [2]. The lynx favours musk deer and chamois as its prey, which, as a solitary and largely nocturnal species, it hunts at dusk and dawn [1].

Distribution in Europe

The lynx first appeared during the late Pleistocene in Europe [3], where it was widely distributed in the Black Sea region [4]. Eurasian lynx inhabited the Iberian peninsula alongside the Iberian lynx (*Lynx pardinus*) during the late glacial period, but disappeared from the area by the Holocene [3]. During the past 500 years, the species has been in decline in Europe, likely due to deforestation and hunting pressure on both the lynx and its prey species. It survived in small, fragmented populations, particularly in mountainous areas where habitat was left largely intact, e.g. the Carpathians and the Balkan Peninsula. Most other populations faced extirpation, declining significantly by the end of the 19th century [4]. Presently, the species in Europe, an estimated 8,000 individuals (excluding Russia), survives in populations which remain fragmented outside the strongholds [1]. More recently, large increases of local populations have been reported [2].

Habitat preferences and general densities

The Eurasian lynx is widely distributed throughout continental Europe in boreal, deciduous and Mediterranean woodland areas. Optimal habitat for lynx consists of large forests supporting stable populations of small ungulates [1]. The

Scale	Status	Population trend	Justification	Threats
Global [5]	Least Concern	Stable	Wide range	1. Illegal hunting 2. Habitat loss 3. Prey base depletion
Europe [8]	Least Concern	Unknown	Wide range High abundance	1. Prey base depletion 2. Legal and illegal hunting 3. Habitat destruction 4. Human encroachment 5. Collisions
Europe 25 [8]	Near Threatened	Unknown	Small population size Small, fragmented populations	N/A
Europe – regional populations	Critically Endangered: Vosges-Palatinian, Eastern Alps, Bohemian-Bavarian, Balkan [8] Endangered: Jura, Western Alps, Dinaric [8] Least Concern: Carpathian, Scandinavian, Karelian, Baltic [8]	Decrease: Balkan, Vosges-Palatinian [6] Mixed: lpine, Dinaric [6] Stable: Baltic, Bohemian-Bavarian, Carpathian, Karelian [6] Increase: Scandinavian, Jura [6]		1. Alpine – Persecution, Low acceptance due to conflicts with hunters, Infrastructure development due to transport (roads/railways), Inbreeding [6] 2. Balkan – Persecution, Over-harvesting of prey populations, Poor management structures, Infrastructure development [6] 3. Baltic – Persecution, Low acceptance due to conflicts with hunters, Vehicle collision [6] 4. Bohemian-Bavarian – Persecution, Low acceptance due to conflicts with hunters, Vehicle collision [6] 5. Carpathian – Infrastructure development due to transport (roads/railways), Infrastructure development due to tourism/recreation, Persecution [6] 6. Dinaric – Inbreeding, Persecution [6] 7. Jura – Low acceptance due to conflict with hunters, Vehicle collision, Persecution, Inbreeding [6] 8. Karelian – Harvest [8] 9. Scandinavian – Persecution, Low acceptance (conflict with livestock; conflict with hunters; as form of political opposition to national/EU intervention; due to fundamental conflict of values about species presence) [6] 10. Vosges-Palatinian – Low acceptance due to conflict with hunters [6]

Table 1. Summary of Global and European Red List assessments and threats listed for the Eurasian lynx.

natural density of lynx varies according to prey abundance and is also limited by the territoriality among individuals, but the availability of suitable habitat becomes the prevailing limiting factor in cultivated landscapes [2]. Reported densities vary between 0.25 individuals/100 km² in Norway where there is low prey abundance to 1.9–3.2 individuals/100 km² in Poland [2].

Legal protection and conservation status

The Eurasian lynx is listed on CITES (Appendix II), and protected under the Bern Convention (Appendix III) and EU Habitats and Species Directive (Annexes II and IV) [5], and therefore strictly protected in all EU member states except Estonia, where it is included on Appendix V [6]. However, implementation of this protection varies between countries; Sweden, Latvia and Finland, for example, use derogations of the directive for limited culls by hunters [6]. In Norway, the lynx is hunted as a game species with annual quotas [6]. Only half the range countries currently have management plans in place, while several others are in the process of drafting one [6]. Trans-boundary agreements exist in the Alps [6] and the Carpathians [7]. In addition to legal protection, conservation measures include public education, and reintroductions. A high-profile introduction was carried out in the Swiss Jura mountains in the 1970s as part of a plan to boost the Alpine lynx population, which has also included other reintroductions in Slovenia, Germany, Austria and Italy [1].

The global IUCN Red List categorises lynx as Least Concern with a stable population trend throughout most of its range (Table 1). In Europe, the species is also listed as Least Concern but the population trend is unknown (Table 1).

Abundance and distribution: current status

In terms of population size (Table 2), a recent estimate puts the total number of individuals globally at 50,000, with the European population (excluding Russia, Belarus and Ukraine) accounting for 9,000–10,000 or a minimum of 18% of these, while also covering around a fifth of

	Estimate	Year assessed	Reference
Global	**50,000**	**?**	[5]
Europe (excl. Russia, Belarus)	**9,000–10,000**	**2008**	[6]
% of global population	**18%**		
Bohemian-Bavarian	50	2012	[6]
Vosges-Palatinian	19	2012	[6]
Jura	>100	2012	[6]
Alpine	130–160	2012	[6]
Dinaric	120–130	2012	[6]
Balkan	40–50	2012	[6]
Carpathian (excl. Ukraine)	2,300–2,400	2012	[6]
Scandinavian	1,800–2,300	2012	[6]
Karelian (excl. Russia)	2,430–2,610	2012	[6]
Baltic (excl. Russia, Belarus)	1,600	2012	[6]

Table 2.
Latest population estimates for the Eurasian lynx globally, in Europe and for European populations. In addition, there are a number of lynx stemming from more recent introductions, e.g. in the Harz mountains in Germany.

the global range. In Europe, the lynx can be found in 10 populations, the largest of which occur in Karelia (excluding Russia, 25%), the Carpathians (excluding Ukraine, 23%), Scandinavia (18%) and the Baltic (15%), which together account for around 81% of European lynx (Table 2). All of these (and the Balkan population) are autochthonous, i.e. not the result of reintroductions [6, 9]. Most European lynx populations are stable or increasing [6].

A population of about 2,500 lynxes occurs in the Karelia region of Finland [6], which was recolonised from Russia following local extinction by the 1950s [8]. Since then, the population has increased in abundance and range, particularly over the last twenty years and, as a result, now connects with neighbouring populations [8]. The lynx is not fully protected in both countries within this population; it is a game species in Russia and is harvested annually in Finland (59 per year between 1996 and 2001) [8].

One of the largest continuous lynx populations in Europe occurs in the Carpathians [6]. The lynx is stable here and currently strictly protected in all countries within this range, except in Romania, where hunting occurs under derrogation [6]. Despite the complete isolation from other populations, there are no concerns about genetic variation of this population [2]. Having been on the brink of extinction in the early 20th century, the Scandinavian population now numbers around 2,000 individuals [6], with the majority occurring in Sweden [10]. Controlled hunting (90 per year between 1996 and 2001 in each country) is carried out due to conflicts where livestock depredation is highest. There is a compensation scheme in place in both Norway and Sweden [8]. The Baltic population is continuous in the northern part of its range (Estonia, northeast Latvia and northern Belarus) [5] but fragmented in the south

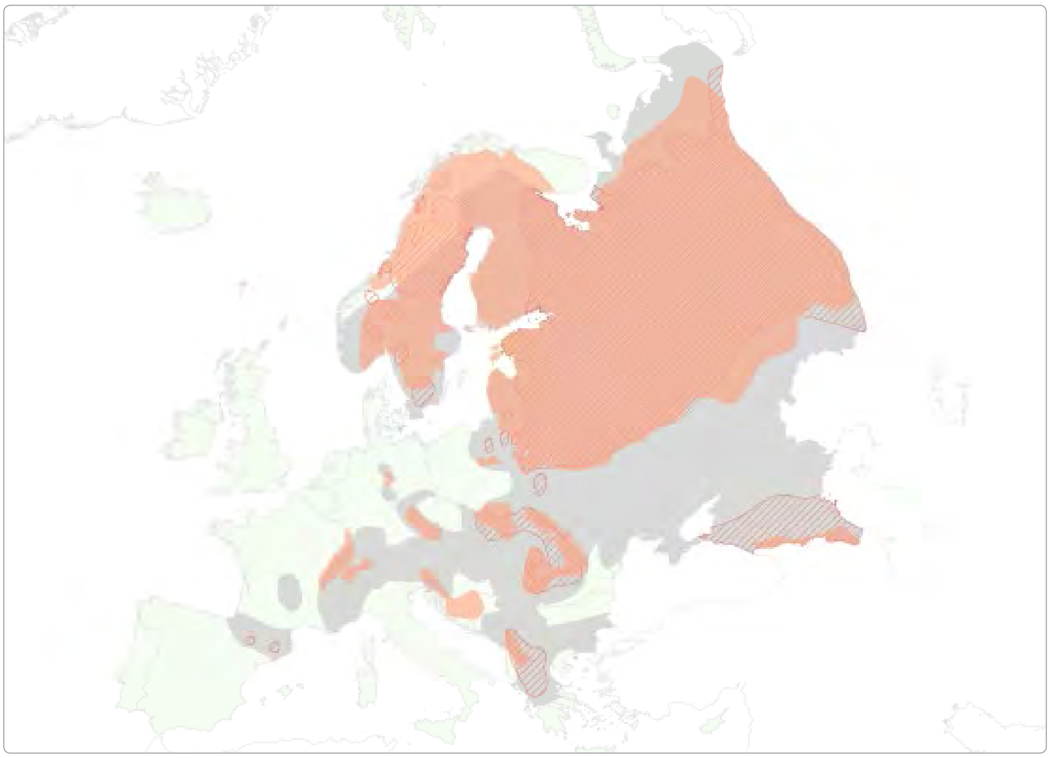

Figure 1a. Distribution of Eurasian lynx in **1800** [4], **1960** [4, 16] and **2010** [5].

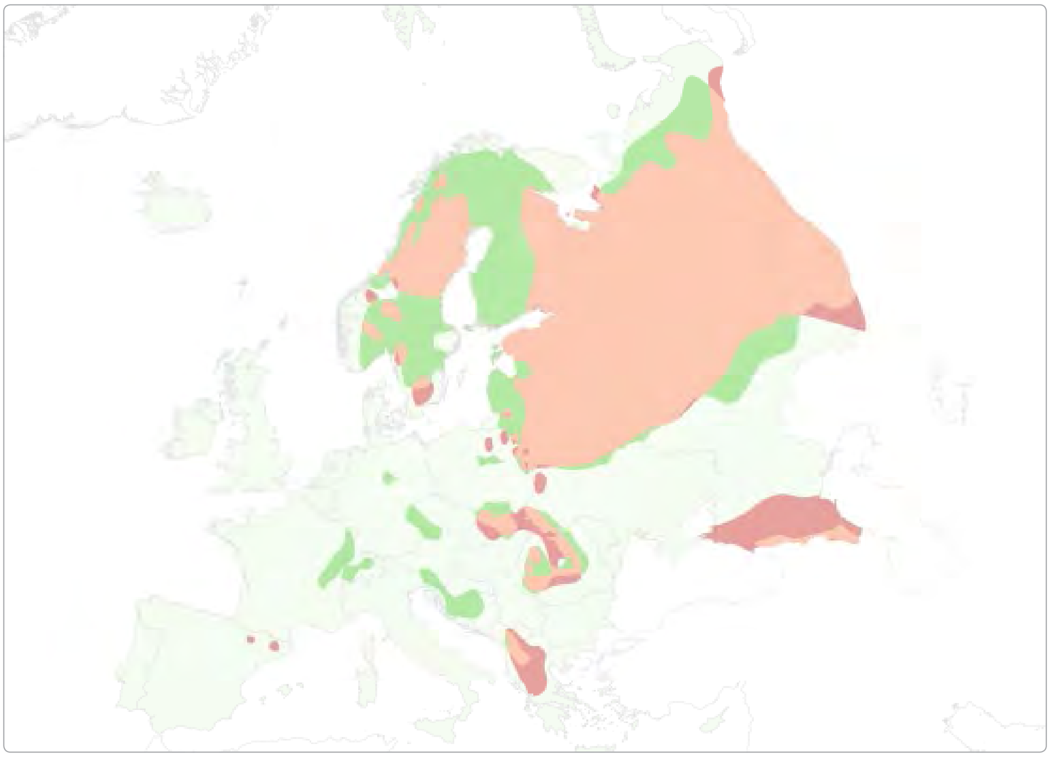

Figure 1b. Map highlighting areas of range **EXPANSION**, **PERSISTENCE** and **CONTRACTION** of the Eurasian lynx in Europe between 1960 and 2010.

(southern Latvia, Lithuania, rest of Belarus, Poland, Ukraine and Kaliningrad) [8, 11]. Trends are believed to be stable despite being hunted [8]. The highly fragmented populations in the south are a major concern [8], as they are threatened through limited opportunities for gene exchange [12]. With the Baltic Large Carnivore Initiative cross-border network between Estonia, Latvia and Lithuania, created in 2000 [8, 10], a first step towards trans-boundary action was taken.

The Balkan population is estimated at less than 50 individuals and occupies a highly fragmented range of less than 6,000 km² [2], and is therefore of the greatest conservation concern [6]. Genetic analyses have shown that it differs from the nearest neighbouring Carpathian lynx population [13], and it is thus considered a rare subspecies [14, 15]. Threats include limited prey base, illegal killing, wood extraction and infrastructure development [10].

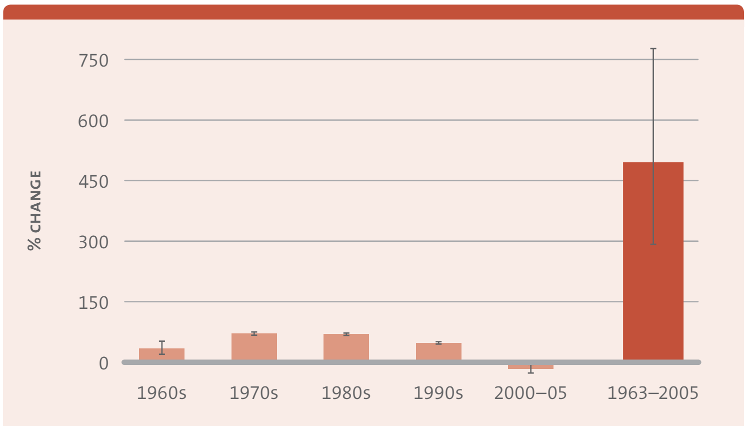

Figure 2. Change in Eurasian lynx population **abundance by decade** and **overall change** between 1963 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

Abundance and distribution: changes

In line with the significant decline reported towards the end of the 19th century [4], the lynx's range decreased by 48% between 1800 and 1960, and the species retracted to its distribution limits (e.g. Russia, Scandinavia and the Balkans) and a number of refugia throughout the continent (southern and northern Spain, the Carpathians and the Alps) (Figures 1A and B). This was followed by a 37% increase in occupied area in the second half of the 20th century. Despite a complete loss from the Iberian peninsula and severe range contraction in the Balkans during this period, there has also been an expansion from the limits in Russia and Scandinavia (with the exception of southern Russia), and a spread into new areas in France, Germany, the Czech Republic and Poland, many or all of which can be attributed to reintroductions [10]. The lynx currently occupies 71% of its historical range in Europe (Figures 1A and B).

The more recent range expansion is also reflected in the population trend for European populations of Eurasian lynx (Figure 2). The analysis which starts in 1963 due to non-availability of data before this period, shows an increase of nearly 500% by 2005 (Figure 2), with consistently positive population change in all decades except between 2000 and 2005 (Figure 2). This recent decrease is attributable to populations from Norway, Poland and Russia. The abundance trend for Eurasian lynx is based on 25 populations from across its current range, representing 4,350 individuals or 44% of the total European population of 2010. The country coverage is good at around 66%. Data were missing from only a few locations within the species' current range, namely southern Russia and the critically endangered Balkan population.

Table 3. Major reasons for positive change in the status of the Eurasian lynx in Europe.

Rank	Reason for change	Description
1	**Legislation**	The Eurasian lynx is listed on CITES (Appendix II), and protected under the Bern Convention (Appendix III) and EU Habitats & Species Directive (Annexes II and IV) [5], and therefore strictly protected in all EU member states except Estonia [6].
2	**Species management – translocations, reintroductions and captive breeding**	Half of the current 10 Eurasian lynx populations are the result of reintroductions in the 1970s and 1980s; these are Dinaric, Alpine, Jura, Vosges-Palatinian and Bohemian-Bavarian populations [6]. Occurrences in the Harz mountains are also attributable to reintroductions [6]. Translocation of three individuals from Estonia to Poland in 2012 [6].
3	**Other – Natural recolonisation**	The Finnish lynx population was re-established in the 1950s by recolonisation from Russia and Sweden [17]. Bulgaria is currently being recolonized by individuals from the Carpathian or Balkan population [17]

Drivers of recovery

The most severe persecution of the lynx in Europe ceased in the middle of the 20th century, which halted the shrinking of its range and fixed its westernmost range limits in eastern Europe and in some parts of Scandinavia [4]. In our data set, increases in abundance in the Eurasian lynx appear to be associated with specific countries and regions. The countries with the most pronounced recoveries were Austria, Germany, France and Italy (not shown), all in the Western European region with the exception of Italy, and covering the Alpine, Bohemian, Jura and Vosges populations (Table 2). None are from protected locations, and all are threatened by habitat loss and degradation, so the increase is likely the result of reintroductions or recolonisations in areas from which the lynx had previously been extirpated.

Countries in southern Europe were associated with relatively stable trends, especially those within the range of the Balkan subpopulation, such as Albania and Serbia. However, it is populations in eastern Europe (Czech Republic, Slovakia, Poland and Russia) and therefore the Carpathian and Baltic populations, which are faring the worst. Both of these populations were reported to have stable to decreasing, and decreasing trends between 1996 and 2001 [10]. The last comprehensive report [6] lists persecution and low acceptance, as well as infrastructure development as major threats throughout Europe.

Overall, the recovery of the Eurasian lynx is attributable to active conservation action such as the legal protection of the species and its habitat, and continued reintroduction and translocation efforts, but also to natural recolonisation (Table 3).

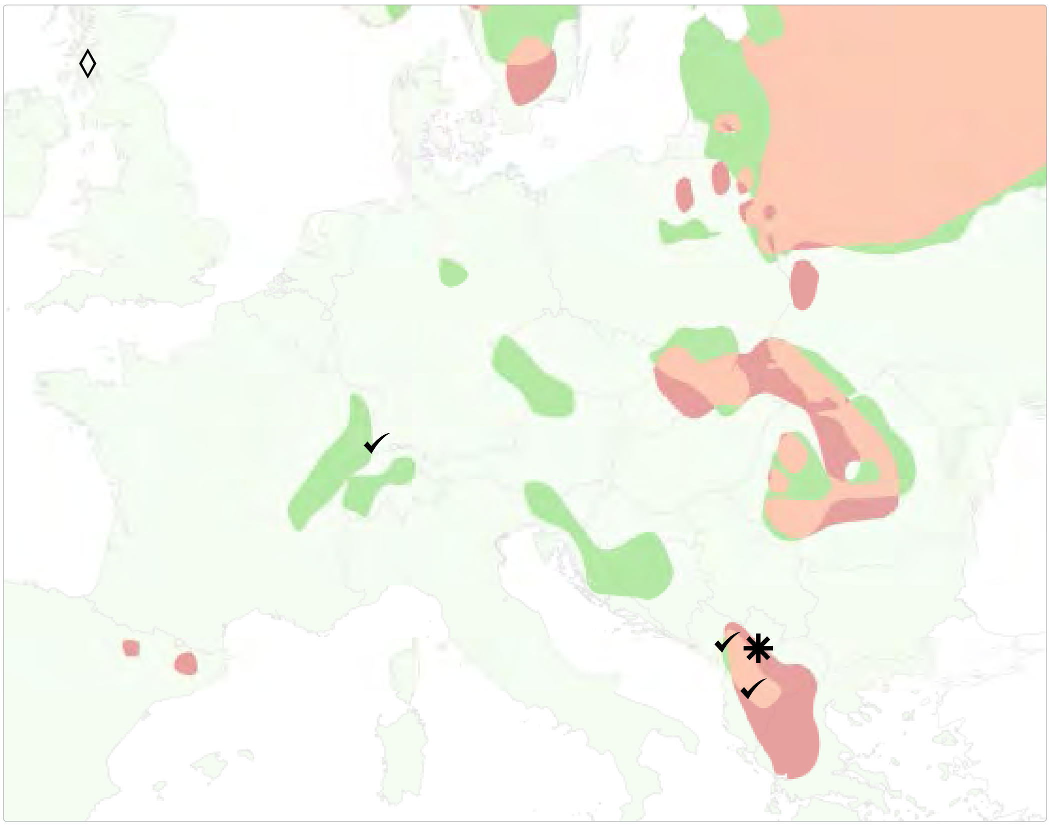

Figure 3. Map of recent developments recorded for the Eurasian lynx in Europe.

Expansion
Persistence
Contraction
✱ Monitoring (radio collaring)
◊ Reintroduction
✓ Confirmed presence

Recent developments

Much of the recent conservation attention has been on the critically endangered Balkan subpopulation, especially regarding the improvement of monitoring and the closing of gaps in ecological knowledge [15]. It appears that efforts are showing signs of success: using camera traps, at least nine lynx were detected in Mavroro National Park (Macedonia) in spring 2010 [15, 18]. Definitive evidence has also been found in in the Jablanca-Shebenik mountains in December 2010 [15, 19], and there has been a first camera trap success in Albania in April 2011 [20]. In the Western part of the species' range, there have also been positive developments. In 2009, lynx tracks were recorded for the first time after a long absence in Krkonoše Mountains National Park in the Czech Republic [21], and other evidence has been collected since. In nearby Bohemian Switzerland (also in the Czech Republic), camera traps confirmed the presence of lynx, believed to have been drawn there by the relative tranquillity in winter and expected to move on to Saxony in the summer [21]. There has also been a first direct sighting of a lynx in the southern Black Forest region of Germany in March 2013 [22].

In addition to conservation efforts in the countries of occurrence, there are also moves towards re-establishing populations in locations from which the species has long been absent. For example, the Lynx UK Trust has recently applied for a license to introduce the lynx into a forest on the west coast of Scotland [23]. This would initially comprise two pairs to test the feasibility of the reintroduction process in preparation for potential further reintroductions to Wales and Northern England [23].

Despite range expansion, the genetic variability remains compromised in some populations of lynx, e.g. in Scandinavia [24], the Carpathians [24], and the Dinaric, Alpine and Jura populations [6]. There are also concerns over the Balkan and Palatinian populations, who are believed to have decreased and even disappeared respectively [6]. Because of its dietary specialisation, which necessitates low lynx population density and good cover, the species is believed to be particularly sensitive to habitat loss and fragmentation, which, in turn affects genetic status [24]. The linkage of populations therefore has to be a top priority in future management, especially between Alpine, Jura and Dinaric populations [6]. The probability of linking Bohemian-Bavarian and Carpathian populations, however, is very low due to man-made barriers [6]. Other threats include poor management, accidental mortality, and persecution resulting from conflict with hunters [6]. In fact, with increasing populations, low or decreasing acceptance has been recorded in the Alps, Balkans, Jura, Karelia and Scandinavia [6]. Because of this, public awareness and education has been a major research focus. Fear was an important predictor of negative attitude towards lynx in Slovakia [25] and Poland [26] and knowledge appears to play a role. Associations between lack of knowledge of lynx and negative attitude have been found in Poland [26] and Macedonia [27], while higher levels of species knowledge resulted in a more positive attitude in Slovakia [25]. Overall, these studies highlight the importance of dissipating and counteracting fear through communicating up-to-date knowledge of the lynx in Europe. It is likely that such initiatives would be successful for the most part, as the lynx is generally the most accepted of the three large European carnivores [25], perhaps because damage to livestock is marginal except in Karelian and Scandinavian populations [6].

The lynx has been subject to significant conservation effort across most of its former range, and, as a result, populations have more than quadrupled in abundance over the past 50 years. Although we were unable to identify major reasons in this study, literature suggests that legal protection, reintroductions and translocations and natural recolonisation are likely to have contributed to recent comeback of the species. The Eurasian lynx is, however, still under threat, especially in its isolated populations (Table 3).

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Reviewer

- **Professor Luigi Boitani**

3.13. Iberian lynx

Lynx pardinus

Summary

The Iberian lynx was previously widespread and common on the Iberian peninsula, but declined from the 1960s due to prey depletion, habitat loss and fragmentation, and non-natural mortality. At present, the species is extinct in Portugal and restricted to two populations in southern Spain. Both of these have shown moderate improvements in status over the past few decades, much of which appears to be attributable to habitat and species management.

With continued conservation measures, particularly those focussing on connecting fragmented populations, mitigating threats and ensuring genetic integrity, the Iberian lynx should be able to expand into areas where suitable habitat remains.

Background

General description of the species

Despite a superficial resemblance to the more common Eurasian lynx (*Lynx lynx*), the Iberian lynx (*Lynx pardinus*) is remarkably different in terms of size, habitat preference and behaviour [1]. As a solitary [2] and mostly nocturnal species [3], the lynx hunts at dusk and dawn [3]. It feeds almost exclusively on rabbits; these make up at least 90% of its diet and it requires approximately one per day [4]. Occasionally, other prey is taken, especially during the winter months when rabbit numbers are low [4].

Distribution in Europe

The Iberian lynx was sympatric with the Eurasian lynx in southern France and Iberia during the Pleistocene [5]. In the Iberian peninsula, which acted as a Pleistocene refuge for the European rabbit (*Oryctolagus cuniculus*) [6], the species was widespread until the mid-19th century [4, 7]. By the 20th century, the species had become rare in the north but remained abundant in the centre and south of Spain, but by the mid-1960s, it was limited to the southwestern part of the Iberian peninsula [4, 7], where it had a fragmented distribution [8]. At present, the species is extinct in Portugal [9], and restricted to two separate populations in southern Spain [10].

Habitat preferences and general densities

The Iberian lynx requires Mediterranean scrubland to live, i.e. a mosaic of dense scrubs for shelter and open pasture for hunting [11]. Densities vary with habitat quality, especially rabbit abundance [12]. For example, the best quality habitat in Doñana supports 0.8 adults/km^2, whereas 0.1 to 0.2 adults are found per km^2 in areas with moderate rabbit density [12]. The estimated mean density is 0.2

Scale	Status	Population trend	Justification	Threats
Global / Europe	Critically Endangered	Decreasing	Small population size Small, fragmented populations	1. Prey depletion 2. Non-natural mortality 3. Habitat destruction and fragmentation
Europe – regional populations	Spain [13], Portugal [20]: Critically Endangered	N/A	Spain [13], Portugal [20]: Range contraction Decrease in abundance Causes of decline have not ceased	Spain [13]: 1. Prey depletion 2. Habitat destruction and fragmentation 3. Non-natural mortality Portugal: [20]: 1. Habitat destruction and fragmentation 2. Prey depletion 3. Non-natural mortality

Table 1. Summary of Global and European Red List assessments and threats for the Iberian lynx [18, 21].

adults/km² across Doñana [13] and 0.08 adults/km² over most of the species' range [12].

Legal protection and conservation status

Throughout its present range, conservation measures are in place to ensure the continued survival of the Iberian lynx. It is listed on Appendix I of CITES [14], Appendix II of the Bern Convention [15] and Annexes II and IV of the EU Habitats and Species Directive [16]. The Spanish government paid for the destruction of lynx until the 1950s, and it was only declared a protected species here in 1973 [12]. Conservation action plans were not implemented until the 1980s, although many of the earlier efforts proved to be ineffective, most likely because of lack of funding [10]. Around 80% of lynx occur on private property, which is mostly managed for hunting [10]. *Ex situ* strategies include captive breeding programmes in Spain [17], where animals have already been released, and The National Centre for the Iberian Lynx in Portugal, which opened in 2009 [10]. The remaining two wild breeding populations are being closely monitored and conserved, and reintroductions have been carried out in suitable areas [10]. In addition, public awareness and education programmes have helped attitude change, particularly among private landowners [18].

The global IUCN Red List and European Red List both categorise the Iberian lynx as Critically Endangered due to its small, fragmented populations and decreasing trend (Table 1). It is considered the most threatened cat in the world [19] and on the brink of extinction [18]. It is listed as Critically Endangered on the National Red Lists for Spain [13] and Portugal [20].

Abundance and distribution: current status

In terms of population size, a recent estimate from 2010 puts the total number of individuals at 279 (Table 2). The largest population occurs in the eastern Sierra Morena, which accounts for 68% of the free-living individuals of the species. The other extant population in Doñana numbers around 77 individuals. The species is believed to be extinct in Portugal [9].

With good evidence for the extinction of the Iberian lynx in Portugal [9], the species now exists in only two populations in Spain isolated from one another [18]. The Coto Doñana population numbers around 77 individuals or 28% of the global population, with only limited connectivity between some of eight subpopulations [23]. Doñana lynx have lost the pelage variation found in other populations, giving rise to only a single fur design in the area since the 1960s [24], and the suspected genetic impoverishment has now been confirmed at a molecular level [25]. This is particularly remarkable considering the fact that the diversity of the species is already much lower than in other felids. Although Doñana is within the Natura 2000 network, lynx frequently disperse into the unprotected surrounding areas, where they are at risk from poaching and road-related mortality [26]. For example, ten lynx were killed in collisions between 2004 and 2006 [27], and this mortality could potentially affect population size. In addition, other anthropogenic causes of mortality identified included illegal trapping, hunting and drowning in man-made wells [28].

The larger of the two remaining Iberian lynx populations occurs in Andújar-Cardeña in the eastern Sierra Morena mountain range. It accounts for around 68% of the global population, with 190 individuals counted in 2010. The region has

Table 2. Latest population estimates for the Iberian lynx in Europe.

	Estimate	Year assessed	Reference
Global / Europe	279	2010	[22]
% of global population	100%		
Doñana	77	2010	[22]
Sierra Morena	190	2010	[22]

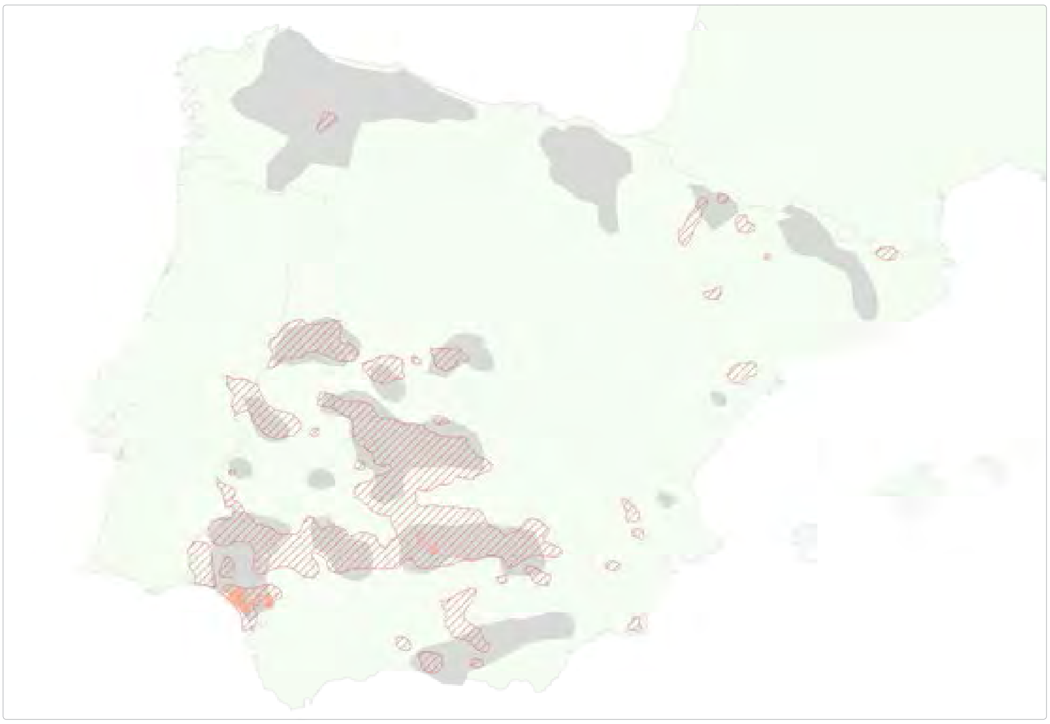

Figure 1a. Distribution of the Iberian lynx **pre-1900** [40], in **1960** [32] and **2008** [21] in Spain. No data were available for Portugal. Please note that the pre-1900 map represents an approximation of actual range and may differ in resolution from maps for other time periods.

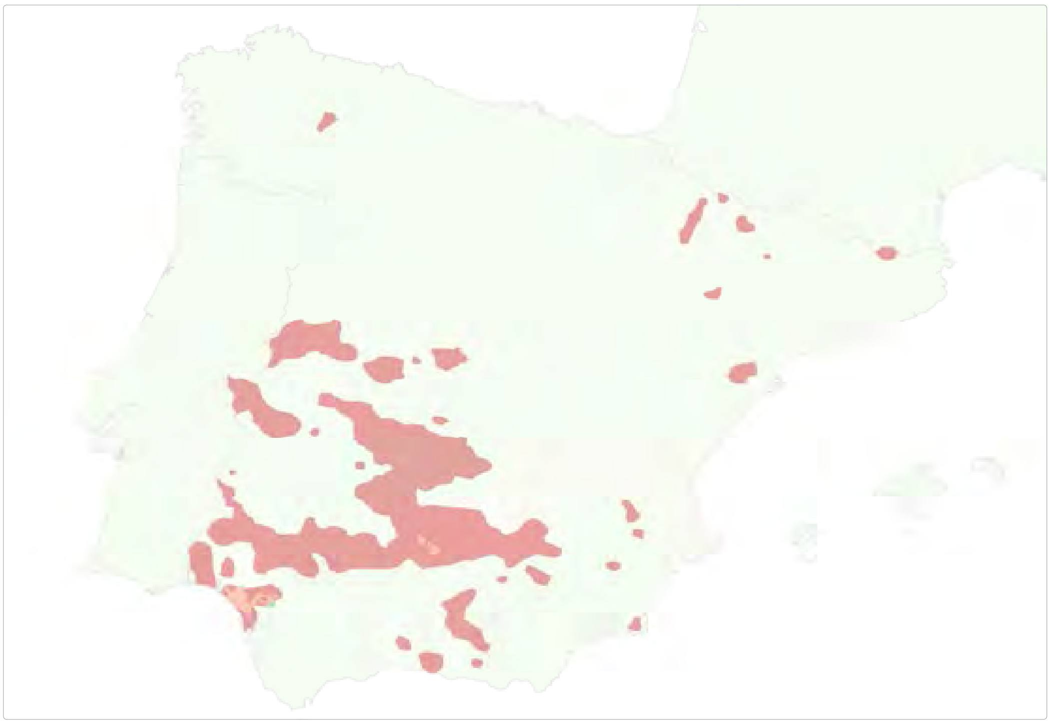

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Iberian lynx in Europe between 1960 and 2008. Please note that due to differences in resolution, the range change depicted may not be accurate.

an estimated carrying capacity that is 2–3 times higher than that of Doñana [29]. Individuals from this population have been released into Doñana to increase the genetic variability of the local population [30, 31].

Abundance and distribution: changes

In line with the significant range reduction reported to have occurred after the mid-19th century [32], the lynx's range decreased by 43% between pre-1900 and 1960 (Figure 1a). By this time, the species was relatively rare in the north but remained abundant in the centre and south of Spain [33]. The latter half of the 20th century saw another drastic reduction (Figures 1a and b). At this point, the Iberian lynx occupied just over 1% of its historical range in Europe. This decline is comparable to Figures reported elsewhere, which quote a range loss of 80% between 1960 and 1990 [12], of 88% from 1985–89 to 1999–2001 [7, 8] and a 98% decline in distribution area during the second half of the 20th century [8, 34, 35].

The widespread range contraction is also reflected in the population trend for European populations of Iberian lynx (Figure 2). The trend, which starts in 1965 due to non-availability of data before this period, shows a decrease of around 85% by 2005, with consistently negative change in all decades except between 2000 and 2005 (Figure 2). According to our data, species abundance declined by 80% in the 1960s and 1970s, which is in line with the 80% reduction estimated in Spain for the period 1960–1978 [36], with local extinctions reaching a high in 1970–75 [7]. This decline was previously attributed to the introduction of myxomatosis from Australia via France [37], however the most likely explanation is that this factor made populations vulnerable to anthropogenic-induced changes in land use, level of exploitation, and prey and habitat availability [7]. For example, urban migration after 1960 resulted in the loss of diversity in the Mediterranean scrubland at the landscape level, as well as the replacement of native vegetation by plantations [7].

A small but sustainable population of around 1,100 animals remained in the early 1980s [38], although another rapid decline followed between 1980 and 1985 [7]. The introduction of Rabbit Haemorrhagic Disease (RHD) in 1988 again caused high mortality in rabbits [12]. While affecting the lynx directly, profit losses from small game hunting due to rabbit decreases may have encouraged owners to optimise habitat for big game species, which further suppressed rabbit recovery, and human-induced mortality including illegal hunting and traffic deaths will have also played a role [12]. Between 1950 and 1989, and an average of 31.5 lynx were lost per year due to non-natural causes, although this is likely to be an underestimation [39].

Our results indicate that the 1980s were the second most devastating during the study period, with a decline of nearly 40% (Figure 2). Some sources quote a decline of more than 80% between 1987 and 2007 [18]; this could not be confirmed in this study, where an increase occurred between 2000 and 2005. Protection, captive breeding and other conservation measures are likely to have contributed to this [38]. Overall, the decline observed from 1960 is attributed to rabbit decline, habitat loss and fragmentation, and non-natural mortality [8, 39]. The abundance trend for Iberian lynx is based on five populations from Spain, representing an average 190 individuals or 68% of the total European population from 2010. The country coverage is 50% because the data set comprises no populations from Portugal. However, it is generally accepted that the species has gone extinct in Portugal [9], so it is reasonable to assume that the coverage is, in fact, 100%.

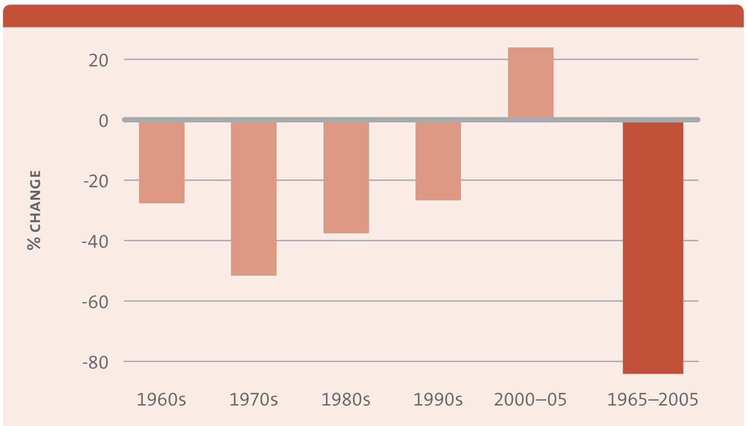

Figure 2. Change in the Iberian lynx population **abundance by decade** and **overall change** between 1965 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change. For this species, 95% confidence limits could not be calculated.

Drivers of recovery

No associations with increasing or decreasing population-level trends could be found in our data set, which may be due to small sample size, as well as the fact that a combination of different threat processes may have affected the species at different times over the past 50 years [8]. As discussed above, the decline observed since the 1960s has been attributed to a combination of prey base depletion through disease, habitat loss and fragmentation, and non-natural mortality [8, 39]. Fragmentation of habitat and populations is a particular concern, as Iberian lynx do not cross open areas over five km wide [41], making them very sensitive to discontinuous ranges [23, 26, 42].

While the recent increase in population size as well as parts of the species' range is insignificant compared with the magnitude of former decline, the identification of beneficial factors is relevant to the future conservation of the Iberian lynx (Table 3). Legal protection has been suggested as one of the causes of the recent moderate recovery in numbers, and although mortality ratios were indeed lower after 1973, in some regions the decrease of natural mortality started long before, probably because of changes in game management [39]. In addition, the high relative density of lynx found in protected areas is likely due to specific habitat management strategies as opposed to protection *per se* [43]. While management changes associated with a shift from small to large game hunting was previously associated with declines in Iberian lynx, lower levels of predator control and the growth of thick scrubland may have been beneficial for rabbits and, consequently, for the lynx in the Sierra Morena [39].

Management strategies have been intensified within the framework of several EU LIFE projects, which include a variety of conservation measures such as habitat quality improvements, monitoring, disease prevention and addressing natural and human-caused mortality [10]. The latter focuses on public outreach, patrols for illegal poaching and increased road safety (e.g. under-/overpasses, reduced speed zones, fencing, reflective lighting) [10], and these actions are argued to have greatly decreased mortality [44]. Stakeholder engagement has led to some landowners signing agreements with the administration in order to, for example, suspend rabbit hunting [1]. However, these were based mostly on economic compensation and there is no published study that demonstrates a change in owners' attitudes towards Iberian lynx [1]. Nevertheless, the involvement of land owners is important, as the majority of lynx occur on private property [10]. The translocation of four individuals from Sierra Morena has successfully increased genetic diversity in the Doñana population [45, 46], and reintroductions have been undertaken into Guadalmellato and Guarrizas [10] using individuals raised as part of the Iberian Lynx Captive Breeding Programme [47]. However, captive breeding cannot really be argued to have contributed to the conservation of extant wild population and the success of the reintroductions is pending rigorous evaluation [1].

Overall, both extant populations of lynx have shown moderate improvements in status over the past few decades, and much of this appears to be attributable to habitat management while the relative importance of education, road safety measures and reintroductions remains unknown.

Recent developments

The Doñana population has been increasing at a lower rate than the other extant population over the past few years, and this increase is attributable to recoveries outside the National Park, while inside its boundaries the trend is reasonably stable [44].

Table 3.
Major reasons for positive change in the status of the Iberian lynx in Europe.

Rank	Reason for change	Description
1	**Land/water protection & management**	Lower predator control and growth of thick scrubland associated with a shift from small to large game hunting management may have been beneficial for rabbits and therefore lynx in the Sierra Morena [39]. Habitat quality improvements are argued to have contributed to some improvements in status in both extant populations [10]. The high relative density of lynx found in protected areas is also attributed to habitat management strategies [43].
2	**Species management – measures to decrease non-natural mortality**	Patrols for illegal poaching and better road safety [10] are argued to have greatly decreased mortality [44].
3	**Species management – translocations, reintroductions and captive breeding**	Translocation has increased genetic diversity in Doñana [45], and reintroductions have been undertaken into Guadalmellato and Guarrizas [10] using captive-bred individuals [47].
4	**Species management – stakeholder engagement & education**	Some landowners have signed agreements to suspend rabbit hunting [1]. However, these were based on economic compensation and it is not clear whether attitudes towards the species have improved [1].

However, the population's genetic diversity is of concern, being much lower than that of the Sierra Morena [46]. In a bid to increase genetic diversity, a total of four individuals were translocated from the Sierra Morena in 2007, 2008 and 2010 [45, 46, 48, 49]. These releases are set to continue until a minimum of four individuals have settled permanently in Doñana [44] (Table 3).

The Sierra Morena population, on the other hand, has more than doubled since 2002 [44]. An extensive breeding programme resulted in the first kittens being born in captivity in 2005 [50]. The first half of 2009 saw the survival of 17 cubs, bringing the number raised in the Iberian Lynx Captive Breeding Programme to 77 [47]. In Portugal, the National Centre for the Iberian Lynx opened in 2009 [47]; it is the first captive breeding centre in the country and lynx are to be transferred here from Andalusia [47]. With the opening of another facility at Cáceres in 2011, breeding centres now exist in four locations in Spain and one in Portugal [51]. While captive breeding has clearly been successful, the significance of its contribution to the conservation of the species is unknown [1].

Reintroductions into an area deemed suitable in Guadalmellato (Córdoba) started in 2009 and appear to be successful so far despite a number of setbacks [52–54]. Releases are continuing, with three juvenile males and two females being the first to receive a hard release in March 2011 [55, 56], bringing the current number of individuals in this population to 12 [57]. Another target area for reintroduction is Guarrizas [58], where five individuals were introduced in 2011 [59] after spending a year in pre-release enclosures [49]. Despite the loss of a female [60] and one of the founding males [61], reintroductions are continuing [61], and the population currently numbers five [57]. In addition, habitat management is ongoing as part of the LIFE programme in various regions, including Castilla-La Mancha and Andalucía in Spain, and in Portugal [10].

One continuing problem for the Iberian lynx is human-induced mortality. For example, in Doñana, at least 62% of all deaths had anthropogenic causes [28]. In particular, infrastructure developments in and around the parks, as well as dispersal of a growing lynx population, have resulted in a large increase in road casualties. To ease the impact of traffic on the lynx, two overpasses opened in 2011 around the Doñana Natural Area [62] and there is evidence that these are being utilised by the species [63]. The threat remains, however, and roads are also a major concern in Sierra Morena, especially near the reintroduction site Guadalmellato [64].

Although there is evidence of a more recent recovery in abundance of the Iberian lynx in

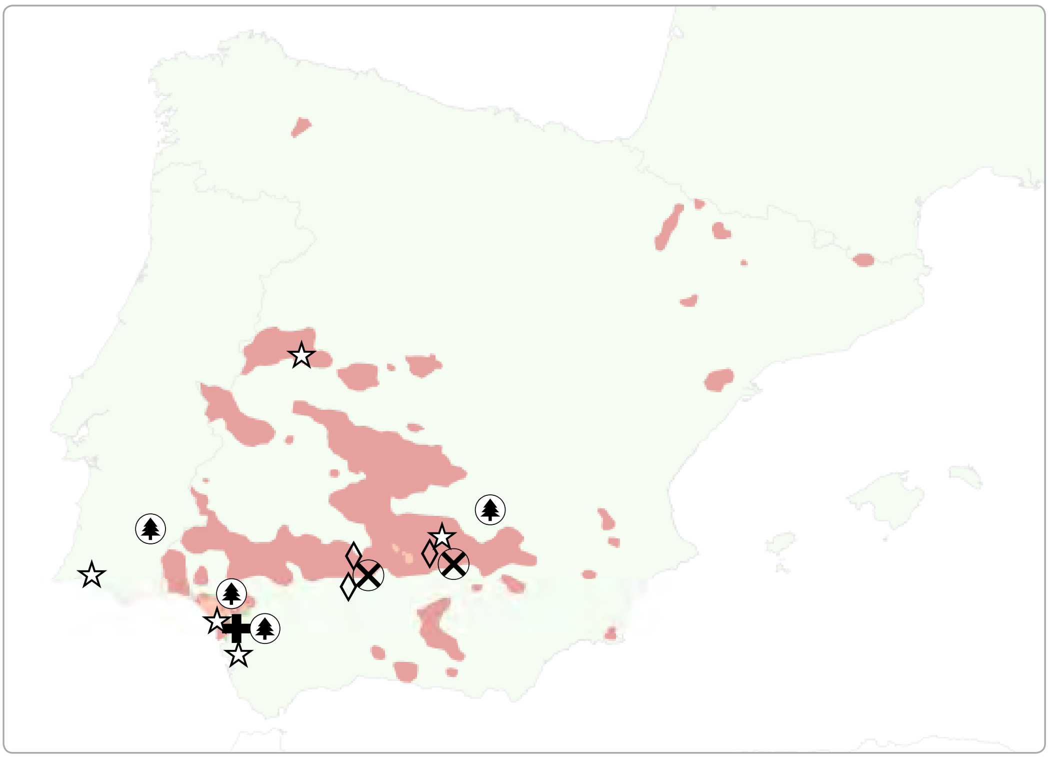

Figure 3. Map of recent developments recorded for the Iberian lynx in Europe.

Expansion
Persistence
Contraction
Captive breeding
Habitat management
Poaching
Genetic supplementation
Reintroduction

Europe, the species' conservation has been criticised for lack of continuity and focus on small areas, and the species continues to be at risk of extinction through continued habitat loss, anthropogenic mortality, and disease [65]. However, the current species status is perhaps more positive than described [10]. A range of conservation measures are being taken, with the hope to improve the species' status sufficiently to downlist it to Endangered [10]. Continued and targeted management of the species and its habitat is of utmost importance, and particular focus should be on joining up fragmented populations [66] to contribute to more genetic variability and thus increased viability [23]. Exchanges are already occurring between the two newly reintroduced populations and the extant Sierra Morena population [10]. If threats can be successfully mitigated and genetic integrity ensured, it is not unreasonable to assume that the Iberian lynx can reclaim some of the territory it has lost, at least in areas where suitable habitat remains.

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3.14. Wolverine

Gulo gulo

Summary

The Wolverine was historically widespread in Scandinavia and eastern Europe, but declined in distribution and abundance from the mid-19th century due to intense persecution. Recovery started from as early as the 1970s in some countries, facilitated by legal protection, natural recolonisation, and the implementation of a conservation performance payment system. The species now occupies over one third of its historical range, but is still affected by high levels of culling in some areas, which are limiting expansion into the vast available areas of suitable habitat that the Wolverine requires.

Background

General description of the species

The Wolverine (*Gulo gulo*), the largest terrestrial member of the *Mustelidae* family, has a circumpolar distribution, existing in large numbers in Canada and North America [2]. It is a solitary, generalist species that obtains food by scavenging or hunting, and caching food in summer and winter [3].

Due to special dentition and associated musculature, the Wolverine is able to forage on frozen meat and bone [1]. In Eurasia, the main prey is reindeer (*Rangifer tarandus*), with which it shares a sympatric distribution [3]. Depending on the location, its diet also includes larger ungulates such as deer (*Cervus spp*) and Eurasian elk (*Alces alces*), which are usually taken as carrion, as well as hare (*Lepus spp*), Ptarmigan (*Lagopus muta*) and rodents (*Castor spp*, *Marmota spp*, *Microtus spp*) [3]. Wolverines predate on domestic sheep and semi-domestic reindeer [4], causing conflict with humans, for example in Scandinavia [5].

Distribution in Europe

In the Upper Pleistocene, the Wolverine occurred as far South as the Czech Republic [6] and was widespread through central and eastern European countries including the United Kingdom, Denmark, France, Germany, Switzerland, Estonia, Latvia, Hungary and the Ukraine [7]. With progressive warming, the species retracted northwards into Scandinavia and Russia, but steep declines only began in the mid-1800s through intense human persecution [8].

The species was considered functionally extinct in southern Norway by the 1960s [9] and had declined in Sweden, Finland and Russia by the end of the 20th century [1, 4, 8]. Since then, legislation has provided some protection in Scandinavia [8, 10], although extensive culling is still employed in Norway [4]. Populations in Russia are declining and not well studied [11, 12].

Scale	Status	Population trend	Justification	Threats
Global [2]	Least Concern	Decreasing	Widespread distribution Large population size	1. Residential & commercial development 2. Agriculture & aquaculture (livestock farming) 3. Transportation and service corridors 4. Hunting & persecution 5. Human disturbance
Europe [12]	Vulnerable	Decreasing	Small population size Declines outside the northern part of the range	1. Residential & commercial development 2. Agriculture & aquaculture (livestock farming) 3. Hunting & persecution 4. Human disturbance
Europe – regional population	Vulnerable: Sweden [23] Endangered: Norway [24], Karelia [12]	N/A	Scandinavia [12]: Stable but small population, limited connectivity, genetically distinct Karelia [12]: Small and declining	Scandinavia [12]: Hunting & persecution Karelia [12]: Poaching, Depletion of prey base

Table 1. Summary of Global and European Red List assessments and threats listed for the Wolverine.

Habitat preferences and general densities

In Europe, the Wolverine has a broad range [1], occurring primarily in boreal forest and tundra [4]. Because Wolverines exist at low densities [4] and have large home ranges, they require vast areas of suitable habitat for viable breeding populations [1]. Males have significantly larger home ranges, which overlap with females but are exclusive with other males [13]. Den sites are placed primarily in steep, rugged terrain with bare rock, which is some distance from infrastructure such as roads [14]. Wolverines select habitats that promote survival through limited encounters with humans but which are rich in prey, and this selection is stronger in winter [15]. The species occurs at extremely low densities of between 0.1 and 1.5 individuals per 100 km^2 [1].

Legal protection and conservation status

The Wolverine is protected under the Habitats Directive (Annexes II and IV) in Sweden and Finland [16] and the Bern Convention (Appendix II) in all three Scandinavian countries [17]. Limited culls are undertaken in Sweden, and Norway heavily manages the species to control numbers [18]. Compensations schemes are in place for damages to semi-domesticated reindeer (all three countries) and sheep (Norway and Sweden) [18, 19]. Much of the biology and ecology of the Wolverine was not known until fairly recently, but highly cooperative research projects are now in place in Sweden [20], Finland [21], and Norway [18] to collect missing information about wolverine ecology, for instance assessing the impact of the species on reindeer, and exploring interactions with the Eurasian lynx (*Lynx lynx*) [20, 22].

At a global level, the Wolverine is classified as Least Concern due to the species' wide distribution and large population size, as well as on-going expansion into its former range (Table 1). However, densities remain low, and the overall species trend is believed to be declining in number despite signs of range recovery (Table 1). In Europe, the species is currently classified as Vulnerable with a decreasing population trend (Table 1). Despite this, extensive hunting quotas and lethal control, which are indirectly related to depredation conflicts, are implemented in Norway to decrease population size, while Sweden only culls the species at a very local level [4, 5].

Abundance and distribution: current status

Recent population estimates suggest that the current European population comprises just over 2,600 individuals (Table 2), forming two populations between which there is believed to be some exchange [18]: the Karelian population (European Russia and eastern Finland) and the Scandinavian population (Sweden, Norway and the rest of Finland). At a country level, the largest populations occur in Russia and Sweden, which account for 53% and 26% of the European population respectively (Table 2). Smaller populations exist in Norway (15%) and Finland (6%). It should be noted, however, that the estimate for European Russia may be outdated.

Of the largest population of the species in Russia (based on information from 2005), the majority occurred in the Komi Republic according to a pre-2000 estimate [1]. Although undoubtedly important in terms of size, the Russian population

Table 2. Latest approximate population estimates for the Wolverine in Europe and for European populations. Please note that the estimate for European Russia may be outdated.

	Estimate	Year assessed	Reference
Global	No data	-	[2]
Europe	2,630–2,640	2005–11	[11, 18]
% of global population	No data		
European Russia	1,400	2005	[11]
Finland	165–175	2011	[18]
Norway	385	2011	[18]
Sweden	680	2011	[18]

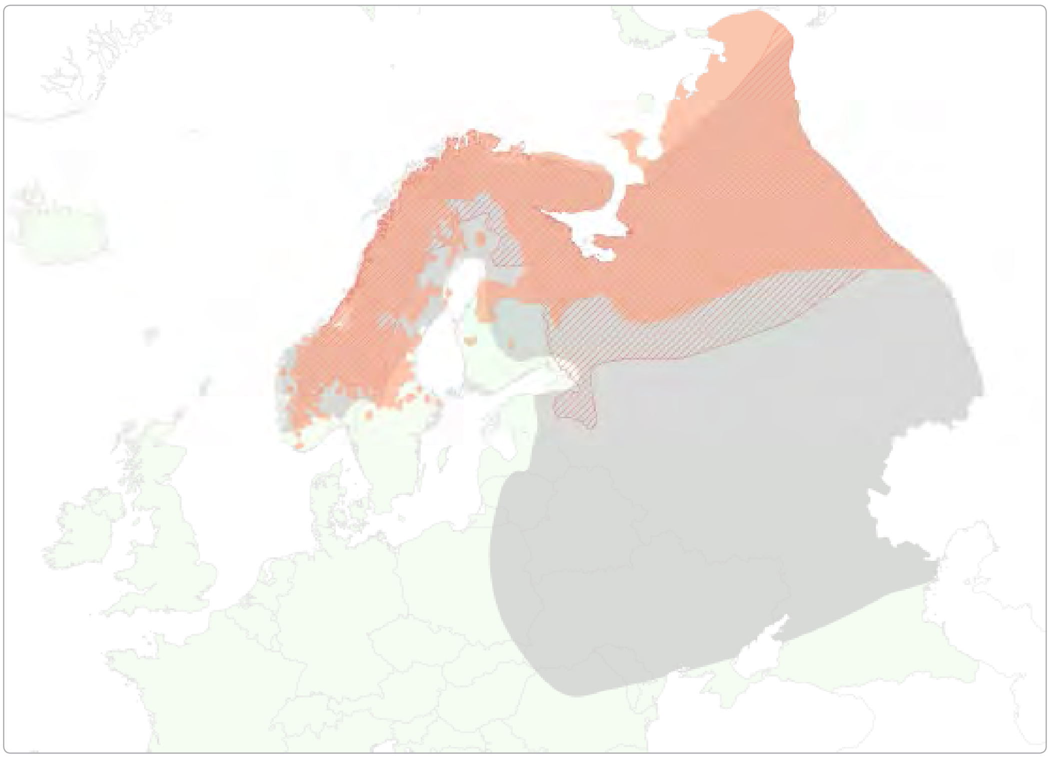


Figure 1a. Distribution of Wolverine in Europe in 1850 [1], 1955 [31] and 2009–12 [2, 18]. Please note that the map for 1850 is based on bounty statistics compiled at the county level, which results in an overestimation of the occupied range [19]. The map for 2009–12 includes areas of sporadic occurrence as well as confirmed reproduction [18].

is presumed to have been overestimated, with some suggesting that it is, in fact, smaller than the combined numbers in Norway, Sweden and Finland [25]. Wolverines in European Russia are believed to be declining [1, 12] due to low reindeer density [11], high human density [11] and high levels of poaching [26].

The second largest population by country can be found in Sweden. Following increases and expansions [27, 28], two new populations that were confirmed in the centre of the country in the 1990s [29] have now been incorporated into the species' range, thus creating a continuous population across Sweden and Norway [27, 28]. The Wolverine is more widely distributed in northern Sweden although densities vary at a local level [27], and the species is continuing to spread south- and eastwards [28]. Wolverines are protected under Swedish law, but the overlap with reindeer herding areas [27] and resulting depredation causes conflict, which is a common problem throughout much of their northern European range [1, 4, 29].

Abundance and distribution: changes

Like many other large carnivores, the Wolverine has experienced a pronounced reduction in range since historical times. Once widespread across most of Scandinavia and Eastern Europe, the species lost over 60% of its territory between 1850 and 1955 (mainly from the south), leaving it confined to the northern parts of its historical distribution (Figure 1a). During this period, it retreated to uninhabited and remote areas especially mountainous regions in Scandinavia, which remained a stronghold for the species [1, 27, 29]. It should be noted, however, that differences in map resolution between the 19th and 20th century, caused by differences in data collection methodology and mapping accuracy, are likely to lead to over- or underestimations in range change over time. Because the 1850 distribution is based on bounty statistics at the county-level, it is reasonable to assume that the species' actual range was smaller than depicted [19], which would, in turn, lead to a smaller contraction by 1955. Similarly, the subsequent expansion from mountainous refuges into forested landscape [19] at the Wolverine's southern limit in Sweden and Finland (Figures 1a and b), which primarily occurred in the 21st century (not shown), was perhaps more pronounced than depicted. This is because the 1955 map is based on reports and assumptions, while the present distribution resulted from a modern, large-scale monitoring programme [19]. It is therefore possible that the contractions observed in some areas, particularly in southern Russia (Figure 1b), are an artefact of the difference in the types of measurements that are being compared. In addition, the expansions in southern Norway may not reflect reality because the present day range information comprises areas of sporadic occurrence where the species is heavily culled, which in turn has a profoundly negative effect on reproductive success [30]. According to the perhaps biased estimates presented here, the

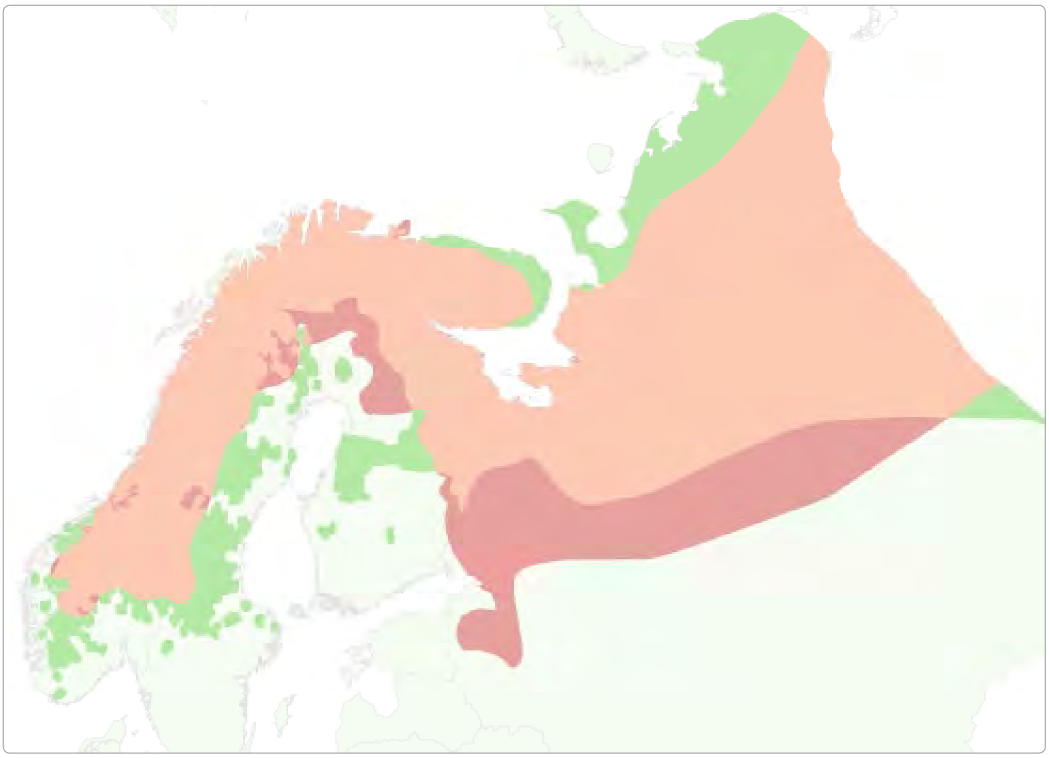


FIGURE 1B. Map highlighting areas of range **EXPANSION**, **PERSISTENCE** and **CONTRACTION** of the Wolverine in Europe between 1955 [31] and 2009–12 [2, 18]. Please note that the contraction observed from 1955 to 2012 is likely to be an artefact of the difference in map resolution caused by a disparity in the accuracy of the methods used. Expansions in southern Norway are likely to be overestimations resulting from the use of range information comprising areas of sporadic occurrence in which the species is culled.

Wolverine now occupies approximately 1,938,000 km², which is just under 40% of its historical distribution (Figure 1A).

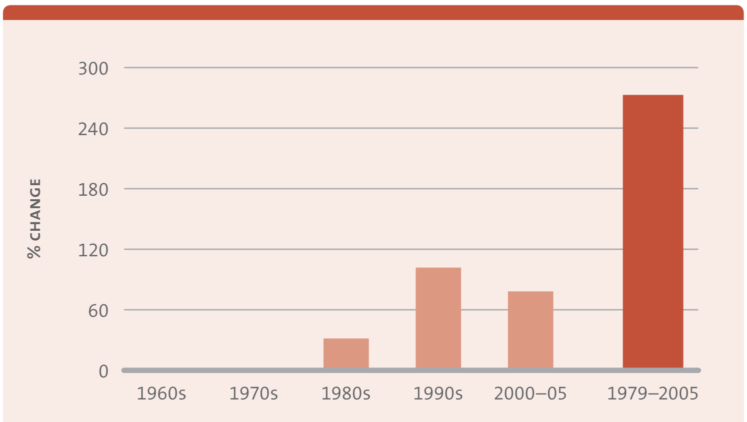
The recent positive change in distribution is also reflected in the abundance trend of monitored Wolverine populations. The species shows a steady increase of approximately 270% over the 26-year period between 1979 and 2005, with a doubling in number in the 1990s (Figure 2). The trend, which starts in the late 1970s due to non-availability of data before this point in time, is based on 19 populations from Norway, Sweden, Finland and Russia, representing a minimum of 245 individuals or 9% of the total European population from 2009–12. It should be noted, however, that this Figure is likely to be an underestimate, as most of the populations used density measures, which are unusable for estimating the minimum number of individuals represented. In addition, existing estimates may not be reliable for this hard-to-monitor species.

DRIVERS OF RECOVERY

The gradual range expansion and population increase observed in Europe since the 1960s can be explained by a number of reasons discussed in the literature. Much of the initial contraction observed in the Wolverine from the mid-19th century (Figure 1A) can be attributed to human persecution due to livestock depredation [4, 8, 29], which was reinforced by a bounty payment system. The impact was primarily on females with cubs because these bounties were paid per individual, and den sites were often easier to find. Legal protection, which started in Sweden in 1969 and was gradually established in Norway between 1973 and 1983 [8, 29], has therefore played a major role in the recent comeback of the species. It has resulted in increases in the populations of both countries [8], and allowed the Wolverine to spread naturally into the forested landscapes from which it had been extirpated in Sweden [28].

However, divergent management strategies have led to differing rates of recovery in the two countries. In Norway, the species is publicly hunted using generous quotas, and there is extensive lethal control in certain regional management zones [4]. Some areas in the southwest follow a zero tolerance rule regarding Wolverine breeding to minimise conflict with sheep husbandry, which reduces the probability of reproduction by 25 times compared

FIGURE 2. Change in Wolverine population **ABUNDANCE BY DECADE** and **OVERALL CHANGE** between 1979 and 2005. Please note that for this species, 95% confidence limits could not be calculated.



Rank	Reason for change	Description
1	**Legislation**	Legal protection first started in Sweden in 1969 and was gradually established in Norway between 1973 and 1983 [8, 29].
2	**Species management – Compensation schemes**	A compensation scheme paying for reproductions of Wolverines has been instrumental in the increase of and expansion of the species in Sweden [30].
3	**Other – Natural recolonisation**	Through population increases initiated by legal protection, the species was able to spread naturally into the forested landscapes in Sweden from which it had been extirpated [28].

Table 3. Major reasons for positive change in the status of the Wolverine in Europe.

to other areas [30]. In addition, direct compensation is in place for depredation events [32].

The situation is, however, very different in Sweden; no hunting is permitted, and although lethal control has been carried out in special cases as a final conflict-mitigating measure, it is believed to be of limited importance at the population level [5]. In reindeer husbandry areas, a conservation performance payment system using a positive reinforcement approach was implemented in 1996 [32]. Under this system, 200,000 Swedish Kronor are paid to reindeer herding districts for each documented Wolverine reproduction irrespective of predation level, both to cover the costs of depredation and disturbance, and to encourage herders to take actions that decrease losses [33]. While this has not prevented illegal killings (poaching is the main source of mortality [5]), adult females have lower mortality, which leads to a reproduction rate which is twice as high as in similar habitat in Norway [30]. The scheme is believed to have been instrumental in the increase in population size of 3.8% per year and the concurrent expansion since its introduction [30]. However, it is not known whether acceptance among those affected has actually increased or whether it is the associated extensive monitoring needed to verify reproductions that is acting as a poaching deterrent [30].

Recent developments

The Scandinavian Wolverine population appears to be stable at present [12] and a continuous range across Sweden and Norway [27, 28] has been created through natural spread. Highly cooperative projects have been on-going since the 1990s in Sweden [20] and Norway [18], and large-scale research is now also being undertaken in Finland [21]. However, the high level of culling in some areas of

Norway [4] is believed to represent a barrier to the continued recovery and expansion of the species into areas of suitable habitat that exist here, and the suggestion is that the national target population size for Wolverine should be raised. There is also a need to increase our knowledge of the species' status in Russia, where research is made difficult by its low densities, elusive nature and preference for remote areas. For example, there was a difference of 700 individuals or 50% in the Karelian population between 2008 and 2010 [25, 27], which was attributable to opinion rather than reflective of a genuine trend. The reported declines in Russia [11, 12] – attributable to prey depletion in the west of the country [19] – are of particular concern considering that this population may account for over half the individuals in Europe (Table 2).

These issues will need to be tackled in order to safeguard sustainable populations of the Wolverine in the long-term [5, 8]. In addition, ensuring legal protection and improving public support, especially from those individuals directly affected by depredation events such as reindeer and sheep herders, will be important elements when considering the future conservation of the Wolverine.

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3.15. Grey seal

Halichoerus grypus

Summary

With a formerly continuous distribution along the European coast, the Grey seal started to decline in abundance and range from the late middle ages due to human pressures, particularly overexploitation. Over the past 50 years, the species has been able to recover in much of its former range because of legal protection. However, anthropogenic threats such as conflicts with fisheries continue to be a problem, and the species is also likely to be increasingly affected by climate change in the future.

Background

General description of the species

The Grey seal (*Halichoerus grypus*) is divided into two subspecies (*H. g. grypus* in the Atlantic, *H. g. macrorynchus* in the Baltic Sea) [1]. There are three populations – West Atlantic (North America), East Atlantic (Europe) and Baltic – that differ in size [2], breeding habitat [3, 4], pupping dates [1], weaning mass and lactation duration [2]. Seals are generalist feeders, often foraging hundreds of kilometres offshore [5], and their diet varies with location and age. In Europe, Grey seals feed demersally [6], mainly from the seabed to depths of 100 m [7]. Sandeels are the main prey, but other species such as gadids (white fish) are also consumed [8]. The species is active day and night on land [9], and may travel very long distances [10] between haul-out sites, where it rests and moults, and specific breeding colonies, which are used considerably less frequently at other times of the year [11]. During the breeding season, males defend territories in these colonies in order to mate with oestrous females [9]. Pup mortality may be as much as 15%, but can increase to 40 to 60% up to the age of 12 to 18 months [12] depending on habitat quality, birth site, maternal care, predation and the amount of male-male aggression [1].

Distribution in Europe

The Grey seal was historically much more widespread than today [13], with a continuous distribution along mainland Europe [14]. Gradual declines due to human interference [14], particularly intense hunting pressure [13], started in the late Middle Ages in the Wadden Sea and late 19th century in the Kattegat-Skagerrak. At present, the Eastern Atlantic population is centred around the UK and Ireland. Grey seals also occur in Iceland, the Faroe Islands, along the European mainland coast from the Kola peninsula to the south of Norway, and from Denmark to Brittany [1]. The Baltic population resides in the Baltic Sea only [1], and has been reproductively isolated since at least the Last Glacial Maximum [15, 16].

Scale	Status	Population trend	Justification	Threats
Global [1]	Least Concern	Increasing	Large population Increasing trend over the past 30 years in the three subpopulations (East Atlantic, West Atlantic, Baltic) No fragmentation Low likelihood of extinction	1. Exploitation 2. Persecution/control 3. Pollution 4. Entanglement (None are major threats)
Europe [25]	Least Concern	Increasing	N/A	1. Exploitation 2. Persecution/control 3. Pollution 4. Entanglement (None are major threats)
Europe – regional populations [26]	Endangered: Poland Near Threatened: Norway, Finland, France Least Concern: Sweden	N/A	N/A	Baltic [27]: 1. Habitat loss due to coastal development 2. Entanglement UK [28]: 1. Entanglement 2. Extreme weather 3. Disturbance

Table 1. Summary of Global and European Red List assessments and threats listed for the Grey seal.

Habitat preferences

Grey seals haul out on rocky coasts, sandy beaches, tidal flats and sandbanks in estuaries [9] that offer good access to the open sea [17]. Breeding colonies are on remote or undisturbed islands, stretches of coast or in sea caves where disturbance is minimal. Grey seals are very sensitive to disturbance, although they can become habituated to the presence of humans [7].

Legal protection and conservation status

The Grey seal is listed under the Bern Convention [18] and the EC Habitats Directive (Annexes II and V) [19], as well as the Bonn Convention (Appendix II, Baltic only) [20]. The species became protected throughout its European range in the 20th century [14], starting with the UK in 1914 [21]. Other countries followed: Germany in 1955 [13], Denmark in the late 1960s [14]; the Republic of Ireland [22], Åland, Latvia, Lithuania, Russia, and eastern Sweden [13] in the 1970s [23]; and Poland [13], Estonia [13] and Finland [4] in the 1980s. Laws were strengthened in the UK in 1970 [23], Lithuania in 1992, Denmark in 1997, and Latvia in 2000 [13]. Conservation areas have been set up throughout Europe, there is international cooperation in species management in the Baltic [4] and the Wadden Sea [24], and harvests and culls are regulated in many countries [3]. The Grey seal is listed as Least Concern globally and in Europe because of large population size, an increasing trend, and low likelihood of extinction. However, the species is Endangered or Near Threatened in some countries (Table 1).

Abundance and distribution: current status

The IUCN estimates a global population of 400,000 individuals, with the European population accounting for around 164,000 or just over 40% of these (Table 2). The largest European populations occur in the UK (67%), the Baltic Sea (14%) and Iceland (7%). Smaller populations are found in Norway, Ireland and the Wadden Sea.

The largest European population of Grey seal occurs in the United Kingdom, and this is also believed to have been the source from which the North Sea was recolonised [13]. As one of the most intensively monitored large mammal population in the world [1], the UK population (as derived from pup production) accounts for around 90% of the European population outside the Baltic Sea [7]. Over 75% of individuals breed in Scotland, with main concentrations in the Outer Hebrides, Orkney, Inner Hebrides and the Firth of Forth [7].

At the beginning of the 20th century, up to 100,000 individuals existed in the Baltic Sea proper [27], but the species was almost extirpated through hunting in the 1930s [29]. Declines and subsequent extinction in the Kattegat-Skagerrak area was attributed to the introduction of bounty systems in Denmark and Sweden [14]. Within the Baltic Sea, regular monitoring first started in Finland in the 1970s [4]. Now, around 97% of individuals are concentrated in the northern part (north of latitude 59°) [29], with no resident colonies on the southern coast between east Germany and Latvia [14]. A very small number of individuals are seen in the Kattegat-Skagerrak [14]. The Baltic population is of great importance in the HELCOM area (the area of the Baltic Sea under the auspices of the Helsinki Commission) [27] and is increasing in abundance [29]. In Iceland, the seal has seen a dramatic reduction since 1990 from 13,000 to 6,000 animals, followed by resurgence in the Húnaflói stock in recent years [33].

Historically, there were few seals south or north of the mid-Norwegian coast, but recently

	Estimate	Assessed	Reference
Global	**400,000**	**2008**	[1]
Europe	**163,750–165,324**	**2005–11**	[7, 22, 24, 29–32]
% of global population	**41%**		
Baltic Sea (eastern Germany, Poland, Baltic states, Baltic Russia, Finland, Sweden, Kattegat-Skagerrak)	22,640	2009	[29]
Wadden Sea (Netherlands, western Germany, south-west Denmark)	3,300	2011	[24]
Belgium	Unknown	-	-
Faroe Islands	<500	2005	
France	161	2009	[30]
Iceland	11,600	2007	[31]
Ireland	5,509–7,083	2005	[22]
Norway	8,740	2011	[32]
Russia (Murmansk)	Unknown	-	-
United Kingdom	111,300	2010	[7]

Table 2. Latest population estimates for the Grey seal globally, in Europe and for European populations. Please note that abundance measures differ between populations because of differences in reproduction and behaviour. Population size derived from pup production estimates are used for all but the Baltic population, where the number of hauled out moulting individuals is counted [1].

populations have expanded, especially in the North [32]. Abundance increased from 3,100 in the late 1980s to 4,000–5000 in the early 1990s and to over 8,700 in 2011 (Table 2) [32]. Ireland holds the fifth largest number of individuals, with 65% occurring in seven sites, including the Inishkea Islands in County Mayo [22]. The seal was absent from the Dutch Wadden Sea until 1950, with the first breeding colony established in 1980 [34]. This colony has since split up and moved because the sandbanks have disappeared [14], indicating that suboptimal sites are being utilised [34]. Most individuals are present in the northern part of the Netherlands [14]. In Germany, the first regularly visited site was Amrum, where regular pupping was recorded from 1983 [35]. Another stronghold is Helgoland; seals have been present here since 1989 and breeding activity started in the 1990s [14].

Abundance and distribution: changes

In 1955, one continuous population of Grey seal occupied the coastal regions of northern and western Europe, from Murmansk in Russia to northern Portugal in the south, including the British and Faroe Isles (Figure 1A). This population may have also had connections with the seals found along the Icelandic coast (Figure 1A). A third population occurred in the Baltic Sea, with no individuals in the Kattegat-Skagerrak around Denmark. Overall, the species occupied an area of over 1,900,000 km². By 2008, the range had decreased by 11%, with contractions on the north coast of Iceland, and the Portuguese, Spanish and French Atlantic coast. The southernmost point now lies at Nantes in France (Figures 1A and B), and the two populations in the Atlantic/North Sea and the Baltic remain isolated from one another, with the species now occupying 89% of its 1955 range.

It should be noted, however, that some of this observed change may be attributable to differences in map resolution between the two time periods, and may thus not represent genuine change.

The contraction in range since the mid-1950s is not reflected in the change in population size over a comparable period. The species increased in abundance by just under 900%, with growth occurring in all decades of the study period (Figure 2). The largest increase was observed in the 1970s when the population doubled, and in the 1980s, when the change was 150% (Figure 1A). The trend is based on 19 populations from the species' current range, covering a minimum of 108,000 individuals and thus roughly 65% of the European population. Data was from 65% of the species' countries of occurrence, and comprised information from all of the major populations (Table 2).

Drivers of recovery

In our dataset, trends differed significantly between populations of different countries. For example, the largest increases in abundance were observed in the Netherlands, the Åland Islands, Denmark, the Republic of Ireland and Norway, with the only decline occurring in Iceland. The recovery in the Åland Islands is in line with the dramatic increases recorded in southwest Finland in 1994 and 1999 (23% per year), and as much as 35% thereafter [37]. This has been attributed to a rise in the number of individuals immigrating from the resurging Swedish population [4]. In Norway, populations have increased and expanded since the 1960s, especially in the north of the country [32].

When comparing populations in Iceland, the UK, France, Ireland, Norway and the Wadden and Baltic Seas, the largest increase is observed in the Wadden Sea, followed by Norway, the British Isles and the Baltic Sea (not shown). This is not in line with the literature, as the Baltic is supposedly recovering at a faster rate than the UK [7], with the greatest increases before 2004 in the Northern Baltic Sea [38]. However, this is a more recent assessment, while our time series covers population change since 1977. The UK has seen a rise in pup production since regular surveys began in the 1960s [7], with a constant increase in the Inner Hebrides since the 1990s [7]. However, there has been a decline in the Outer Hebrides, which is believed to be due to a combination of a reduction in reproductive rate and survival of pups, juveniles and adults [7].

As exploitation has been responsible for historic decreases of once abundant species, protective measures have contributed to the recolonisation of much of the European continent [14]. For example,

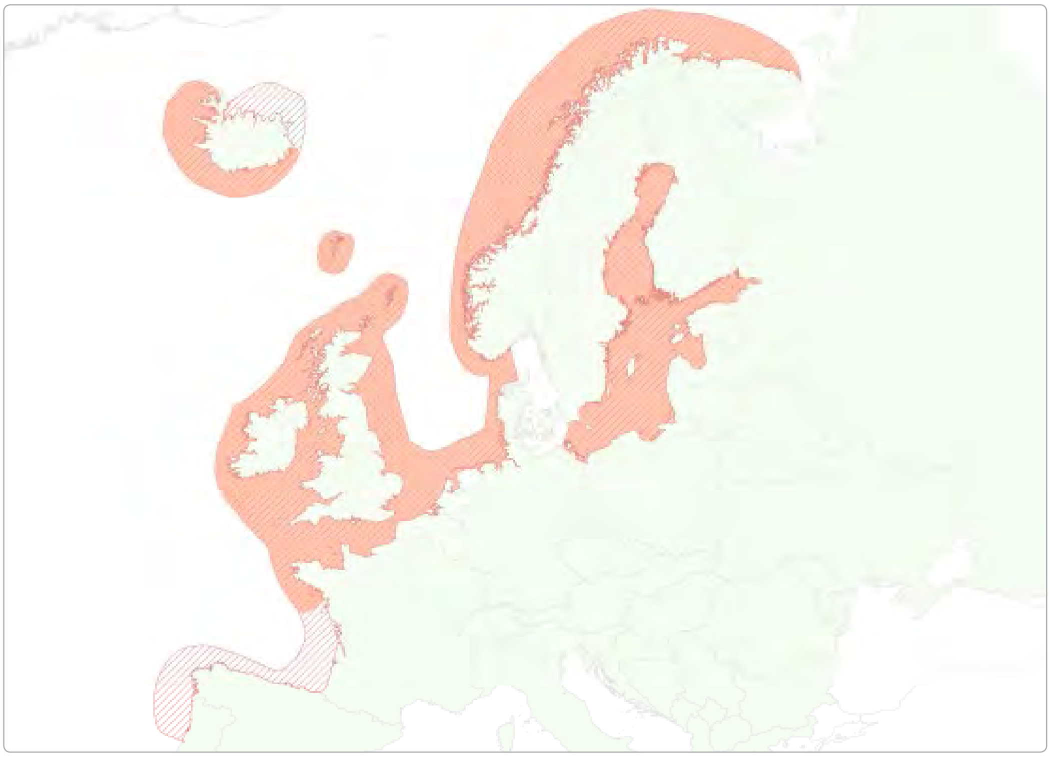

Figure 1a. Distribution of Grey seal in **1955** [36] and **2008** [1].

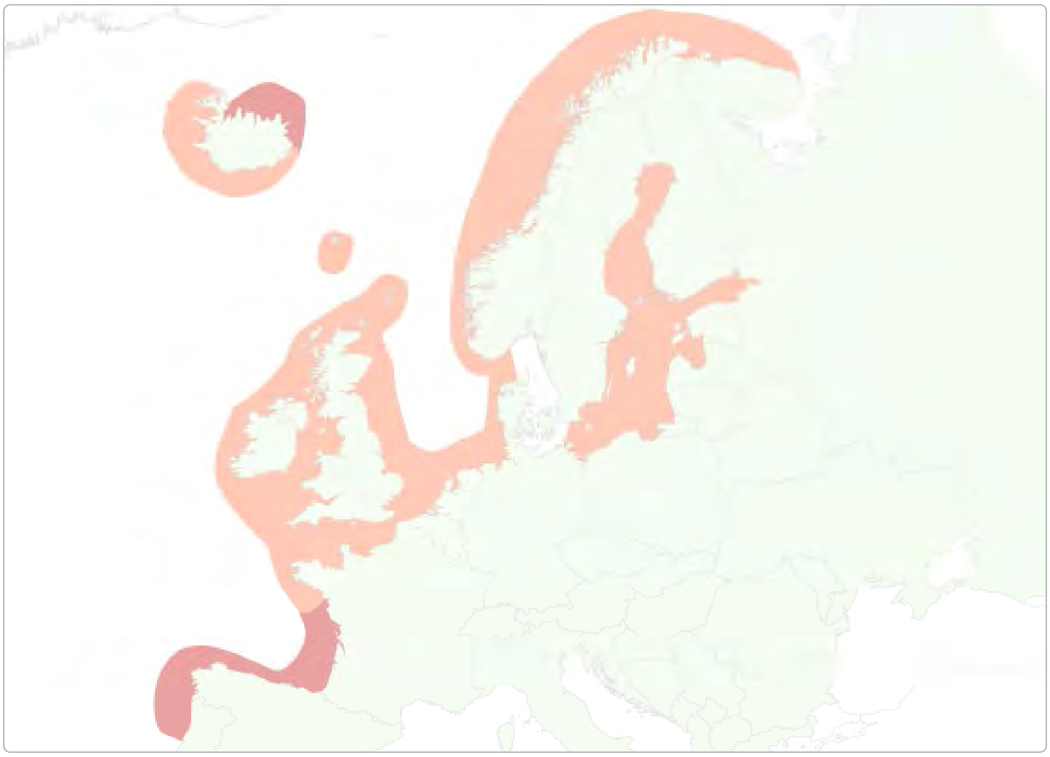

Figure 1b. Map highlighting areas of range **persistence** and **contraction** of the Grey seal in Europe between 1955 and 2008.

the UK became a refuge early on through the introduction of a hunting ban, which resulted in the recovery of the local population, allowing for the repopulation of much of the North Sea [13]. High pollutant loads caused by PCBs and DDTs led to widespread reproductive and population declines [39], especially in the Baltic population [1]. Consequently, the reduction of these loads resulting from a ban in the 1970s [1] has contributed to an increase to 22,000 individuals in the Baltic population [29].

Recent developments

The Grey seal has been able to recover in abundance and range across most of Europe over the past 50 years. In the Wadden Sea, the number of Grey seals has been steadily increasing: over 4,000 animals were counted in 2012, which represents a 22% increase compared to the previous year [24]. With the designation of the Wadden Sea as a World Heritage Site in 2009 [41], this resurgence is likely

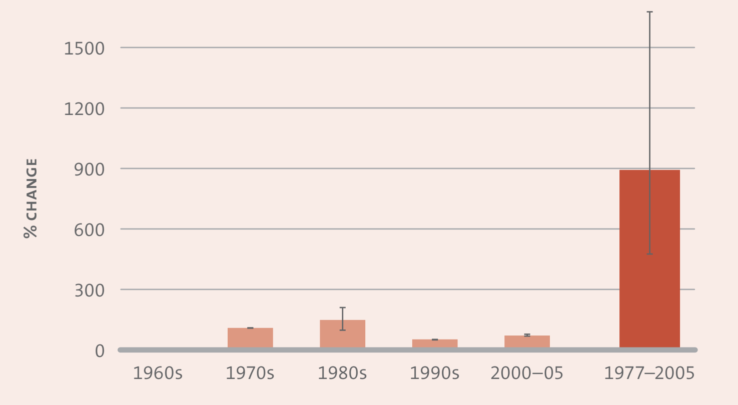

Figure 2. Change in Grey seal population **abundance by decade** and **overall change** between 1977 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

to continue. Increases have also been detected in Norway [32], and the Baltic [42], where the species has not yet reclaimed all of its natural area of occurrence [29]. There are, however, signs that growth is levelling off in some areas. For example in the UK, pup production has not increased in the north and west of Scotland, which is believed to be the result of a combination of reductions in the reproduction and the survival of pups, juveniles or adults [7]. New breeding colonies in the southeast of the country are, however, expanding rapidly [7], and further research should attempt to identify the different factors that are affecting seal colonies in these areas.

In addition, the species continues to be affected by a number of threats, all of which are of anthropogenic origin. For example, entanglement in nets may be a larger issue than previously thought and a considerable source of mortality in some populations [43]. Environmental contaminants, and chemical and oil spills will also continue to be problematic [4], and seals may also experience increasing disturbance through a surge in coastal recreation activities and ecotourism, especially at haul-out and breeding sites [28]. In the Baltic Sea, for example, recolonisation of former haul-out sites has been hampered by increasing human activities [29].

Table 3. Major reasons for change in the status of the Grey seal in Europe.

Rank	Reason for change	Description
1	Legislation	The Grey seal became protected throughout its European range in the 20th century [14]. The species is listed on the Habitats Directive Annexes II and V [19] and the Bern Convention [18].
2	Species management – Reduced exploitation and persecution	In the UK, an early hunting ban (as early as 1914) resulted in increase in numbers [13], which meant that the Grey seal could recolonise the North Sea [13]. There are protective measures in place to limit harvest, culls, disturbance and by-catch in many countries [3].
3	Land/water protection & management – Site protection and ban of DDTs/PCBs	Many seal conservation areas have been set up throughout the species' range, and the Grey seal is protected within these sites, e.g. in the UK in Sites of Special Scientific Interest (SSSIs) [40] and Special Areas of Conservation designated under the Habitats Directive [19]. A decline in pollutant loads in the Baltic following the ban on DDTs and PCBs in the 1970s [1] led to an increase in Grey seal numbers [29].

There are also novel threats emerging for the Grey seal. For example, climate change is believed to play an important role in the future of the species. A worst-case-scenario prediction of an 80% reduction in ice cover in the Baltic Sea will negatively affect breeding conditions and reproductive output of the seal population [4, 29]. But climatic changes also have more immediate consequences, as pup mortality rates are likely to be affected by extreme weather events. For example, pupping cave systems collapsed during the pupping season in Cornwall in the UK in 2011, and storm surges on pupping beaches and ledges have washed large numbers of pups out to sea in the Farne Islands [28]. In addition, the species may be increasingly driven from sites through developments in marine renewables such as coastal and off-shore wind farms, as has been observed at Scroby Sands in the UK [44]. Across Europe, an increasing number of seals are found with corkscrew lacerations, i.e. single cuts spiralling down the body from the head, and often detaching skin and blubber from the underlying tissue [7, 45]. These are caused by being drawn through a new type of ducted propeller, and although the level of mortality is negligible in large populations, it may well exacerbate declines in smaller colonies [7, 45].

Despite the current and future threats described above, the European population of Grey seal is likely to grow further, especially as legislation is strengthened. This will undoubtedly lead to greater conflicts with fisheries, as many fishermen continue to regard seals as the single biggest threat to their livelihood [4]. The species is often killed because of its reputation for feeding on commercially important fish, damaging nets and traps, and acting as vectors for parasites that can impact fisheries [1]. In Finland, the majority of fishermen consider the seal population too large, arguing that the species is harmful to their livelihoods [4]. Despite this animosity, many do recognise its importance as an indicator species for the Baltic and an important component of biodiversity [4]. Indeed, there is little scientific or direct evidence of seals damaging nets [28], and the spatial overlap between fisheries and seals is not as great as once thought [46]. As a top marine predator, the seal may, in fact, play a key role in the maintenance of healthy ecosystems and thus commercially viable fish stocks [47]. If the seal is to continue its recolonisation of the European continent, these on-going conflicts will need to be mitigated by the further development of seal-proof fishing gear (which may also reduce by-catch mortality), as well as the continued protection of the species and its sites. In a landmark case in Scotland, the first custodial sentence of 80 days for killing 21 seals was issued in 2009 to a local fisherman [48].

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Reviewers

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3.16. Harbour seal

Phoca vitulina

Summary

The Harbour seal has had a varied history in Europe, with populations declining to low levels through hunting and disease during the last 100 years. While disease and pollution are still threats to the species, measures are being taken across borders to ensure its continued recovery and survival. Particularly beneficial factors have been the legislation on hunting, the protection of haul-out sites and collaborative management measures, and numbers are increasing in most, but not all, of Europe.

Background

General description of the species

With the widest distribution of any phocid species, the five subspecies of Harbour seal (*Phoca vitulina*) occur along the eastern and western shores of the North Atlantic and North Pacific [1]. In Europe, the Eastern Atlantic Harbour seal subspecies (*Phoca vitulina vitulina*) [2] ranges from Iceland in the west to the Baltic Sea in the east, and from northern France in the south to Svalbard in the north [3]. Harbour seals haul out in sheltered waters to rest; they give birth in June and July and moult in August [3]. They usually feed within 40–50 km of these haul-out sites, consuming a variety of prey [3], although they are primarily dependent on fish [4]. While this species is long-lived, surviving up to 20–30 years, first year mortality is generally high, with 60% of individuals not reaching adulthood in the Wadden Sea [5]. The Harbour seal is considered non-migratory with high site fidelity; however, juveniles usually disperse from natal areas before returning to within 40–50 km of these sites when they reach reproductive age [6].

Distribution in Europe

The Harbour seal has had a dynamic history in Europe. While it is now abundant in areas from which it had been absent (e.g. the Kattegat/Skagerrak until the 17th century [7]), it has also disappeared from areas where populations were previously healthy, for example the Bristol Channel and Oosterschelde estuary in the Netherlands [8]. Much of this change is attributable to anthropogenic effects: the seal was hunted during the 19th and first half of the 20th century in the Wadden Sea [9] and Kattegat/Skagerrak [4]. More recently, habitat destruction, pollution and disease have been major factors; Baltic and Wadden Sea populations have been affected by reduced fertility due to organochloride contaminants [10], and by two outbreaks of phocine distemper virus (PDV) [11, 12]. Despite these setbacks, the Wadden Sea population has increased rapidly since the late 1980s [13].

Scale	Status	Population trend	Justification	Threats
Global	Least Concern	Stable	Large stable or increasing population	1. Competition with humans (entanglement, by-catch and overfishing of prey species) 2. Climate change 3. Overexploitation 4. Disease 5. Pollution 6. Development
Europe	Least Concern	Unknown	Large population size Increasing population	1. Competition with humans (entanglement, by-catch and overfishing of prey species) 2. Overexploitation 3. Disease 4. Pollution
Europe – regional populations	Endangered: Sweden (Baltic) [20] Vulnerable: Norway [21] Near Threatened: France [22]	N/A	N/A	N/A

Table 1. Summary of Global and European Red List assessments and threats listed for the Harbour seal [1, 14].

Habitat preferences and general densities

Harbour seals are found in more sheltered coastal waters [14]. Haul-out sites cover a variety of habitats such as rocks, sand and shingle beaches, sand bars, mud flats, man-made structures, glacial ice, and occasionally sea-ice [1]. Unless habituated to humans, Harbour seals are naturally wary, fleeing into the water on approach [1]. Population density varies greatly, depending on habitat and food availability and, in some areas, the level of human disturbance.

Legal protection and conservation status

In Europe, Harbour seals are protected under the EC Habitats Directive (Annexes II and V) [15], and the Bern Convention (Appendix III) [16]. Subpopulations in the Baltic and Wadden Seas are listed under the Convention of Migratory Species (Appendix II) [17]. Hunting is prohibited in the Wadden Sea area [2] and this population is managed according to the Trilateral Seal Management Plan (SMP) adopted by the Netherlands, Germany and Denmark at the Leeuwarden Conference in 1994 [18]. The only countries that allow hunting are Norway and Iceland, where the estimated annual catch is between 5,000 and 7,000 individuals [2]. In Svalbard, however, the Harbour seal population is included in the Norwegian Red List and completely protected [1]. In the United Kingdom, licenses for shooting seals are issued for the purposes of protecting the fisheries [1], although there are significant differences in legislation between England, Wales, Scotland and Northern Ireland (in some areas, seals can be shot without a licence at certain times of the year) [19]. The global IUCN Red List categorises the Harbour seal as Least Concern because the population is large, and either stable or increasing (Table 1). In Europe, the species is also listed as Least Concern with an unknown population trend, while some regional populations are Near Threatened, Vulnerable or Endangered (Table 1).

Abundance and distribution: current status

In 2008, the size of the world's Harbour seal population was between 350,000 and 500,000 individuals, with the European population accounting for just over 81,000 or a minimum of 18% of these (Table 2). The largest European populations occur in waters around the United Kingdom (32%), the Wadden Sea (22%), the Kattegat, Skagerrak & Lijmfjorden area (16%) and Iceland (15%).

Approximately 32% of European Harbour seals are found in the United Kingdom, a decrease from 40% in 2002 [3]. The species is widespread on the west coast and northern isles of Scotland and on the southeast coast of England [3]. On the

Table 2. Latest population estimates for the Harbour seal globally, in Europe, and for European sub-populations. Please note that all estimates represent the number of seals counted, not the population size estimated from these counts.

	Estimate	Year assessed	Reference
Global	**350,000–500,000**	**2008**	[1]
Europe	**80,648**	**1996–2010**	[23]
% of global population	**>16%**		
Wadden Sea	18,000	2010	[23]
Kattegat, Skagerrak & Lijmfjorden	12,750	2007–8	[23]
Baltic	1,350	2008	[23]
United Kingdom (England, Scotland, Wales, Northern Ireland)	25,943	2007–10*	[23]
Republic of Ireland	2,905	2003	[23]
Iceland	12,000	2006	[23]
Norway	6,700	2006	[23]
Svalbard	>1,000	2010	[24]

** (Northern Ireland: 2002)*

east coast, the distribution is restricted to major estuaries, such as the Thames, The Wash, Firth of Tay (where it is declining) and the Moray Firth [3]. The UK population was also greatly affected by the PDV epidemic in 1988, while the second outbreak in 2002 was less severe, with its effects restricted to southeast England [3]. It was only by 2010 that seal numbers in the Southeast had started to recover to pre-epidemic levels [3]. Whilst harvesting ended in the early 1970s in England and Wales [3], the Conservation of Seals Act 1970 permits the shooting of Harbour seals for the protection of fisheries, but offers some protection during the breeding and moulting periods [25]. Following the 1988 PDV outbreak, Harbour and Grey seals (*Halichoerus grypus*) were protected year-round on the east coast of England [26]. Seals in Scotland can only be shot under licence from the Scottish Government [27], while in Northern Ireland they are fully protected [28].

Another large population occurs in the Wadden Sea [3]. Once abundant (38,000 animals in 1900 [9]), it was hunted up until the 20th century [9]. Following a reduction in exploitation levels and increased habitat protection in the second half of the 20th century, the Harbour seal recovered from 3,000 individuals in 1974 to more than 15,000 in 2003 [13]. This population, along with the Kattegat population, was heavily affected by the PDV outbreaks in 1988 and 2002, which reduced it by up to 50%, although it was able to recover after both events [29]. Since 1978, the Netherlands, Denmark and Germany have been collaborating on the protection and conservation of the species to address management, monitoring, research and political matters [30], which has resulted in detailed conservation management plans [31–33]. In 2011, the Wadden Sea population was estimated to be 24,000 [13].

There are concerns for populations in Svalbard and the Baltic Sea. Historically, the Harbour seal has always been much rarer than other seal species [34] and numbers are low in both locations [14]. It increased during the 19th century, reaching a maximum in 1905 [34], which was followed by a rapid decrease to a few hundred individuals by 1960 due to Swedish bounty hunting [35] and pollution [34]. The nearby Skagerrak/Kattegat population, which is actually considered to be part of the North Sea population, has been affected by three mass mortality events: by PDV in 1988 and 2002 [12] and an unknown pathogen in 2007 [36]. The

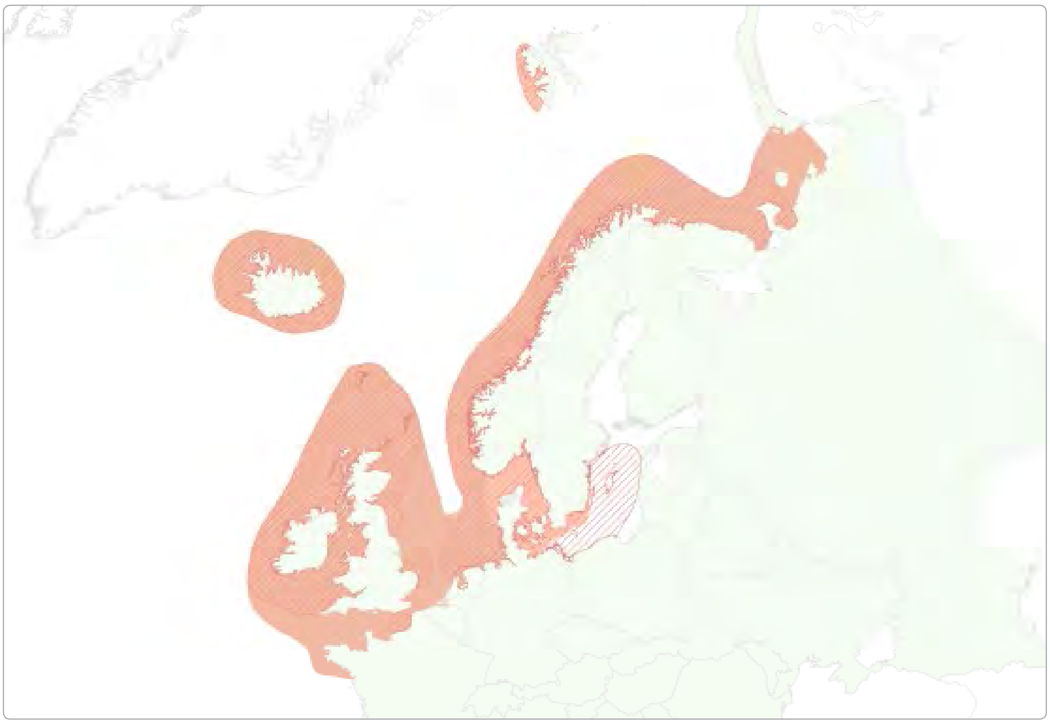


FIGURE 1A. Distribution of European Harbour seal in **1599** [7], **1955** [41, 42] and **2008** [1].

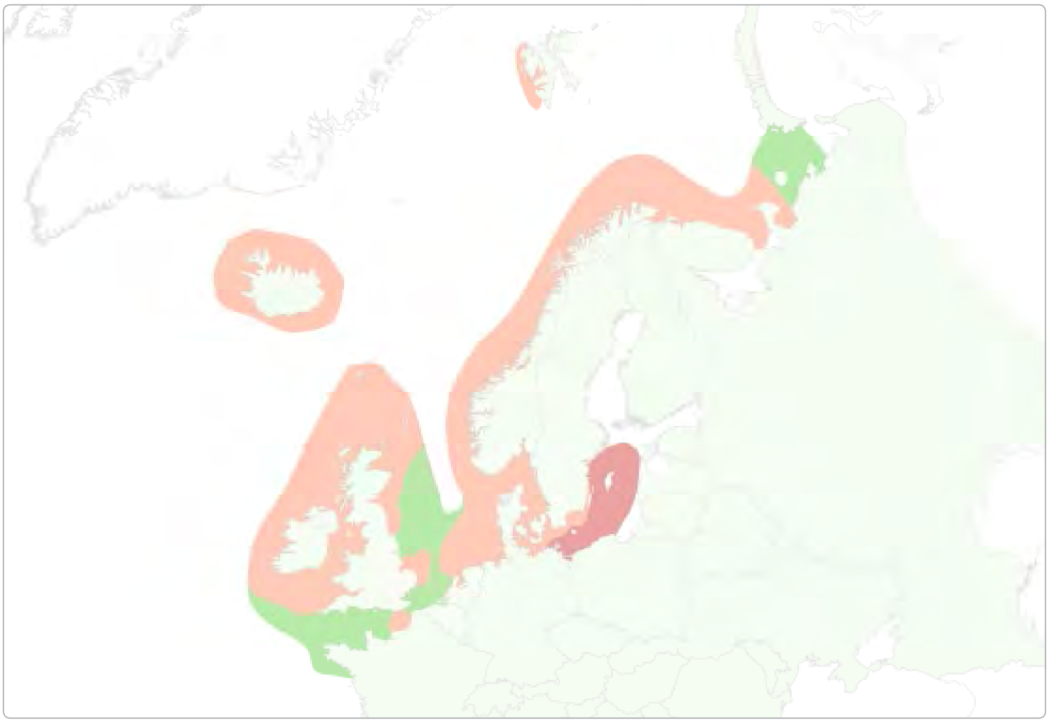


FIGURE 1B. Map highlighting areas of range **EXPANSION**, **PERSISTENCE** and **CONTRACTION** of the Harbour seal in Europe between 1955 and 2008.

recovery rate has been low in the Kattegat since the 2002 epidemic [37]. There has also been a decline in the Baltic Sea proper, where population size reduced from 5,000 animals between the 19th and 20th century to 1,000 in 2007 [38]. The Kalmarsund population is genetically distinct from the Southern Baltic and Kattegat populations [39], and the species was able to recover here from only 50 animals in the 1970s [34] to 630 in 2007 [40] due to protection. There is no information on the Icelandic population of Harbour seal.

ABUNDANCE AND DISTRIBUTION: CHANGES

Because fine scale maps are not often available for wide-range species such as the Harbour seal, we included locations outside the pre-defined study area for the purposes of examining distributional change. It should be noted, however, that to a large extent, the changes described are attributable to differences in the resolution of the maps presented, For example, the decrease of around 7% in Harbour seal range between historical times

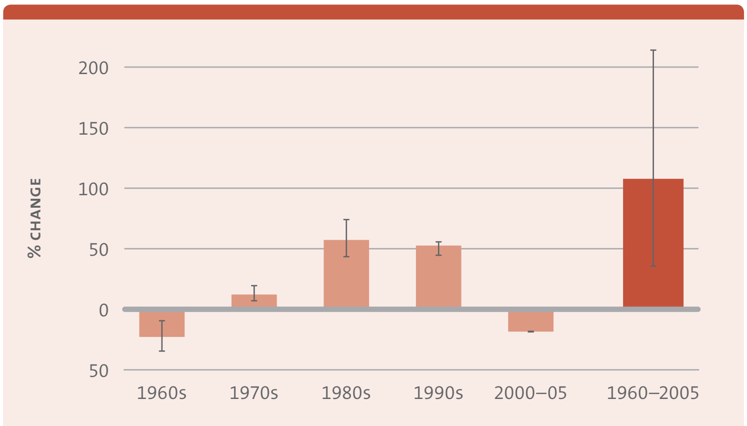


Figure 2. Change in Harbour seal population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

(1599) and 1955 in the English Channel, North Sea and northern Russian coast is likely an artefact of incomplete distributional information in historic times. It seems plausible that seals were, in fact, only documented in areas that were of interest to humans [19]. In addition, the 1955 map may suffer from lack of detail, giving rise to over- or underestimations of change to the present day. According to the information in Figures 1a and b, the species lost territory in the Baltic Sea while it expanded around the United Kingdom and the Russian coast. This represents a recovery from range decreases prior to the middle of the 20th century, leaving the species to occupy an area that is 6% larger than in historical times.

The increasing trend in distribution is in line with the change in population size, as European Harbour seals doubled in abundance over the 45-year study period between 1960 and 2005 (Figure 2). Declines occurred in the 1960s and 2000s, the latter coinciding with the second outbreak of PDV [12]. However, the trend in Figure 2 also suggests increases in the 1970s and 1980s, which are unexpected due to the PDV outbreak in 1988. It is therefore possible that the expected declines are masked by increases in unaffected populations. Although the overall size of the European population of Harbour seal is twice that of 1960 by the end of the time series in 2005, abundance at this point is decreasing. The trend for Harbour seal is based on 20 populations from Denmark, Germany, the Netherlands, Sweden and the United Kingdom, which represent an average of 47,000 individuals or 58% of the total European population of 2008, and cover 33% of the countries of occurrence.

Table 3. Major reasons for positive change in the status of the Harbour seal in Europe.

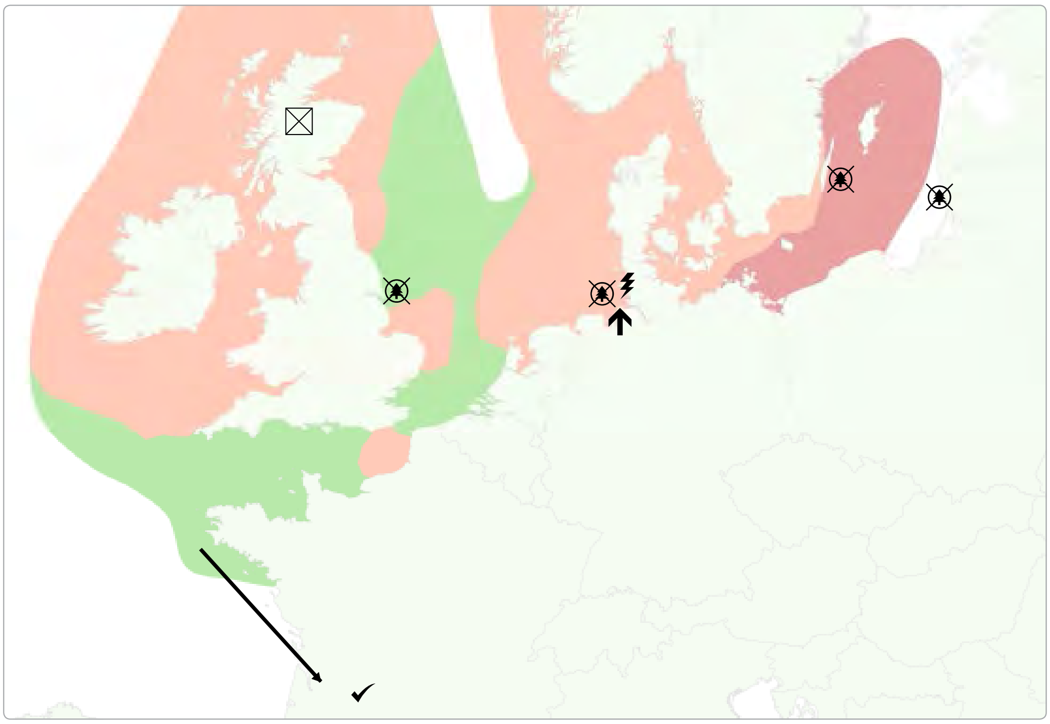
Rank	Reason for change	Description
1	**Species management – Reduced hunting pressure**	Following a reduction in hunting pressure, the Harbour seal recovered from 3,000 individuals in 1974 to more than 15,000 in 2003 in the Wadden Sea [13].
2	**Legislation**	Increased European-wide and country-level legal protection of the species and its haul-out sites from the late 1970s helped recovery throughout its range [15, 16]. The Kalmarsund population recovered from 50 in the 1970s [34] to 630 in 2007 [40] due to protection. Hunting is now prohibited in all countries except Norway and Iceland [2].
3	**Land/water protection & management**	Habitat protection also contributed to the recovery of the Harbour seal in the Wadden Sea [13].
4	**Other – Collaborative management**	Some countries are collaborating on management plans, e.g. the Netherlands, Germany and Denmark in the Wadden Sea [30–33].

Drivers of recovery

As discussed above, disease has had a profound impact on the abundance trend of the Harbour seal in Europe. Along with exploitation, disease emerged as one of the predicting factors of population decline from our analysis, while habitat degradation and unknown threats were generally associated with positive trends. In addition, the presence of management intervention, specifically the cessation of hunting, was beneficial, although change was also positive for those populations which received no attention. As expected, non-utilised populations increased, while those with unknown utilisation status declined.

The importance of the factors identified in our data set is also confirmed by the literature (Table 3). Increased legal protection was implemented from the late 1970s both in individual countries at a European scale [15, 16], and this undoubtedly helped the Harbour seal recover in number and range. For example, protection was key in the recovery of the Kalmarsund population in the Baltic from a mere 50 individuals in the 1970s [34] to 630 in 2007 [40]. In the Wadden Sea, the species increased from 3,000 individuals in 1974 to more than 15,000 in 2003 due to a reduction in hunting pressure and increased habitat protection [13], made possible by collaborative management between the Netherlands, Germany and Denmark [30–33]. At present, hunting is prohibited in all countries except Norway and Iceland [2]. Other, non-governmental conservation measures include the rescue and rehabilitation of seal pups [43], and while these efforts were unable to save infected seals during the two epidemics, they may have made some contribution to population recovery. However, there is some debate as to whether this intervention is beneficial for the species in the long-term, as it side-steps natural selection by keeping alive individuals that may otherwise perish, and also increases the risk of infection if healthy seals are brought to a centre where the disease is present.

Figure 3.
Map of recent developments recorded for the Harbour seal in Europe.



- Expansion
- Persistence
- Contraction
- Habitat degradation/ change
- Legal protection
- Accidental mortality
- Population increase
- New sighting (in river tributary)
- Further range expansion

Recent developments

There have been a number of mass mortality events in European seals in the past [12,36], and disease [44] and high levels of pollution [45] continue to be a problem. For example, over 900 seals, many of them juveniles, were left dead on the Schleswig-Holstein coast in 2010 due to a suspected nematode infestation [46]. In addition, widespread high concentrations of organochloride compounds from contaminated prey have been identified in a number of seal populations, including the Baltic area and Swedish coast [47], the Dutch coast [48], German Wadden Sea [49] and Britain [50]. These contaminants are released in the seal's body when fat reserves are mobilised and have been shown to affect reproductive success [10,47]. Conflict with fisheries, and associated culling and by-catch mortality, are also sizeable threats to the species. In addition, human disturbance is an issue; it has been shown, for example, that human presence at haul-out sites has a detrimental effect on seal behaviour [51]. There are also concerns over the genetic diversity of the species in Europe due to bottlenecks and the resulting fragmentation of populations, with some populations showing low effective population size, such as in Svalbard [52].

Recently, an increasing number of seal carcasses has been found in England (Norfolk), Scotland and Northern Ireland [53] exhibiting so called corkscrew lacerations [23,53]. The resulting single smooth-edged cut starting at the head and spiralling down the body (skin and blubber are often detached from the underlying tissue) [23] is consistent with seals being drawn through a ducted propeller [23, 53]. In total, over 65 grey and harbour seals of all age classes and sexes have been recovered [23]. While this level of mortality is negligible in large populations, it may well exacerbate declines in smaller populations [23]. For example, it is considered a significant cause of mortality in the Firth of Tay [53]. In addition, the species may be increasingly driven from sites through developments in marine renewables such as costal and off-shore wind farms, as has been observed at Scroby Sands (UK) [54].

However, there are also positive developments for the Harbour seal. In Scotland, the outdated Conservation of Seals Act 1970 was replaced with the Marine (Scotland) Act 2010 (Part 6) [27]. This Act increases protection, including a new offence of harassment at designated haul-out sites. Although shooting of seals for the protection of fisheries is still permitted, it is regulated by licence and there are specific limits on numbers that may be taken in each of seven Seal Management Areas around Scotland [27]. Plans by the Scottish government to protect coastal sites used by only half the nation's seals have been widely criticised [55], but may represent an important first step. In Germany, counts of Harbour seals on the Niedersachsen coast revealed the largest population size since records began in 1958, with a total number of over 6,600 individuals [56]. Overall, the number of seals in the Wadden Sea reached over 21,600 in 2009 [57] and grew to over 24,100 in 2011 [13]. There are also records of the species spreading further south, and into large rivers. One individual was sighted 200 km inland in the Dordogne river in southwest France [58].

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Reviewer

- **Callan Duck**

3.17. Brown bear

Ursus arctos

Summary

The Brown bear, the second largest mammalian predator in Europe, was previously widely distributed but now occurs primarily in inland forested and mountainous areas with low human activity. Once extensively hunted, the species has increased as a result of legislation, species management and education. However, despite stable or increasing population trends, the Brown bear remains threatened by habitat loss due to infrastructure development, disturbance, poor management structures, intrinsic factors, accidental mortality and persecution. It is thought that low acceptance by stakeholders and the public will present the greatest obstacle to the future conservation management of the species, especially in areas where increasing abundance and range expansion is leading to greater contact between bears and people.

Background

General description of the species

The Brown bear (*Ursus arctos*), the most widespread bear in the world [1] and second largest mammalian predator after the Polar bear in Europe, is found inland throughout the continent [1]. Brown bears have large home ranges to search for mates, winter dens, and food including berries, shoots, seeds, fresh meat and carrion. Males are largely solitary and only come together with females to reproduce, while mothers stay with their cubs for 1.5 to 2.5 years, after which male young disperse [2]. While younger bears are often diurnal, many adults show nocturnal behaviour which is believed to be driven by negative experiences with humans [3], although environmental conditions and food abundance may also play a role [1]. The species undertakes the majority of its activity in spring (mating season), summer and autumn (foraging) whilst during the winter, individuals go through a period of winter torpor, spending most of their time in dens in a state of partial hibernation [1].

Distribution in Europe

Bears were first present in Europe in the late Pleistocene and one of the first species to repopulate the region in the Holocene following the Last Glacial Maximum, when they occurred at high densities [4]. Bears continued to range over the entirety of the European continent except large islands such as Iceland, Gotland, Corsica and Sardinia, and until recently (c. 1850) had a wide range [1]. During the 19th century, populations declined dramatically in most European countries due to widespread deforestation and increased persecution [5]. Many populations have since become extinct, particularly in low lying

Scale	Status	Population trend	Justification	Threats
Global [10]	Least Concern	Stable	N/A	1. Low population size 2. Conflict (depredation/raiding of beehives & crops, straying into settlements) 3. Road and train track collisions 4. Illegal poaching 5. Over-harvesting 6. Fragmentation and degradation of habitat
Europe (incl. Russia) [11]	Least Concern	Stable	Wide range Large population size	1. Habitat loss due to infrastructure 2. Development 3. Disturbance 4. Low acceptance 5. Poor management structures 6. Intrinsic factors 7. Accidental mortality and persecution [7]
Europe – regional populations	Critically Endangered: Alpine, Apennine, Cantabrian, Pyrenean Vulnerable: Dinaric-Pindos, Carpathian, Balkan Least Concern: Scandinavian, Karelian, Baltic [7]	Strong increase: Karelian, Scandinavin Increase: Baltic, Dinaric-Pindos, Cantabrian, Pyrenean Stable : Carpathian, Alpine, Apennine Stable or decrease: Eastern Balkans [7]	Small population size leading to compromised long-term viability [11]	N/A

Table 1. Summary of Global and European Red List assessments and threats listed for the Brown bear.

regions with high levels of human-bear conflict. As a result, the remaining European Brown bears occur in forested, mountainous areas where, although widespread, four out of ten populations are small and localised [2, 6].

Habitat preferences and general densities

The species is adaptable to environmental conditions, and previously occupied a range of habitats including deciduous and coniferous forest, steppes and northern and alpine tundra [1]. Now most of its former range is unsuitable because of human habitat alteration and presence, and the species is found mostly in forested, mountainous areas with low human activity [1]. Overall, bears require large, continuous habitat with sufficient preferred food, escape cover, suitable den sites and low human disturbance [1]. Like many carnivores, the Brown bear occurs at low densities especially at the northern limit of its range [1]. Figures range from 0.5 bears/1000 km^2 in southeastern Norway and 20–25 bears/1000 km^2 in central Sweden to 100–200 bears/1000 km^2 in Romania [1].

Legal protection and conservation status

The Brown bear is protected under the pan-European Habitats Directive [7], and there are national level conservation measures in place to support populations [8]. These include the establishment of protected areas and various hunting regulations [8]. Countries with limited culls by hunters include Sweden, Finland, Romania, Estonia, Bulgaria, Slovenia and Slovakia [7]. Other governments manage the carnivore as a game species with limits decided following the rules of the Bern Convention, e.g. Croatia and Norway [7].

Common management measures include erection of fencing in areas vulnerable to human conflict issues (e.g. agricultural areas and beehives), reintroductions and population augmentations (e.g. Italian Alps, Austria and France), protection from poaching, limiting public access to core areas, and public education programmes and scientific research [9]. The Brown bear is covered by management or action plans or a species-specific strategy in most countries [7], and there are compensation schemes in place throughout the continent [7]. Both at a global and European level, the Brown bear is listed as Least Concern with a stable population trend due to its wide geographic range and large population size (Table 1). Within Europe, the species' status varies by population, with some thought to be Critically Endangered or Vulnerable (Table 1).

All in all, recent abundance trends are increasing or stable, although a decrease is suspected in the Eastern Balkans (Table 1). A number of threats affect the bear at the global and European level (Table 1).

Abundance and distribution: current status

In terms of population size (Table 2), an estimate from 2000 puts the global population at over 200,000 individuals. European populations (not including most of Russia, and all of Belarus and Ukraine) account for around 17,000 and therefore for at least 8.5% of these. The largest populations occur in the Carpathians (42%), followed by Scandinavia (20%) and the Dinaric-Pindos region (18%) (Table 2). At the country level, most individuals are found in European Russia (9,700 in 2005 [12] (not shown in Table 2)), Romania (6,000 in 2012 [13] or 35% of the European population excluding Belarus, Ukraine and Russia) and Sweden (around 3,300 in 2012 [13], accounting for around 97% of the Scandinavian population; Table 2).

Although not included in the Figures presented in Table 2, European Russia represents an important stronghold of the Brown bear, maintaining the largest population (39% of the European estimate from 2008) and range (covering more than 50% of the 2001 range [11], most of which is unfragmented). Russian bears are connected to the Karelian and Baltic populations, and viability is high as both of these populations are interconnected and mix with the larger Siberian population [12]. Outside these areas, populations are fragmented [12]. The species is exploited in Russia, and the population trend is classified as stable or slightly increasing [12].

Romania is home to 6,000 [13] or 35% of European Brown bears (Table 2) and trends are believed to be increasing [12]. In 2005, the highest densities occurred in the "elbow" of the Romanian Carpathians in the counties of Brasov, Harghita, Covasna, Vrancea, Sibiu and Arges [12]. Compared to the European estimate from 2012, Sweden's increasing [12] population accounts for around 19% of Europe's total (Table 2). Bears occur throughout most of northern and central Sweden north of 60°N in three subpopulations [13], although they are rarely found on the Baltic coast [12]. Conservation measures have been implemented but a number of threats, such as persecution, remain [12]. Harvesting is not an issue, as the population has increased from 750 to 3,500 under a managed harvest regime [2].

Bears are believed to be extirpated in Austria, and Switzerland only receives dispersing individuals [2]. Numbers remain low in some countries, e.g. in Latvia, where the population is perhaps no more than 10–15 individuals [13] thought to be migratory between Russia and the remaining Baltic States [14]. Despite the small size and restricted range of some populations and the problems resulting from this, population trends are stable in the core populations in Russia [12] and increasing in Sweden (4.5% per annum between 1998 and 2007 [15]). However, this situation represents the end point in a varied history of abundance and range changes in Europe, as discussed below.

Table 2. Latest population estimates for the Brown bear globally, in Europe and for European populations. Please note that populations from Belarus, Ukraine and Russia have not been included.

	Estimate	Year assessed	Reference
Global	**>200,000**	**2000**	[10]
Europe (based on below)	**16,929–17,164**	**2010–12**	[13]
% of global population	**>8.5%**		
Cantabrian	195–210	2010–12	[7]
Pyrenean	22–27	2010–12	[7]
Apennine	37–52	2010–12	[7]
Alpine	45–50	2010–12	[7]
Eastern Balkan	600	2010–12	[7]
Dinaric-Pindos	3,070	2010–12	[7]
Carpathian (excl. Ukraine)	7,200	2010–12	[7]
Scandinavian	3,400	2010–12	[7]
Karelian (excl. Russia W of 35°E)	1,650–1,850	2010–12	[13]
Baltic (excl. Russia* & Belarus)	710	2010–12	[7]

** Russian oblasts of Leningrad, Novgorod, Pskov, Tver, Smolensk, Bryansk, Moscow, Kalinigrad, Kaluzh, Tula, Kursk, Belgorod and Ore.*

Abundance and distribution: changes

Like many large carnivores, the Brown bear has experienced a large reduction in range compared with its historical distribution: by 1955, the species occupied only 37% of its 1700s range, losing the majority from Southern and Western Europe (Figure 1A). In Switzerland, for example, Brown bear range had contracted to around half its 1800 range by 1850. By 1900, its range was reduced by 75%, and only around 2% of its former range remained in 1950 (Figure 2). This pattern is mirrored in many western and southern European countries. However, a comeback of the species has been recorded in Europe (Figures 1A and B); by 2008, it had increased its range by 13% compared to the mid-1950s, reaching 41% of its historical distribution. There are also positive changes occurring in northeastern countries, e.g. Latvia (not shown) and Finland (Figure 3).

The recent recovery is also reflected in the abundance trends of European Brown bear populations, which have doubled over the last 45 years (Figure 4). The trend is based on 21 populations from across Europe, representing a minimum of 8,200 individuals or 48% of the total European population of 2010–12 and 52% of all European countries of occurrence. Data were missing from a number of locations within the species' current range, including Belarus, Estonia, Latvia, Czech Republic, Italy, Slovenia, Croatia, Serbia, Bosnia and Herzegovina, Montenegro and Macedonia.

Figure 1a.
Distribution of Brown bear in 1700 [8], 1955 [16] and 2008 [8, 10, 17].

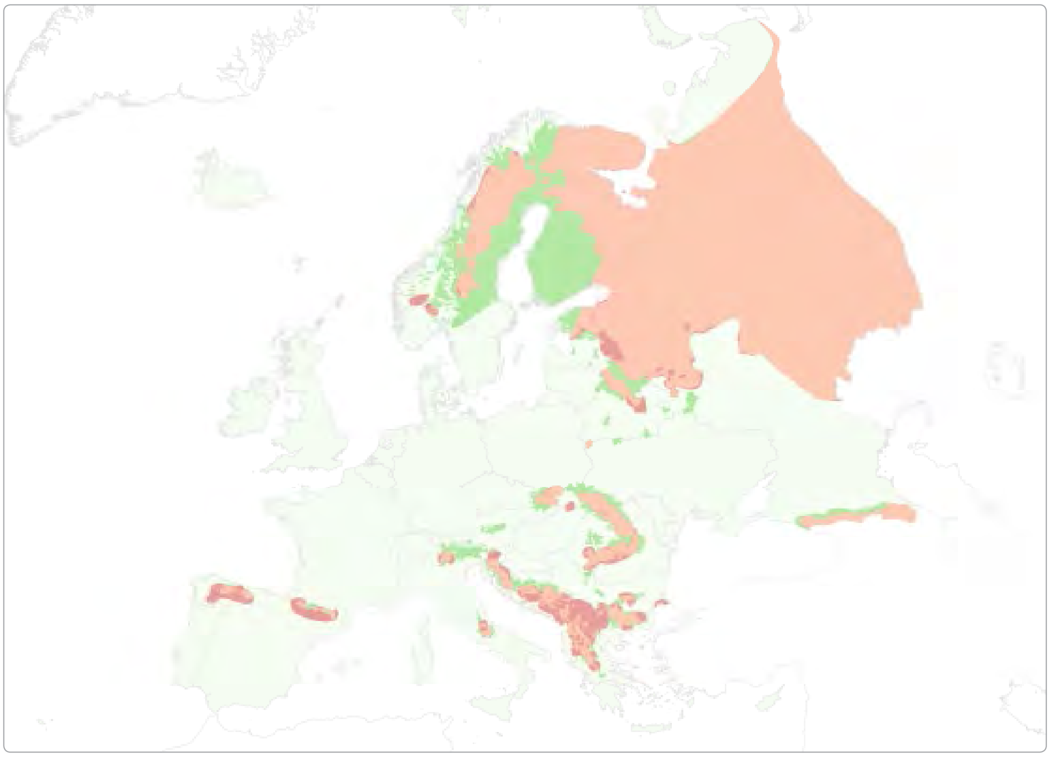


Figure 1b.
Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Brown bear in Europe between 1955 and 2008.

Drivers of recovery

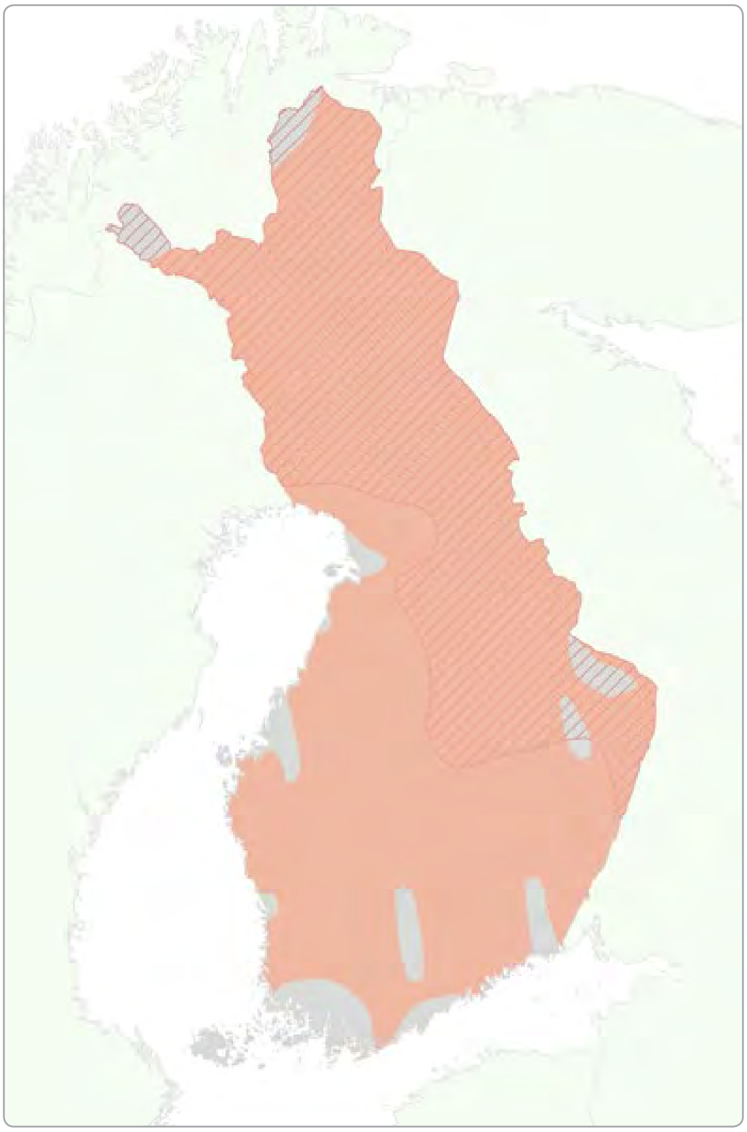
Within our dataset, we identified a number of reasons for the increases in population size observed in European populations of Brown bear. At a habitat scale, bears associated with boreal forest and taiga, coniferous forest and Mediterranean forest biomes have, in general, increased in abundance. An opposite trend is apparent in broadleaf and mixed forest populations, despite the fact that nearly 66% of these have received some form of conservation management (e.g. direct protection, habitat conservation, public education, hunting restrictions and management of prey species). Geographically, this would suggest that populations in the southern Balkans, the Carpathians, the Alps and in northern Europe are faring best, while declines are localised in European Russia. This may be associated with hunting pressures, although this is not listed as one

Figure 2.
Distribution of Brown bear in Switzerland in **1700**, **1800**, **1850**, **1900** and **1950** [18].

Figure 3.
Distribution of Brown bear in Finland in **1700**, **1900** and **2001** [8, 17]. Between 1700 and 1900, ranges halved in Finland but by 2000, around 91% of the original range was considered bear country.

of the main current threats to the species within Europe [7] and there is no current information on Russian bears [13]. It is, however, reasonable to assume that legal protection and the control of exploitation and hunting has likely been one of the greatest factors in the initial bear recovery (Table 3). In Sweden, for example, it is believed that the establishment of lower hunting quotas from 1981 has contributed to the tremendous growth of the country's populations since [2].

Naturally, obtaining an accurate measure of the health of wide-ranging species such as the Brown bear across Europe is complex. Some recent regional and national trends tell the same story: an increasing abundance trend in the Finnish population matches an expanding range (Figure 4), and we found an overall decline in the abundance of the Critically Endangered Cantabrian bear population, which faces a number of threats, including low densities and lack of connecting corridors [12]. Others, on the other hand, show mixed fortunes, e.g. an increase is apparently occurring at the same time as a range contraction in Bulgaria (not shown), although this may be attributable to the large time gap in the spatial data (1900 and 2001). Smaller temporal bands may indeed yield similar results. This suggests that local management is likely to be of great importance to dealing with the steadily increasing European populations, and supports the need for an integrated programme of management, with local rewilding sites playing key roles, particularly in creating interconnected networks for wide-ranging species.



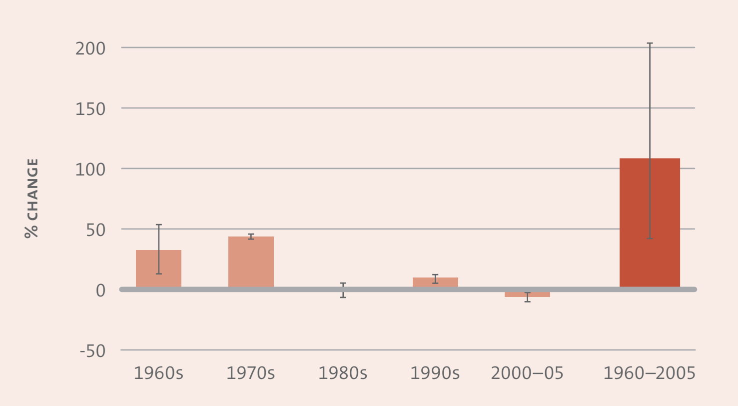


Figure 4. Change in Brown bear population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

Engagement of stakeholders, especially hunters and farmers, through compensation schemes and provision of anti-predation measures, has been supporting the recovery and maintenance of Brown bear in a number of countries, e.g. Croatia, Romania and Spain [13]. However, there are fears that this engagement will deteriorate as the species becomes fully protected when Croatia joins the EU and revenues from trophy hunting vanish [13]. Some compensation schemes have been criticised for failing to stimulate investment in protective measures, for example in Slovenia where the value of compensation usually exceeds that of the destroyed property [13].

According to our results, exploitation is the primary driver of a population decline, while management intervention efforts have had a positive effect on abundance. Our data suggest that future conservation efforts should focus primarily on reducing threats and increasing legal protection as well as food availability (both of these were recorded as interventions for some of our populations). It is advisable to implement these interventions where habitat is suitable and human-wildlife conflict is likely to be low, for example in areas that are being abandoned across the continent. In recolonised areas with significant predator-livestock conflict, some countries can provide valuable examples of how to mitigate such problems, e.g. Croatia [13], Romania [13] and Slovakia [19].

Table 3. Major reasons for positive change in the status of the Brown bear in Europe.

Rank	Reason for change	Description
1	**Species management – Legal protection and hunting restrictionss**	The establishment of reliable hunting quotas is believed to have been the main reason for the comeback of the Brown bear in Sweden after 1981 [2].
2	**Education –Engagement of stakeholders**	Engagement of stakeholders, especially hunters and farmers, through compensation schemes and provision of anti-predation measures, has been supporting the recovery and maintenance of Brown bear in a number of countries, e.g. Croatia, Romania and Spain [13].
3	**Species management – Local management**	Local management of bears is likely to be of great importance to managing the steadily increasing European populations, and supports the need for an integrated programme of management.

Recent developments

One recent development particularly highlights the positive effects of species protection, as well as the problems associated with the recolonisation of human-occupied areas by large carnivores. Bruno, the first brown bear to venture into Bavaria in 170 years, was shot dead in 2006 after a decision made by the appropriate authorities (Figure 5) [20]. While his appearance was welcomed by conservationists, hailed as evidence for expanding range and population size, various factions expressed concerns about Bruno's increasingly fearless behaviour. Bruno's brother JJ3 was shot dead in Switzerland in 2008 [21]. Their deaths highlight that despite the acceptance of this species in some countries [22] and positive attitude change over time [23], there is a deep-rooted negative attitude towards large predators in areas from which they have been absent for centuries.

This is also the case in Arbas in the French Pyrenees, where the French government arranged for five bears to be released as part of a plan agreed by Spain, France and Andorra. Following protests by local people and the death of some animals, this project was put on hold [24].

In addition, there are reports from Romania, which is home to over a quarter of Europe's Brown bears, hinting at an increase in poaching [25]. This is happening despite existing laws and protection, and in the country's protected areas [25], thus highlighting the need for more rigorous monitoring and reinforcement. Poaching has also been identified as the reason for the very recent extirpation of the reintroduced Brown bear population in the Northern Limestone Alps of Austria in spite of the wealth of suitable habitat here [26].

On a more positive note, there is recent evidence that the Critically Endangered Cantabrian population, which is believed to be stable after decreasing in the eighties and nineties [27], is now recovering [28] (Figure 5), although this has been criticised by some [29]. In addition, the Preservation and Protection of Natural Environment in Albania was able to prove the existence of bears in the Shebenik Mountains near the border to Macedonia for the first time using camera traps [30].

It appears that, overall, the Brown bear is increasing in number and range in Europe. However, there are still concerns over the lack of necessary cooperation between different states, as all but two populations (Apennine and Cantabrian) reach across two or more countries [7]. Population-level management is generally seen as important, and although there is some movement towards joint management and sharing infor-

mation, e.g. between Slovenia and Croatia [13], there is no formal plan in place in any of the countries of occurrence as yet [7]. In Norway, for example, current policy will not allow for a dramatic increase in the small local population, although its future will be secure as long as their neighbours Finland and Sweden do not change their management procedures [13].

Despite stable or increasing population trends, the Brown bear remains threatened by habitat loss due to infrastructure development, disturbance, poor management structures, intrinsic factors, accidental mortality and persecution [7]. Most of these are expected to become more important in the future [7]. However, it is low acceptance by stakeholders and the public alike that will present the greatest obstacle in the future conservation management of this species [31], especially in areas where increasing abundance and range expansion is leading to greater contact between bears and people. In Finland, 50% still consider the species a threat to human safety [13]. And although attitudes towards Brown bears were generally positive in the Croatian Dinaric Mountains, the public has become less accepting over time as a result of more centralised species and hunting management, and a growing population size [32]. However, often it is feelings rather than the perceived impact or indeed knowledge about the species that act as a stronger predictor of accepted management options [33], so there are opportunities to influence public opinion through continued education. Active and continuous participation of stakeholders in management and decision-making, which includes hunting, can increase the support of species conservation by evoking a sense of ownership and control over carnivore populations [32, 34], and this will need to be taken into consideration in any future management of the Brown bear in Europe.

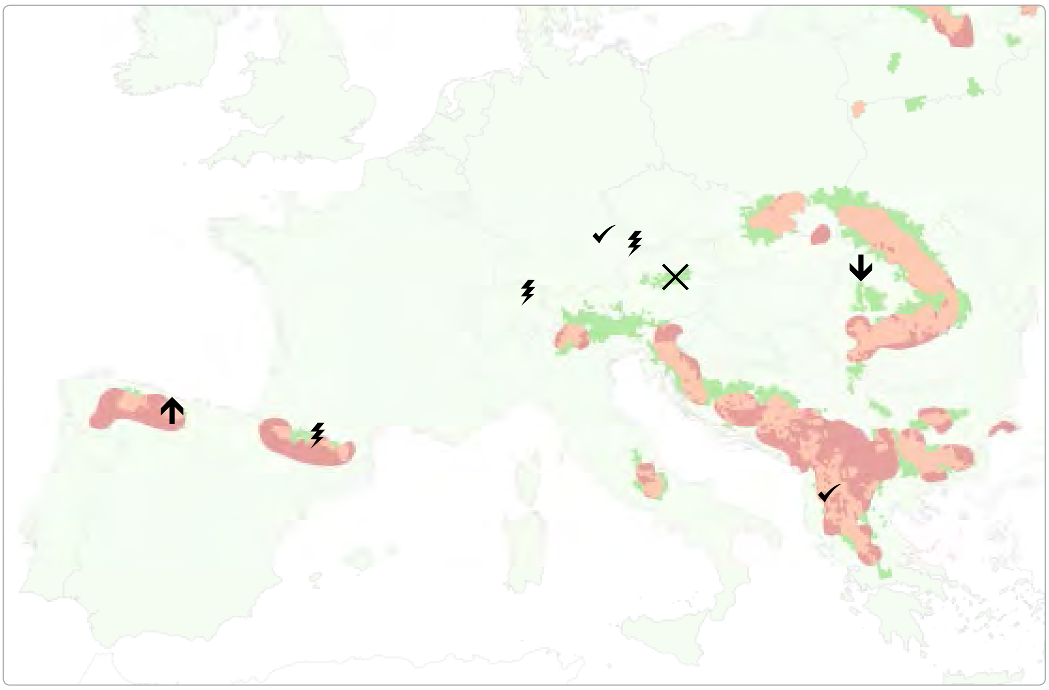


Figure 5. Map of recent developments recorded for the Brown bear in Europe.

- Expansion
- Persistence
- Contraction
- Extirpation
- Intentional mortality
- New sighting
- Population decline
- Population increase

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3.18. Eurasian beaver

Castor fiber

Summary

The Eurasian beaver, once widely distributed across Europe, was reduced to 1,200 individuals by the beginning of the 20th century due to over-exploitation for fur, meat and castoreum, as well as habitat loss. With the help of legal protection, hunting restrictions, reintroductions and translocations, natural recolonisation, and habitat protection and restoration, the species has made a remarkable recovery over the past 40 years. It is now established in almost all of its former range, and further increases are likely. Despite the benefits associated with this comeback, potential conflict will have to be mitigated to allow for peaceful coexistence and mutual beneficence of beaver and man.

Background

General description of the species

The Eurasian beaver (*Castor fiber*) is the second largest rodent in the world, with a distribution from western Scotland across central and northern Europe into Russia, with fragmented populations occurring further west [1]. It is active for 14–16 hours a day, usually from early evening and avoiding the middle of the day [2]. As a herbivore, the species feeds primarily on woody vegetation in winter (which it often caches), and aquatic vegetation in warmer months [3]. It is fiercely territorial, existing in colonies of up to 12 with one dominant, monogamous pair raising up to six or more young each year between January and February, with all family members cooperating in the care for young [3]. The beaver is a keystone species and ecological engineer due to its dam-building behaviour, although it usually settles at sites where this is not necessary [2]. These constructions change the flow and nutrient cycling of a watershed, leading to changes in invertebrate communities, and attract new species of birds, fish and amphibians through the provision of a suitable water table [3]. Once a family group has exhausted the available resources in an area, it moves on [3].

Distribution in Europe

The beaver was once distributed continuously across Eurasia from the British Isles to eastern Siberia [4], although it is not known whether these Siberian animals were *C. fiber*, *C. canadensis* or an extinct species [1]. The species had decreased in number and range by medieval times in most countries, and the introduction of steel traps and fire arms in the 17th century hailed the end of many of the remnant populations [4]. Overall, numbers were severely reduced by the beginning of the 20th century in Europe due to over-exploitation for fur, meat and castoreum (priced as a medicine and

Scale	Status	Population trend	Justification	Threats
Global [10]	Least Concern	Increasing	Good recovery as a result of conservation programmes Ongoing conservation measures	No major threats. Possible threats at local level: 1. Competition with *Castor canadensis* (Finland, north-west Russia) 2. Road mortality 3. Conflict with humans through crop and forestry damage 4. Illegal killing (Mongolia) 5. Habitat loss (Bulgan River, China) 6. Pollution (Bulgan River) 7. Dams (Bulgan River)
Europe [4]	Least Concern	Increasing	Good recovery as a result of conservation programmes Ongoing conservation measures	No major threats. Possible threats at local level: 1. Competition with Castor canadensis (Finland, north-west Russia) 2. Road mortality 3. Conflict with humans through crop and forestry damage

Table 1. Summary of Global and European Red List assessments and threats listed for the Eurasian beaver.

perfume base) coupled with habitat loss [4]. Around 1,200 individuals [5] remained in five isolated European sites – Rhône (France), Elbe (Germany), Telemark (Norway), Pripet (Belarus, Ukraine, Russia) and Voronezh (Russia) [6] – but the species eventually recovered as a result of legal protection and targeted conservation measures (including reintroductions and translocations) [5]. Populations are now established in all countries within the beaver's former natural range in Europe except for Portugal, Italy, and the southern Balkans [5].

Habitat preferences and general densities

The beaver is a semi-aquatic species, which uses a variety of freshwater systems, although it shows a preference for those surrounded by woodland [5]. It may also occur in agricultural land and urban areas [5]. Home range size varies with food availability, watershed size, colony size, and season [3]. Each family group numbers between two and eight animals, with an average of 3.2 individuals [7]. The density of these groups in the landscape depends on the quality of the habitat: less suitable sites support around one family group per 6.6 km of river [7], while in Lithuania, an average density of eight sites per ten km of river bed, i.e. one family per five km^2 has been recorded [5].

Legal protection and conservation status

The Eurasian beaver is protected under the Bern Convention (Appendix III) [8] and the Habitats Directive (Sweden, Finland, Baltic states: Annex V; all others: Annexes II and IV) [9]. Remnant populations have been legally protected since the late 19th century, e.g. in Norway since 1845, France since 1909, Germany since 1910, and Russia and Ukraine since 1922 [6], as have extinct populations in Finland, Sweden, Poland and Spain [6]. Reintroductions have taken place from 1922, when beavers were translocated to Sweden from Norway [5]. Initially, the focus of the efforts was fur-harvesting, only later did conservation and ecosystem management become more prominent [6]. The species is often completely protected but also exploited in some countries, e.g. Sweden and Norway [5]. Many also generate additional income through beaver-related tourism [5]. The beaver is listed as Least Concern with an increasing trend globally and in Europe because of the recovery the species has shown in response to conservation programmes, as well as the wealth of on-going conservation measures taken (Table 1). While no major threats are known to affect the beaver at a global or regional level, some pressures may exist locally, such as competition with other species, road mortality, conflict with humans, illegal killing and habitat degradation, change and loss (Table 1).

Abundance and distribution: current status

The IUCN estimates an increasing global population of over a million individuals, with the European population accounting for a minimum of around 337,500, or 33%, of these. It should be noted, however, that these Figures are likely to be underestimations. The largest European populations occur in Latvia and Sweden (23% each), Norway (16%) and Lithuania (12%), accounting for almost three-quarters of the European population.

In Latvia, the Eurasian beaver went extinct in the 1830s, with the first reintroductions occurring in 1927 and 1935 using individuals from Swedish stock [5]. Following the introduction of Russian beavers in 1952, the country was recolonised naturally from Belarus [5]. Exhibiting the characteristic pattern of slow increase followed by rapid growth, the species now numbers over 100,000 individuals and is growing further. As a result it

	Estimate	Year assessed	Reference
Global	>1,036,226	2012	[11]
Europe (minimum)	>337,539	2003–12	[6, 12–18]
% of global population	33%		
Austria	>3,000	2008	[12]
Belarus	24,000	2003	[6]
Belgium	200–250	2003	[6]
Bosnia and Herzegovina	Unknown	-	-
Croatia	180	2003	[6]
Czech Republic	500	2003	[6]
Denmark	188	2011	[13]
Estonia	11,000	2003	[6]
Finland	2,000	2003	[6]
France	14,000	2011	[14]
Germany	>25000	2013	[12]
Hungary	500	2007	[15]
Latvia	>100,000	2003	[6]
Lithuania	50,000–70,000	2003	[6]
Netherlands	507	2010	[16]
Norway	70,000	2003	[6]
Poland	18,000–23,000	2003	[6]
Romania	>170	2003	[6]
Russia (European)	Unknown	-	-
Serbia	30	2003	[6]
Slovakia	>500	2003	[6]
Spain	18	2003	[6]
Sweden	>100,000	2003	[6]
Switzerland	1,600	2007/8	[17]
Ukraine	6,000	2003	[6]
United Kingdom	146	2012	[18]

Table 2.
Latest population estimates for the Eurasian beaver globally, in Europe and for European populations. Please note that there was no information available for Bosnia and Herzegovina, and European Russia.

is currently found throughout Latvia except the northwestern part [5].

The beaver occurs in all of Sweden except the south, northwest, and the area around Uppsala north of Stockholm, and this population forms part of the continuous distribution of the species from the Baltic to the Atlantic [5]. The population, which was extirpated in 1871 [6], was re-established entirely through reintroductions [2]. Following reintroductions of Norwegian beavers from 1922 at 19 sites, the species was able to expand reasonably quickly due to limited barriers resulting from the topological characteristics of the country [5]. After rapid range extension, the characteristic population explosion took place in the 1970s, resulting in an estimated population of over 100,000 individuals spread across what is now a continuous range [5]. Populations are completely protected in the northernmost province Norrbotten, in the eastern Uppsala and Stockholm provinces, and in the south, while seasonal unrestricted hunting elsewhere results in an annual harvest of around 6% per annum [5].

Growing from a remnant population of around 100 individuals [5], the Norwegian beaver has provided source stock for all Scandinavian populations and now represents up to 21% of the species in Europe (Table 2). After receiving protection in 1845 (which was only effective from 1899), numbers recovered to 7,000 in 1919; however, subsequent over-hunting caused population declines despite reintroductions in the 1920s [5]. In the early 1940s, individuals immigrated to eastern Norway from the reintroduced Swedish population along the Trysil watershed [5]. This natural spread continued, becoming a significant factor in the 1970s, and this, in combination with reintroductions in the 1950s and 1960s in Norway, led to considerable increases in number and range, leaving the species to occupy the country in two disjunct populations (Figure 1A) [5].

Hunted to extinction in 1938, Lithuania provides ideal habitat for the Eurasian beaver [5]. Reintroductions between 1947 and 1959, coupled with immigration from Latvia, Belarus and Kaliningrad in Russia, has led to a constant increase since the end of the 1940s [5]. Even though range expansion halted in the mid-1970s, when the beaver occupied the entire country [5], increases have continued in the late 1990s due to the post-Soviet abandonment of drained farmland leading to scrub regrowth, which combined with existing drainage ditches provide ideal beaver habitat [2].

Abundance and distribution: changes

In 1955, the Eurasian beaver occurred in over 25 distinct populations in eastern Germany, the south of France, eastern Europe and Scandinavia (Figure 1A), occupying an area of over 256,000 km². By 2013, the range had increased by 650% to nearly 1,670,000 km², adding territory across the European continent (Figures 1A and B). While the species seemingly lost ground in the south of France, eastern Germany, Norway, northern Sweden and Ukraine, this is likely to be an artefact of the difference in map resolution. The 1955 map is very simplified, giving the impression that the beaver has contracted compared to the more detailed 2013 range. However, it is possible that even the present day map, although broadly accurate, represents an underestimate of distribution due to the rapidly changing situation of the species across the continent [1], which would lead to greater expansion since 1955 than depicted in Figure 1B. Range loss may, however, be a reality in Finland, where the beaver is experiencing interspecific competition with the introduced North American beaver (*Castor canadensis*) [1]. Despite this, previously disjunct populations have been connected, creating large ranges in central and eastern Europe, and in Norway and Sweden, and creating new populations in countries where the species had been absent for many centuries, for example Spain and the United Kingdom (Figures 1A and B).

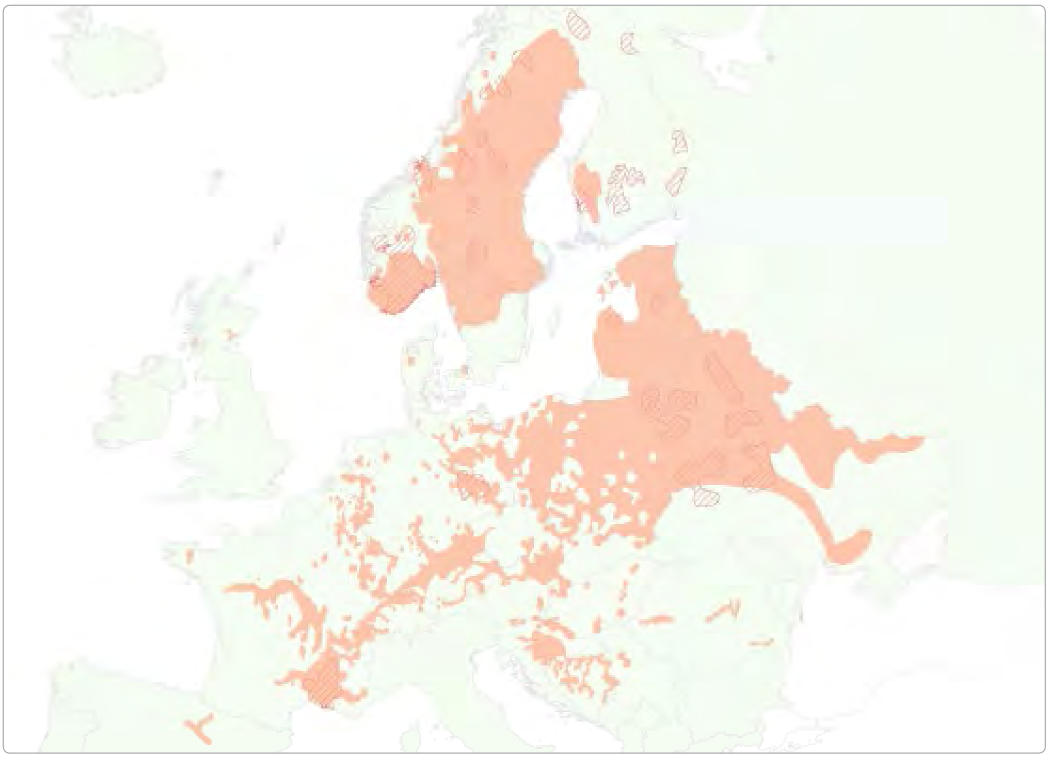

Figure 1a. Distribution of Eurasian beaver in **1955** [19] and **2013** [1]. Please note that Russia has not been included due to lack of reliable data. Range information for 1955 is extremely simplified, leading to apparent declines when compared to the more detailed 2013 map [1].

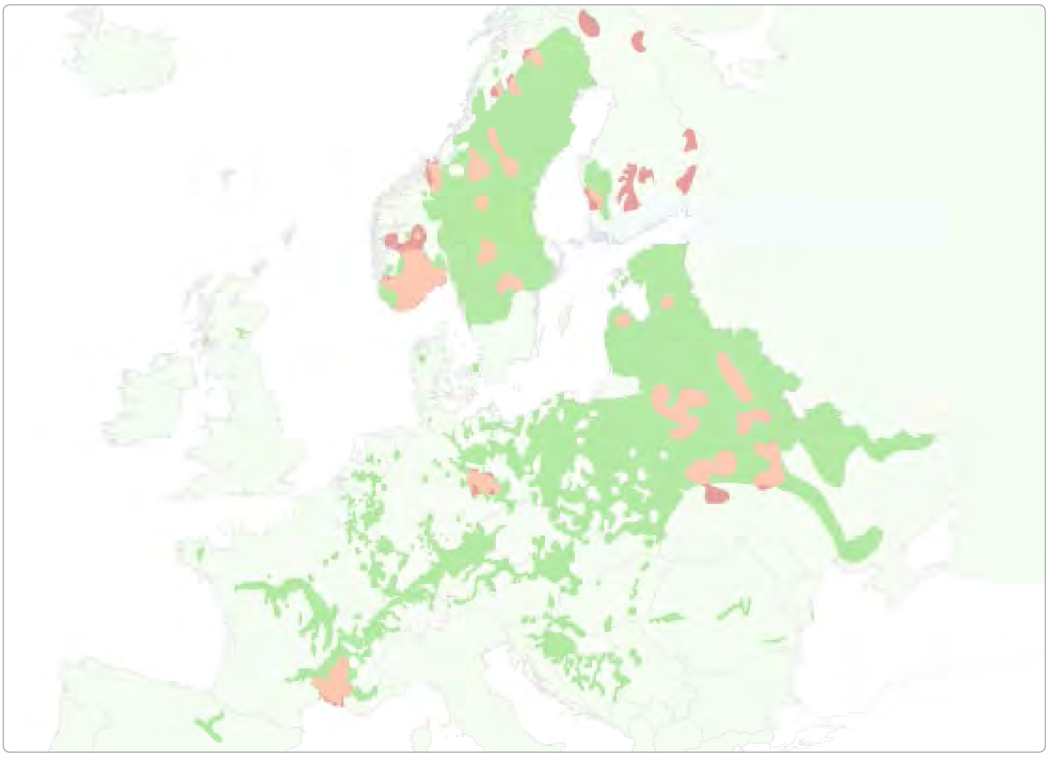

Figure 1b. Map highlighting areas of range **expansion**, **persistence** and **contraction** of the Eurasian beaver in Europe between 1955 and 2008. Please note that Russia has not been included due to lack of reliable data. Range information for 1955 is extremely simplified, leading to apparent declines when compared to the more detailed 2013 map, for example in the south of France, eastern Germany, Norway, Sweden and Ukraine [1].

The large-scale expansion in range between 1955 and the present day is reflected in the change in population size over the same period. The beaver increased in abundance by just over 14,000%, with a doubling or tripling in population size occurring in all decades (Figure 2). The largest occurred in the 1970s, when the population multiplied by two, and the 1980s, when the increase was 150% (Figure 1a). This represents a remarkable recovery in numbers over a mere 45-year period, which can be attributed to conservation successes in the underlying populations in the data set. The trend presented is based on 23 populations from the species' current range, covering a minimum of 96,000 individuals or 23% of the European population. Data were from 46% of the species' countries of occurrence including Lithuania and Sweden (two of the major populations), but the data set was missing vital information from Latvia and Norway (Table 2).

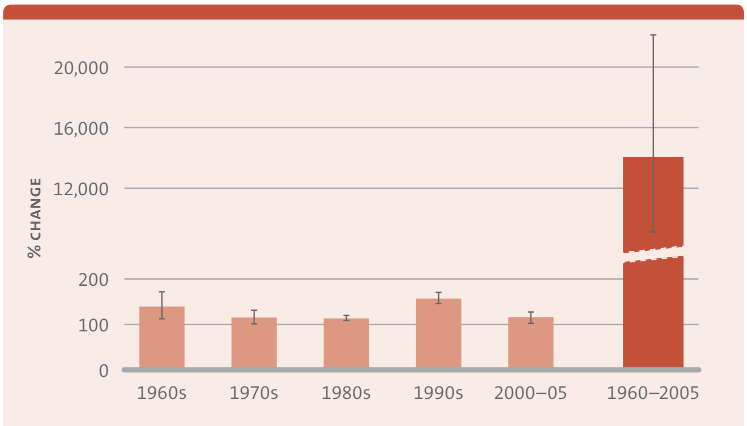

Figure 2. Change in Eurasian beaver population **abundance by decade** and **overall change** between 1960 and 2005. Please note that due to the way change was calculated, decadal change does not sum to overall change.

Drivers of recovery

Although none of the factors tested explained the resurgence of Eurasian beaver observed in our data set, a number of possible reasons for these trends have been discussed in the literature. The most important of these are undoubtedly legal protection and the restriction of hunting, reintroductions and translocations, and natural recolonisation following initial recovery (Table 3).

Legal protection of the five populations remaining at the beginning of the 20th century [5] was key in enabling the species to persist in Europe. In addition to merely preserving genetic material, some of these final five also acted as source populations for many of the extensive reintroduction and translocation programmes that have taken place in at least 25 European countries [5]. Initially, these efforts were motivated by the fur trade, comprised hard releases and lacked habitat suitability assessments, but latterly they became more conservation-focused and better researched [5]. Viable populations have been established in all countries where reintroductions have occurred [5] because the species is robust and will succeed in most river systems if left alone [2]. As part of legal protection, the cessation of hunting, which had driven the species to near extinction, has resulted in population growth, e.g. in Belarus [5].

A robust species, the beaver expands rapidly within a watershed of occurrence to occupy available optimum habitat [20]. However, in medium to large-sized watersheds [2] this reduces beaver density, and the critical threshold for encountering a mate is usually only reached after 10–25 years, leading to an explosion in numbers [20]. In smaller rivers, for example the River Tay in the United Kingdom, this phase of rapid increase occurs almost immediately [2]. The following 10 or so years are marked by population decline as marginal habitats become exhausted, and this is followed by rough stability [20]. While the species can easily spread between watersheds – as has been the case in eastern Norway, which was repopulated from Sweden, the islands of Saaremaa and Hiiumaa from mainland Estonia [5], and Slovenia from Croatian watersheds [2] – natural and artificial barriers can strongly hinder expansion [5].

While legal protection, reintroductions and recolonisation are the key drivers of beaver recovery in Europe, habitat protection and restoration have also played a role in its resurgence. Unsuitable habitat is believed to be the reason for reintroduction failures in Switzerland, and poor habitat quality is limiting reproductive output in the Biesbosch National Park in the Netherlands [5]. On the other hand, the conservation and regeneration of riparian zones around rivers for flood control has created suitable beaver habitat around the continent [5], and has certainly contributed to the observed recoveries. In addition to changes in the way that man is managing the Eurasian beaver, the species' resilience and ability to spread swiftly within a watershed following introduction or colonisation, will also have been beneficial in the increase and expansion observed throughout most of its historic range. Populations have now been established in all former range countries except Portugal, Italy and the southern Balkans [11].

Recent developments

Despite the impressive recovery in abundance and range, the Eurasian beaver still occurs at low densities in some locations, and large areas of suitable habitat remain unused [11], suggesting plenty of opportunity for further spread. Considerable growth in range and numbers is expected, particularly in western Europe and the Danube watershed [11]. This would make the species common in much of Europe within the next few decades [10]. In addition, reintroduction efforts are continuing with an ambitious programme to recolonise the entire Danube basin, with other successful recent reintroductions (or spread) in Denmark, Belgium and Scotland [21]. As a result, many populations are now considered to be at a mature stage of development [5]. There are also proposals to re-establish the beaver in Wales [7] and England [22]. The species is expected to spread from the Tay watershed in Scotland, where the population was discovered in 2010 and increased by around 20% since 2012, to other watersheds such as the Dee, Spey and Forth in the United Kingdom [2]. Although the population was established "illegally", it is unlikely that there will be the resources and public support to eradicate it [2]. In Luxembourg, newly established beavers were found to be North American escapees from

a nearby German wildlife park and removal is planned [2].

However, any increase in distribution or number also entails greater potential for conflict with humans. While public opinion towards the beaver and its reintroduction is often positive [23], those that are more directly affected by beaver behaviour such as farmers and foresters, may display greater scepticism, although some are enthusiastic about the possibility of beaver presence [2]. Level of acceptance depends primarily on social factors [2], and these need to be addressed to mitigate problems. However, there are also opportunities for the local economy through wildlife tourism, so early provision of interpretation and public viewing opportunities are recommended, and this will also help foster positive attitudes towards beavers [5].

There is a particularly great opportunity to promote the positive ecological effects of beaver engineering, including the increase in biodiversity resulting from beaver-induced changes in habitat, and this has been the focus of more recent research. Through the creation of ponds, the beaver increases the amount of available nutrients, which leads to algae and plant growth. As a result, invertebrate species richness and biomass are higher in beaver-influenced streams [24] and clearings [25]. In Bavaria, 38 species of dragonfly were recorded at beaver sites, with 11 profiting directly from the presence of the species [26]. However, vertebrate species also benefit: twice as many fish species occur in beaver-influenced habitat, with densities of up to 80 times higher than in non-beaver sites [26]. Greater numbers of amphibian species were present in beaver sites in the Eifel [27] and Bavaria, where half of all 12 species benefited directly from beaver activity [26]. In a Russian study, amphibian productivity was higher in beaver compared to non-beaver sites [28]. This increase in fish and amphibian prey results in greater bird variety at beaver sites, with over 50 rare species (e.g. Black stork *Ciconia nigra*) recorded in Bavaria [26]. There is also evidence that other mammals such as otters, which can use beaver lodges, take advantage of the increase in available food [26]. More recently, studies have demonstrated a positive effect of beaver clearings for insectivorous bats, providing new foraging sites for species such as *Pipistrellus spp* [29]. More generally, the beaver can support the necessary restoration of waterways undertaken in response to climate change and mitigate effects such as increased flooding at extremely low cost [26].

After a long absence from a large proportion of its range, the Eurasian beaver is now slowly reclaiming its role as an ecological engineer and keystone species in European freshwater ecosystems. The species will undoubtedly increase further in number and range over the coming decades, and as confinement to a particular stretch in a watershed is impractical in the absence of strong artificial barriers because of the species' readiness to disperse, management will have to be implemented at the watershed scale [11]. The associated benefits of waterway restoration and potential for tourism will likely outweigh the cost of beaver-related damage; however, potential conflict will have to be managed in some countries to allow for peaceful coexistence and mutual beneficence of beaver and man.

Table 3. Major reasons for change in the status of the Eurasian beaver in Europe.

Rank	Reason for change	Description
1	**Legislation – Legal protection and hunting restrictions**	Following effective legal protection in 1899, the beaver increased in Norway from 60–120 animals to 1,000 by 1910 and 7,000 in 1919 [5]. All remnant populations received legal protection at the beginning of the 20th century [5]. Population growth resumed in Belarus after a hunting prohibition in 1996 [5].
2	**Species management –Reintroductions and translocations**	Initially, reintroductions were motivated by the fur trade, consisted of hard releases and lacked habitat suitability assessment, but latterly the focus was more on conservation and more thorough research [5]. Reintroductions and translocations have saved remnant populations from extinction and have been key in the recolonisation of areas from which the beaver had gone extinct. Altogether, reintroductions and translocations have taken place in at least 25 European countries [5]. Viable populations have been established in all countries where reintroductions have taken place [5].
3	**Other – Natural recolonisation**	Eastern Norway was repopulated by individuals from the adjacent Swedish population [5]. The Estonian islands of Saaremaa and Hiiumaa were colonised by natural spread in the 1990s [5]. The population in Slovenia derived from releases in Croatian watersheds [2].
4	**Land/water protection and management –Habitat restoration and protection**	Beaver select the very best habitat available [5], but will progressively relax their criteria as better sites are occupied [2]. Poor habitat believed to be limiting reproductive success in Biesbosch National Park in the Netherlands [5]. The conservation and regeneration of riparian zones around rivers for flood control has created suitable beaver habitat around Europe [5].

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Reviewer

- **Dr Duncan Halley**

4. Bird species accounts

Here we present detailed species accounts for 19 species of birds in Europe. Each account covers the background ecology and status of the species, details of current distribution and abundance and an evaluation of how these have changed since records began.

1. Pink-footed goose (*Anser brachyrhynchus*)
2. Barnacle goose (*Branta leucopsis*)
3. Whooper swan (*Cygnus cygnus*)
4. White-headed duck (*Oxyura leucocephala*)
5. White stork (*Ciconia ciconia*)
6. Eurasian spoonbill (*Platalea leucorodia*)
7. Dalmatian pelican (*Pelecanus crispus*)
8. Lesser kestrel (*Falco naumanni*)
9. Saker falcon (*Falco cherrug*)
10. Peregrine falcon (*Falco peregrinus*)
11. Red kite (*Milvus milvus*)
12. White-tailed eagle (*Haliaeetus albicilla*)
13. Bearded vulture (*Gypaetus barbatus*)
14. Griffon vulture (*Gyps fulvus*)
15. Cinereous vulture (*Aegypius monachus*)
16. Spanish imperial eagle (*Aquila adalberti*)
17. Eastern imperial eagle (*Aquila heliaca*)
18. Common crane (*Grus grus*)
19. Roseate tern (*Sterna dougallii*)

4.1. Pink-footed goose

Anser brachyrhynchus

Summary

There are two flyway populations of Pink-footed goose: the Icelandic breeding population, which winters in Britain, and the Svalbard breeding population, which winters in continental northwest Europe. Both populations have increased greatly since the 1950s, thanks to improved protection from shooting and to the increased availability of high quality food in the wintering grounds, as a result of intensification of agricultural practices. The increasing population of the species has resulted in a conflict with farmers in parts of the flyway, as the Pink-footed goose causes damage to agricultural land. International cooperation is necessary in order to effectively manage this issue at the flyway scale.

Background

General description of the species

The Pink-footed goose (*Anser brachyrhynchus*) is a migratory goose species found in northwest Europe and Greenland. It breeds in loose colonies from mid-May to early July and then undergoes a flightless moulting period until August. After moulting, Pink-footed geese migrate to their wintering grounds. Outside the breeding season, Pink-footed geese are gregarious, forming large but loose flocks in autumn and winter [1].

Distribution in Europe

There are two populations of Pink-footed goose, with almost no interchange or overlapping of breeding or wintering distributions [1]. One population breeds in Svalbard and winters in northwest Europe (nearly the entire population concentrates in Denmark, and a declining proportion of birds moves further south to the Netherlands and Belgium). The second breeds in Iceland and east Greenland and winters in Scotland and England [2, 3].

Habitat preferences

In Greenland, Pink-footed geese nest on cliffs, riverbanks and hummocks near dense vegetation. In Iceland, Pink-footed geese used to forage in the uplands in spring and autumn, but currently the majority forage on farmland, including potato fields and improved grasslands. In the UK, salt and fresh marshes were used in the past, but the majority of Pink-footed geese now forage on

Table 1. Global IUCN Red List status [6], European population and SPEC status [7] and EU population status [8] of Pink-footed goose.

Scale	Status	Justification
Global	Least Concern (since 1988)	Very large range and population size, which appears to be increasing.
Europe	Secure (Non-SPECE)	Increasing population.
EU25	Secure	

managed grasslands and since the 1950s they feed on sugar beet in winter [1].

In Svalbard, they nest on rocky outcrops, steep river gorges and islands. They forage in damp sedge-meadows. During migration across Norway in spring, they used to graze on saltmarshes and fens, but since the 1980s they now almost exclusively graze on managed grasslands. In Denmark, they forage in stubbles for spilt grain, but also on grassland and increasingly, notably in winter, on autumn-sown cereals. At the wintering grounds in the Netherlands and Belgium, they mainly graze on grasslands [1].

Legal protection and conservation status

The Pink-footed goose is listed in Annex II of the EU Birds Directive, Annex III of the Bern Convention, and Annex II of the Convention on Migratory Species, under which both populations are covered by the African-Eurasian Waterbird Agreement (AEWA), listed in Column A (category 2a for the East Greenland & Iceland/UK population and category 1 for the Svalbard/North-west Europe population) in the AEWA Action Plan [4, 5].

Abundance: current status and changes

There are no data on the species before the 20th century, as the Pink-footed goose was formerly confused with the Bean goose (*Anser fabalis*) [2]. Systematic autumn counts in Scotland provide an accurate assessment of the size of the Iceland/Greenland population [2]. The species was considered to be a scarce winter visitor in the past [2], but the population size has increased from about 8,500 individuals in 1951 to more than 350,000 individuals in 2013 [9]. The rate of increase was highest in the 1980s [2] (Figure 1).

The Svalbard population was estimated to number 10,000–12,000 individuals in the 1930s and 1950s [3]. By the mid-1960s, when systematic autumn counts began, the population had increased to 15,000–18,000 [3, 10]. The increasing trends continued and by 2012, the population had reached 81,600 individuals [10] (Figure 1).

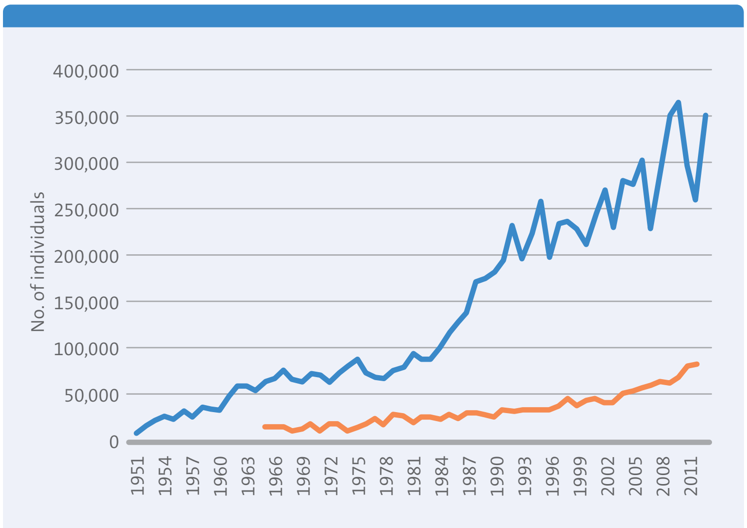

Figure 1. Number of Pink-footed geese since 1951, showing the **Svalbard**, **Iceland and Greenland** populations separately [9, 10].

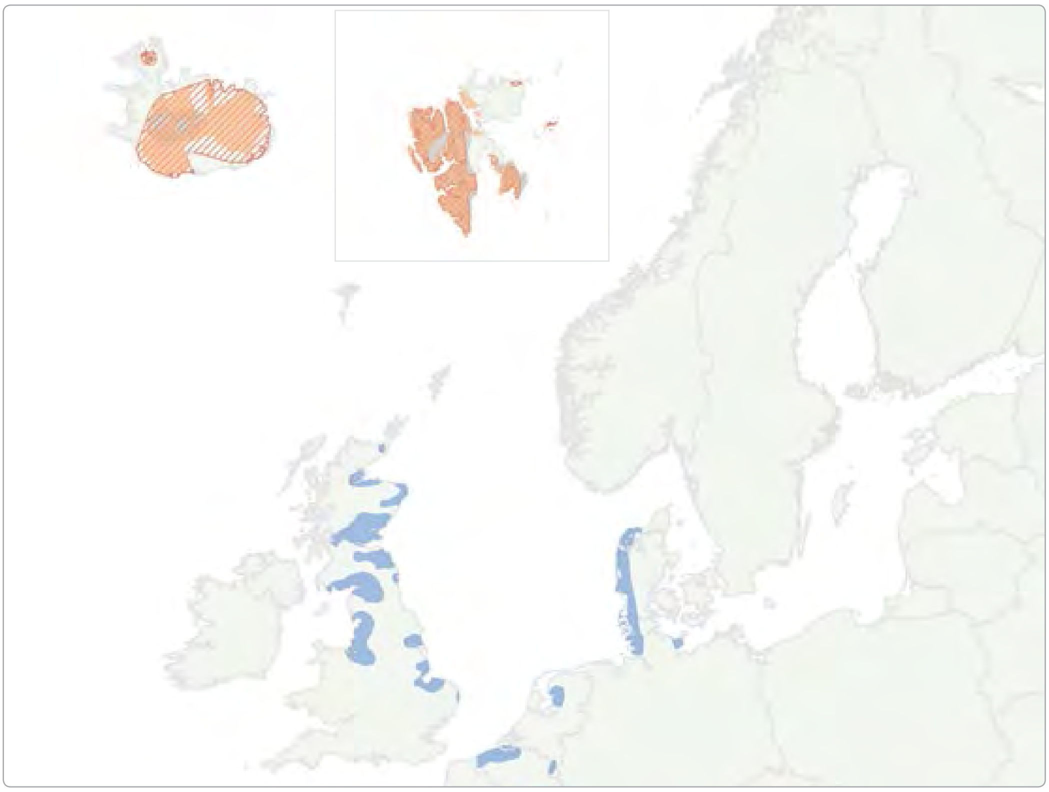

Figure 2. Current **breeding** and **wintering/staging** distribution of Pink-footed goose in Europe and historical breeding distribution in Iceland and Svalbard in the **1950s** [11] and **1980s** [12].

Distribution: current status and changes

The Icelandic population of Pink-footed goose breeds mainly in central Iceland (Figure 2), with smaller numbers along the east coast of Greenland. In Iceland, the species used to occur only in Pjorsaver, an area of wet meadows in the central highlands of the country. Since the early 1980s, it spread out from this area and now breeds over much of the interior of the country. The wintering grounds of the Icelandic population are in Britain, where geese are found in central Scotland in large numbers in early autumn and then progress southwards, to Lancashire and Norfolk in particular [1, 2, 12].

The majority of the Svalbard population breeds in western Svalbard, particularly in Spitsbergen (Figure 2). In the autumn, this population moves southwards via Norway, where there are stopover sites, to Denmark, the Netherlands and Belgium. In Denmark, a narrow zone along the west coast is used (Figure 2). The species used to stage in northwest Germany in the 1950s, but these sites are no longer used [1]. In the Netherlands, Pink-footed geese are restricted to the southwestern part of Friesland (Figure 2). Wintering grounds in Belgium are found in the Flemish coastal polder area (Figure 2) and were traditionally concentrated in a small number of sites, but expanded when severe winters between the 1960s and 1980s pushed the population towards France and new suitable areas were discovered. Since the early 1990s, nearly 75% of the Svalbard population used to winter in Belgium and the Netherlands [3, 12–14], but recently this percentage is much lower (<40%) and increasingly birds remain longer on the Danish wintering grounds [15].

Major threats

One of the most important issues regarding the long-term outlook for the Pink-footed goose is the conflict with agriculture. The increasing trend of both populations of the species has resulted in a conflict with farmers, as the geese cause damage to managed grasslands (in the spring) and other crops [1–3].

Current levels of hunting pressure do not seem to be affecting the overall population [1], but disturbance from persecution/scaring by farmers (scaring is a widely used method of managing the conflict with agriculture) during spring staging in Norway has been shown to have a major impact on breeding success [3]. This is because geese that are disturbed stay at staging areas short a shorter period of time and do not accumulate sufficient nutrient stores [3].

Hunting pressure in Denmark affects the timing, location and number of birds that can be found staging there in autumn en route to the Netherlands, resulting in earlier departure of Pink-footed geese [1, 3]. This has caused an increase in crop damage in the Netherlands. The reverse is also true, with earlier departure from Denmark in spring causing increased damage in Norway [3]. This has increased conflict, especially in Norway [3].

Tourism and infrastructure development have recently increased in Svalbard, but the potential impacts on the Pink-footed goose are unknown [1]. However, increased building development and human activities caused the abandonment of wintering grounds of the Svalbard population in north Germany [1].

Hunting and egg collecting in Iceland resulted in the near extermination of a number of colonies during 1890–1930 and human exploitation maintained the restricted range of the species in Iceland until the 1950s [1, 2]. The range expansion in Iceland has resulted in many birds spilling over into unprotected areas, where they are at risk of persecution [1, 2]. Another important threat in Iceland is the development of hydroelectric projects, which will result in substantial habitat loss [1, 2, 16].

Table 2. Major threats that drove Pink-footed goose decline and may still constrain the population [2, 3, 13].

Threat	Description	Impact
Climate change and severe weather	Habitat loss due to climate change could result in reductions in the available breeding range (northward expansion of shrub and taiga) and fragmentation of winter/spring feeding habitat (sea level rise), as well as a mismatch of the breeding cycle to resource availability.	Unknown, potentially high
Agricultural intensification	Habitat loss due to agricultural intensification (e.g. drainage and ploughing of permanent wet grasslands in Belgium).	High
Agricultural abandonment	Habitat loss due to abandonment of agriculture (e.g. overgrowing of grasslands in Norway).	High
Residential and commercial development	Habitat loss due to urban and industrial development.	Low
Renewable energy	Development of hydroelectric projects planned in Iceland would result in flooding of a major moulting area.	High
Hunting and collecting	Unsustainable illegal hunting and persecution by farmers.	High
Human intrusions and disturbance	Human disturbance from e.g. recreational activities or helicopters surveying for oil exploration.	Medium
Problematic diseases	Avian influenza, parasites or other diseases due to contact with high densities of wild duck and poultry.	Medium
Problematic native species	Recovery of potential predator populations, e.g. Red fox (Vulpes vulpes), Arctic fox (V. lagopus), Polar bear (Ursus maritimus) and White-tailed eagle (Haliaeetus albicilla).	High

Drivers of recovery

The increase in the Iceland/Greenland population, particularly during the 1980s, was the result of increased survival, most likely as a result of site protection of important winter roosts and improved winter feeding conditions [1, 2]. Protection from hunting in Britain was improved, and a protected area network was established. In addition, Pink-footed geese shifted their foraging habitat away from estuaries, where they were vulnerable to shooting and disturbance, to managed grasslands, where food quality is higher. The concurrent nature of these developments makes it difficult to assess the relative importance of each factor, but these improved conditions on the wintering grounds enabled expansion of the breeding distribution in Iceland from the 1960s [1, 2].

The increasing trend of the Svalbard population between the 1960s and 1980s was the result of improved protection and decreased shooting pressure in the staging and wintering areas [1, 3, 13]. Spring shooting was banned in Denmark in 1955 and in Svalbard in 1975, and shooting in the Netherlands was banned in 1976 and in 1977 in Germany [3]. In Belgium, the wintering grounds expanded thanks to the ban on shooting put in place in the early 1980s [3].

Action	Description
Monitoring and planning	Species Management Plan in place for the Svalbard population.
	Regular monitoring is in place for both populations.
Site/area protection	There are 146 IBAs identified for Pink-footed goose in Europe, of which 72% are fully designated as SPAs or other protected areas and 5% are not protected.
Site/area management	Habitat improvement. Protection of key sites.
Problematic species control	Predator control.
Livelihood, economic and other incentives	Compensation/subsidy schemes for farmers.
Legislation	Species is huntable in most countries, but hunting management is often in place, e.g. seasonal hunting bans and licensing.

Table 3. Conservation actions in place for Pink-footed goose [1–3, 13].

Conflict with agriculture is lower in Belgium, as large concentrations of geese are short-lived (departure in early spring) and geese prefer to feed on permanent rather than newly sown grassland or cereal fields [3]. The reduced persecution has also enabled Pink-footed geese in Belgium to make more efficient use of edge vegetation between fields and along roads [3].

Compensation schemes are in place to mitigate conflict with farmers, but international coordination is necessary to effectively manage the issues [1–3, 13].

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Reviewer

- Kees Koffijberg

4.2. Barnacle goose

Branta leucopsis

Summary

There are three discrete Barnacle goose flyway populations, all of which have increased dramatically in size since the 1950s, following historic declines due to hunting. The recovery of the species was thanks to a considerable reduction in hunting pressure and improvements in site protection. The increasing population is increasingly causing conflict with agriculture, as geese grazing on managed grasslands and crops can cause damage. To mitigate this conflict, many countries compensate farmers for damage incurred, or use voluntary subsidy schemes to encourage goose-friendly farming. International flyway management plans are necessary to ensure the continued effectiveness of management efforts.

Background

General description of the species

The Barnacle goose (*Branta leucopsis*) is a migratory goose species native to northern and northwestern Europe. It is a medium sized goose with a characteristic white face, black head, neck and upper breast, and white belly.

Distribution in Europe

There are three or four discrete population of Barnacle goose: one breeding in east Greenland, staging in Iceland, and wintering mainly on islands in northwest Scotland and along the northwestern coast of Ireland (Greenland population); one breeding in Svalbard, staging on the archipelagos of Helgeland and Vesterålen in western Norway, and wintering in the Solway Firth in southwest Scotland (Svalbard population); and one breeding in northern Russia, the Baltic coast and the North Sea coast, staging in Germany, Sweden and Estonia, and wintering in northwest Europe, mainly in Germany and the Netherlands (Russian/Baltic/North Sea population) [1–3].

Habitat preferences and general densities

The main habitats used during the breeding season are polar tundra, wet moss-meadows and mudflats [3]. Barnacle geese nest colonially on steep cliffs or on islands [3], and in newly colonised areas in Russia and the Netherlands they also breed on mainland meadows [4]. On the wintering grounds, Barnacle geese forage on agricultural grassland and arable land, though traditionally unmanaged, coastal meadows and saltmarsh pastures were used [3].

Legal protection and conservation status

The Barnacle goose is listed in Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory

Species [5], under which the three flyway populations of the species are covered by the African-Eurasian Waterbird Agreement (AEWA). In the AEWA Action Plan, the East Greenland/Scotland and Ireland population is listed in Column B (category 1), the Svalbard/Southwest Scotland population is listed in Column A (category 3a) and the Russia/Germany and the Netherlands population is listed in Column C (category 1) [6].

Abundance: current status and changes

All populations of Barnacle goose have had positive trends and numbers increased greatly since regular monitoring began in the 1950s (Figure 1) [10]. The Greenland Barnacle goose population increased from around 8,300 individuals in 1960 to 80,670 in 2013 [11]. Wintering Barnacle geese of the Svalbard population were considered to be common in the Solway Firth in the early 20th century, but substantial declines had occurred by the 1930s [12, 13]. Numbers have been increasing since the 1960s [13], from 1,650 individuals in 1960 to 31,000 in 2013 [11] (Figure1). Russian Barnacle geese were considered numerous in the 19th century, but the population declined to 10,000 individuals by the early 1950s [14]. Numbers recovered to 20,000 in 1959–1960 and since then the population has increased exponentially [14] and the latest population estimate (2009) is around 908,000 individuals [4] (Figure 1).

Distribution: current status and changes

Greenland Barnacle geese breed along the east coast of Greenland. During the spring migration, they stage in northern Iceland and on their return in autumn they stage in the southeast of the island. Small numbers have bred in southern Iceland since the late 1980s [16]. The most important wintering area of the Greenland population is the island of Islay in west Scotland, where about two thirds of the population overwinter [16]. The wintering distribution extended north and east to Orkney in the early 1970s [16]. The foraging areas of Barnacle geese in northwest Scotland have shifted from under-grazed islands to islands with intensified agriculture [16]. In Ireland, wintering sites off the Dublin coast (Lambay Island and the Skerries Island) have been deserted in the last 10 years, the Blasket Islands became abandoned from the 1980s, and two further sites on the east coast (Wexford Slobs and Lurgangreen, Louth) have not been used since the 1950s [16].

Scale	Status	Justification
Global	Least Concern (since 1988)	Very large range and population size with an increasing population trend.
Europe	Secure (Non-SPECE)	Population size increased during 1970–1990 and 1990–2000 and the wintering range has expanded.
EU25	Secure	

Table 1. Global IUCN Red List status [7], European population and SPEC status [8] and EU population status [9] of Barnacle goose.

There were no breeding Barnacle geese in Svalbard in the latter part of the 19th century and it is possible that the Svalbard population was created from a small number of founding birds from the Greenland population [13]. Svalbard Barnacle geese winter exclusively on the Solway Firth on the southwest coast of Scotland [3]. The number and size of breeding colonies in Svalbard increased greatly up to the 1960s [13]. The main sites are the Dunøyane, the Forlandsøyane and the Nordenskiøldkysten along the west/southwest coast. During migration, Svalbard Barnacle geese stage on archipelagos off the coast of Norway, where they forage on fertilised grasslands, and on the island of Bjørnøya, between Norway and Svalbard [13].

Russian Barnacle goose breeding areas have expanded considerably since the early 1970s, when the breeding grounds in the Baltic region (Finland, Sweden) became established [14]. Prior to this, the only known breeding areas of the population were on Novaya Zemlya and Vaygach [14]. The breeding distribution then greatly expanded to the Barents

Figure 1. Size of the Barnacle Goose populations breeding in **Greenland** [11], **Svalbard** [11], and **Russia and the Baltic** [4], since the late 1940s/1950s.

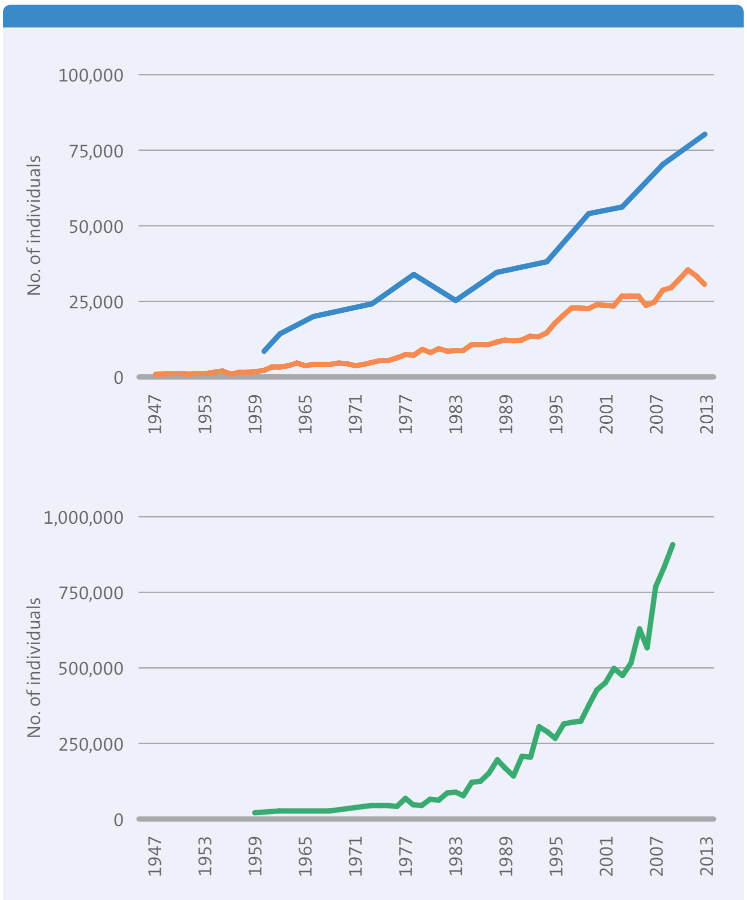

Figure 2.
Current **breeding** and **wintering** distribution of Barnacle goose in Europe and historical breeding distribution in the **1980s** [15].

Sea coast, and simultaneously south to the North Sea region, with colonies becoming established during the 1980s in Germany, Belgium and the Netherlands [17, 18]. The newly colonised areas are part of the flyway of the population, so it is likely that the founders were birds that stopped over at these sites during migration and remained to breed [2, 17]. The majority of the population still breeds in the Barents Sea area [18]. The wintering areas have also expanded since the 1950s, before which time the wintering areas did not reach as far south as the Netherlands [25].

Table 2.
Major threats that drove Barnacle goose decline and may still constrain the population [19, 20].

Threat	Description	Impact
Hunting and collecting	Unsustainable and illegal shooting. Historically, egg collecting used to be an important cause of decline, particularly in Russia [21].	Historically high
Persecution	Increased shooting from the 1970s due to damage caused to agriculture.	High
Agricultural abandonment	Abandonment of grazing in northwest Scotland and Ireland wintering grounds. Possibility of land use change under climate warming scenarios.	High
Human intrusions and disturbance	Disturbance, e.g. due to oil exploration activities in Greenland.	Medium
Problematic native species	Predation by Arctic fox (Vulpes lagopus) has an important impact on the Russian Barnacle goose population. Breeding sites in the North Sea are limited by predation by Red fox (V. vulpes) [17]. Reintroduction of White-tailed eagles (Haliaeetus albicilla) in parts of Scotland may have an impact on population dynamics through disturbance and/or predation events.	Medium
Residential and commercial development	Breeding grounds in Russia are threatened by development of oil and gas industry.	Unknown
Renewable energy	Potential impact of numerous wind farms planned or operational onshore and offshore in England, Scotland and Norway along migratory route and in wintering areas [22].	Unknown

Major threats

It has been suggested that the declines in the Svalbard population in the early part of the 20th century were partly the result of geese stopping short in their migration on Islay, as feeding conditions improved there with intensification of agriculture [13, 23]. However, unsustainable shooting on the Solway was also at least partly to blame [13]. In the mid-1940s, the low numbers of geese counted on the Solway were due to increased hunting pressure and disturbance during World War II [13, 24]. The population may be at risk due to the development of wind power plants along its flyway, as the geese would be vulnerable to collisions with wind turbines [22].

There are concerns over the long-term outlook for the Greenland Barnacle goose, as a very large proportion of the population uses a single haunt, Islay, while other wintering sites have declined in use or been deserted. The increasing agricultural conflict on Islay raises the possibility of strong reactions, such as culling, which could result in population-level impact [16]. Complaints by farmers about damage caused to agriculture has resulted in the establishment of scaring schemes in a number of countries, but they have had mixed effectiveness [16].

Agricultural conflict is not yet an important issue for the Russian/Baltic population [14], but it is a problem in the Netherlands and Belgium [4]. As a consequence, the breeding population in the Netherlands is currently being reduced by culling [26]. Management of the conflict with agriculture is the principal concern regarding the long-term sustainability of Barnacle goose populations.

Drivers of recovery

The dramatic increases in the numbers of Barnacle geese in all three populations since the 1950s are considered to be the result of increased habitat protection and reduced hunting pressure across the species' distribution [2, 13, 14, 16].

The recovery and expansion of the Russian Barnacle goose population since the late 1950s is at least partly attributable to protection from shooting [14]. Russian/Baltic Barnacle geese also benefitted from improved conditions in the wintering areas, where agricultural intensification has made good quality food available, particularly in the Netherlands [14]. Reduced exploitation and disturbance by people in the breeding grounds in Russia, as a result of depopulation in the region, has also been suggested as a possible factor [14]. Also the establishment of breeding Barnacle geese in the Baltic and the North Sea was in part thanks to the high food availability in agricultural areas in these regions, which provide good quality habitat for brood rearing [17].

Protection of feeding areas on the wintering grounds enabled the increase in Svalbard Barnacle geese after the 1950s, while enforcement of the shooting ban also became more effective during that time [13]. The Svalbard Barnacle goose population is one of the best studied populations of migratory geese in the world [13] and also has one of the most comprehensive network of key protected areas of any goose, swan or duck species [2]. There is a need for further research on the more poorly studied Greenland population [16].

There is a need for international cooperation to develop a sustainable conservation policy for the species at the flyway level, to ensure the continued effectiveness of management efforts.

Table 3. Conservation actions in place for Barnacle goose [19].

Action	Description
Site/area protection	There are 371 IBAs identified for the Barnacle goose in Europe, of which 68% are designated as SPAs or other protected areas and 6% are not protected. Protected areas at major breeding sites, feeding and roosting sites. However, site protection and enforcement in Russia is poor.
Livelihood, economic and other incentives	Compensation payments for farmers who suffer damage. Payments for goose-friendly management in NW Scotland and the Solway.
Monitoring and planning	Flyway Management Plan has been drafted for the Svalbard population. Regular monitoring is in place for all populations, but Greenland population is not as well studied [16].
Legislation	Protected by law in most countries, but seasonal or licensed hunting is allowed in some. Goose Management Scheme in NW Scotland and the Solway Firth. Management Scheme also in place in parts of Norway.

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4.3. Whooper swan

Cygnus cygnus

Summary

Intense hunting pressure drove Whooper swans close to extinction in Europe during the 19th and early 20th centuries. Improved protection, along with increased food availability, as the species switched to farmland habitats in winter, resulted in the recovery of Whooper swans, especially of the northwest European population. The ongoing increase in abundance has been accompanied by a southward extension of the breeding distribution of the species in continental Europe. As increasing numbers of birds are utilising agricultural land there is a conflict with farmers, due to the damage caused to crops and improved pastures.

Background

General description of the species

The Whooper swan (*Cygnus cygnus*) is a large, migratory swan species. Autumn migration begins in late September–October and birds return to the breeding grounds in March–April [1]. Sexual maturity is reached at around 4 years of age and 4–5 eggs are laid. In the winter, Whooper swans are gregarious, but in the summer breeding pairs are highly territorial, although non-breeders remain in flocks [1, 2].

Distribution in Europe

The Whooper swan breeds in the northern Palearctic, from Iceland and northern Scandinavia and across Russia [3]. There are two populations of the species in Europe: the Icelandic population, which breeds in Iceland and winters mainly in Britain and Ireland, though some birds winter in southwest Norway and northwest Denmark, and the northwest European population, which mainly breeds in Fennoscandia and northwest Russia, though an increasing number of birds breed in northern continental Europe, and mainly winters in continental Europe, though some birds winter in Norfolk, UK [4, 5].

Table 1. Global IUCN Red List status [12], European population and SPEC status [13] and EU population status [14] of Whooper swan.

Scale	Status	Justification
Global	Least Concern (since 1988)	Extremely large range, very large population size and, although the population trend is not known, it is not believed to be decreasing sufficiently rapidly to approach the threshold for Threatened.
Europe	Secure (Non-SPECEW)	Large wintering population, which was stable during 1970–1990 and increased overall during 1990–2000.
EU25	Secure	

Habitat preferences

The Whooper swan breeds in a variety of wetland habitats, such as islands in or adjacent to shallow lakes or marshes, and selects wetland areas with Horsetail (*Equisetum fluviatilis*) [1, 4]. In Germany, Poland, Lithuania and Latvia, Whooper swans breed in fishponds, while agricultural land is also utilised in Iceland [1, 6]. Until the early 20th century, Whooper swans traditionally foraged on aquatic vegetation during the winter, but since the 1980s most birds in Europe are now using arable land and improved pasture [1, 7–9].

Legal protection and conservation status

The Whooper swan is listed in Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species, under which all four populations are covered by the African-Eurasian Waterbird Agreement (AEWA) [10]. The Icelandic population is listed in Column A (category 2), and the northwest European population is listed in Column B (category 1) [11].

Abundance: current status and changes

Breeding Whooper swans came close to extinction in many countries during the 19th and early 20th centuries, except in Iceland and Russia [15]. However, recovery is currently ongoing for both populations of the species.

The results of the regular international mid-winter census of Icelandic Whooper swans show that the population was stable or fluctuating around 16,000–17,000 individuals until the mid-1990s and has since increased to nearly 30,000 individuals in 2010 (Figure 1) [7].

Substantial declines occurred in the northwest European population in the first half of the 20th century. For example, only 20 breeding pairs remained in Sweden by the 1920s [16, 17] and only 15 pairs in Finland by 1949 [18, 19]. However, the population increased greatly from the 1950s [20]. By 2012, 3,800 pairs were breeding in Sweden [17] and in 2010 there were 8,000 breeding pairs in Finland [19]. Periodic international censuses were initiated for the northwest European Whooper swan in the mid-1990s to document the ongoing increase in the population size, which is now estimated at 59,000 individuals (the final results are not yet available) [20, 21].

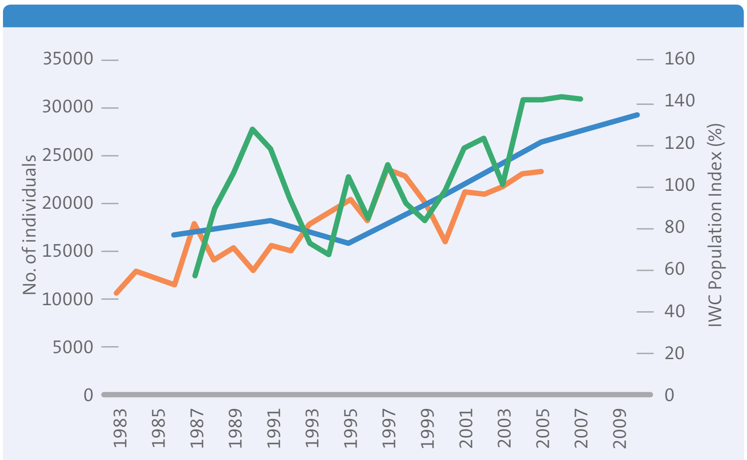

Figure 1. Number of Icelandic breeding Whooper swans in the **Icelandic** population since 1986 [7] and the International Waterbird Census population trends for the **Icelandic** and the **northwest European** populations [22].

Distribution: current status and changes

The breeding distribution of the species contracted northwards during the late 19th and early 20th centuries. For example, breeding Whooper swans were present in southernmost Sweden in

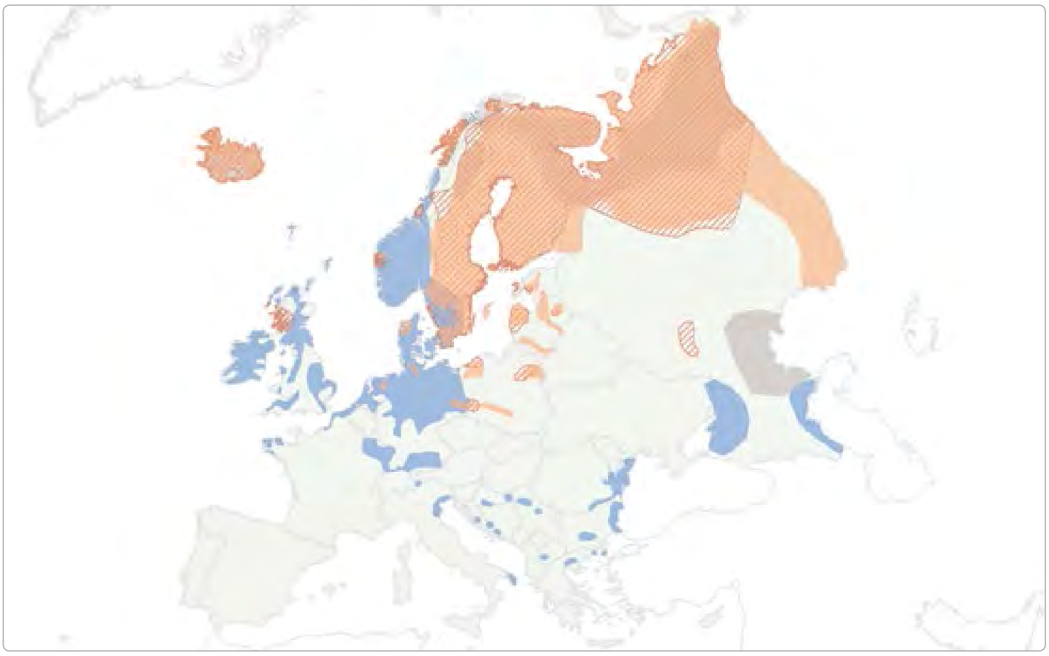

Figure 2. Current **breeding** and **wintering** distribution of Whooper swan in Europe and historical breeding distribution in the **1950s** [23] and **1980s** [24].

Threat	Description	Impact
Hunting and trapping	Hunting, trapping and egg collection.	High
Unintentional effects of hunting and trapping	Secondary poisoning from ingestion of lead pellets.	Medium
Natural systems modification	Drainage of wetland habitats.	Historically high
Transport and service corridors	Collision with overhead power cables.	Medium
Renewable energy	Planned wind power plant developments are likely to be an important cause of habitat loss for Icelandic Whooper swans.	Potentially high

Table 2. Major threats that drove Whooper swan decline and may still constrain the population [1, 4, 47].

Table 3. Conservation actions in place for Whooper swan [1, 4, 7, 52, 53].

the 1840s [25], but the species' distribution in the country contracted 1,100km northwards [16]. Since the 1950s, Whooper swans have been extending their distribution southwards in Norway, Sweden, Finland, and Russia, and have recently become established as a breeding bird in the Baltic States, Poland, Germany, Denmark, the Netherlands, Hungary, Belarus and Ukraine [5, 6, 26–44] (Figure 2), while first breeding in France was recorded in 2012 [45] and a small number breed in the UK [46]. In contrast, the winter distribution has not changed appreciably [8], although there are some indications of a southward shift in Britain and Ireland [7].

Action	Description
Legislation	Legally protected across its range and listed in various international treaties (see 'Legal protection and conservation status').
Site/area protection	There are 737 identified IBAs for Whooper swan in Europe, of which 61% are designated as SPAs or other protected areas and 9% are not protected. Most key wintering areas and many key breeding areas of the northwest European population are protected, but few foraging areas lie in protected areas. Few key sites for the Icelandic population are protected.

Major threats

Unsustainable hunting, trapping and egg collection were the main driver of the decline in Whooper swans in Europe during the 19th and early 20th centuries [48, 49]. Persecution drove the northwest European population northwards into poor quality habitat and unsuitable arctic climate, which resulted in declines in reproductive performance [4, 50]. Habitat loss through the drainage of wetlands is also likely to have had an adverse effect on Whooper swan population size [1, 6]. As the species switched to foraging in agricultural habitats, a conflict with agriculture has developed due to the damage caused to crops and pasture, which is the main ongoing threat to the species [7].

Other threats include lead poisoning from the ingestion of lead shot, collision with powerlines, and the risk posed by development of wind power plants in the UK [1, 51].

Drivers of recovery

The most important driver of the recovery of the species following the declines suffered prior to the 1950s is the protection of the species from hunting [1, 7]. Improvements in food availability during the winter, through the expansion and intensification of agriculture contributed to increase and range expansion of Whooper swans in northwest Europe [54]. Breeding in the Baltics also means that Whooper swans overwinter closer to their breeding grounds, resulting in a shorter migration [55], while milder winters have also been very beneficial to Whooper swan productivity [6].

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4.4. White-headed duck

Oxyura leucocephala

Summary

The White-headed duck is a globally Endangered species. In Europe, the only breeding population of the species is found in Spain, following considerable historic declines. The population in Spain declined in the 1960s and 1970s due to habitat loss and persecution, but effective conservation actions resulted in a remarkable recovery from 22 individuals in 1997 to around 2,000 today. The species' long-term survival is threatened by hybridisation with the non-native Ruddy duck, and considerable efforts are underway for the eradication of the Ruddy duck from Europe.

Background

General description of the species

The White-headed duck (*Oxyura leucocephala*) is the only species of stiff-tailed duck indigenous to the Palearctic [1]. White-headed ducks are chestnut-brown in colour and the males have a white head, black cap and blue bill. They are highly aquatic and are very rarely seen on land [2].

Distribution in Europe

Spain holds the only population of White-headed ducks in Europe, as defined in this study [3]. The population in Spain is resident, although birds congregate at certain sites during winter, the location of which depends on rainfall and other environmental conditions [2].

Habitat preferences

White-headed ducks breed on small, freshwater, brackish or eutrophic lakes with dense emergent vegetation around the fringes. Breeding sites are often temporary or semi-permanent, with a closed basin hydrology. They nest in dense reed beds, and sometimes old nests of Coot (*Fulica atra*) are utilised. During the non-breeding season, larger and deeper lakes or lagoons are used [4]. The species feeds by diving, mainly at night. Diet is composed mainly of invertebrates, particularly benthic chironomid larvae, but aquatic plants are also eaten [2].

Legal protection and conservation status

The White-headed duck is listed in Appendix II of CITES, Annex I of the EU Birds Directive, Annex

Table 1. Global IUCN Red List status [7], European population and SPEC status [8] and EU population status [9] of White-headed Duck.

Scale	Status	Justification
Global	Endangered (since 2000; was considered Vulnerable in 1994–1996 and Threatened in 1988)	The population has undergone a very rapid decline (>50% in 10 years or 3 generations).
Europe	Vulnerable (SPEC 1)	Large future decline (>30%) expected owing to the risk of hybridisation with introduced congener.
EU25	Vulnerable	

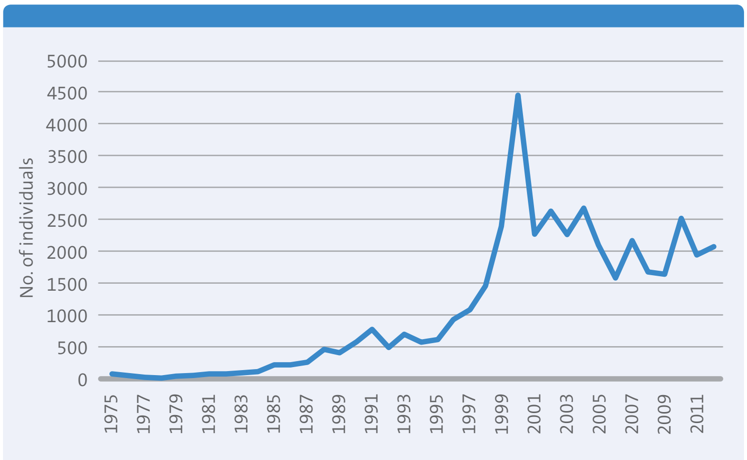

Figure 1. Number of White-headed Ducks in Spain since 1975 [13, 14].

II of the Bern Convention, and Annex I and II of the Convention on Migratory Species [5]. The West Mediterranean population (Spain and Morocco) is classified in Column A of AEWA (categories 1a, b and c) [6].

Abundance: current status and changes

In the early 20th century, the global population of White-headed ducks was over 100,000 individuals, but by 1996 it had declined to 20,000 [1, 10] and today it is estimated at 8,000–13,000 individuals [11]. In Spain, the number of birds declined from about 400 individuals in the 1950s [12] to a low point of 22 individuals in 1977 [13]. Since then, the population has increased by two orders of magnitude, and in 2012 there were 2,080 individuals [14] (Figure 1).

Distribution: current status and changes

Historically, the White-headed duck suffered dramatic declines in distribution in Europe. It became extinct as a breeding bird from Italy (1977), France (late 1960s), Morocco, Hungary (1961), Albania (1920), Serbia (1962), Croatia (1965), Romania (1920), Greece (19th century) and Ukraine [1, 3, 10, 12] (Figure 2). In Spain, the majority of the population has always been found in Andalucía, and during the late 1970s and early 1980s, the entire population was restricted to one wetland in Córdoba [12]. Following the increase in population size in the 1980s, there was considerable expansion of the species' distribution [1] (Figure 2).

Major threats

The greatest threat to the survival of the White-headed duck is hybridisation with the non-native North American Ruddy duck (*O. jamaicensis*) originating mainly from the feral population in the UK, which was introduced from captive collections in the 1950s [1, 16, 17]. Ruddy ducks have dispersed from the UK, reaching Spain, France, the Netherlands, Morocco, Scandinavia, the Czech Republic and Iceland and the population greatly increased [10, 14, 17, 18]. The introduction of Carp (*Cyprinus carpio*) in Spain is also a major threat [19], as habitat modification by the fish amounts to habitat loss for White-headed ducks [1].

In Spain, fluctuations in climate have been shown to influence the population dynamics

Figure 2. Current distribution of White-headed duck in Europe and historical distribution in the early 20th century [12] and in 1977 [15].

of White-headed duck, with increased precipitation during the late summer months resulting in improved recruitment of juveniles to the breeding population, probably through enhanced food availability [20]. The increasing frequency of droughts brought about by climate change will probably have significant adverse effects on the species in Europe, but also in the rest of its global distribution. Simulation of the potential future distribution of the species under climate change suggests that suitable habitat in Europe may not be available in future and that the species has little prospect of long-term survival in Europe [21].

Habitat loss and degradation due to drainage of wetlands for agriculture and infrastructure development were thought to be the most important drivers in the historical decline of the species [22]. It is estimated that in the 20th century half of the area of suitable breeding habitat across the species' distribution was lost [12], while in Andalucía more than 60% of suitable lagoons have been drained [1]. Inadequate management of wetlands in Spain can result in the habitat drying out and also increases the impact of pollution and eutrophication [10].

White-headed ducks lack an escape response when faced with hunters, so they are very easy to shoot [23] and hunting was another important driver of the historical decline of the species. It was considered to be main reason for the declines in White-headed duck population in Spain before the late 1970s [24], while in France, Italy and former Yugoslavia, hunting and egg collection were probably the final causes of extinction [10]. Poaching is known to occur in a number of countries, including Bulgaria [25] and Greece [26].

Diving ducks suffer from lead poisoning through ingestion of lead shot found in wetland sediments. Hunting pressure at many key sites in Spain was high in the past and so they are likely to hold high densities of lead shot. Ingestion of lead in the gizzard can result in significant mortality [10, 27].

Drivers of recovery

White-headed ducks are legally protected in all countries in Europe where they are found, both during the breeding and the non-breeding season. However, enforcement in some countries (e.g. Greece and Bulgaria) is not effective and should be improved [28]. Designation of IBAs is effectively complete in Spain [10, 28]. Protection from hunting in Andalucía was the most important factor that enabled the remarkable recovery of the White-headed duck population in Spain [29, 30]. Habitat management and restoration measures, such as control of pollution, vegetation management and removal of introduced fish species, have also contributed [29].

In response to identification of the threat posed by hybridisation with Ruddy ducks, an international action plan was put in place for the elimination of Ruddy ducks in the Western Palearctic [18]. Ruddy duck control is implemented in 15 countries in the Western Palearctic, including Spain, the Netherlands, Belgium, France and the UK [11, 18]. The control programme in the UK was successful in

Threat	Description	Impact
Invasive non-native/alien species	Hybridisation and competition with North American Ruddy duck (*O. jamaicensis*).	Critical
	Habitat degradation caused by introduced of Carp (*Cyprinus carpio*) in lagoons in Spain.	High
Climate change and severe weather	More frequent droughts due to climate change result in habitat degradation.	Critical
Natural system modifications	Habitat loss through drainage of wetlands for agriculture across breeding and wintering range.	Critical
	Inadequate wetland management can result in habitat loss and degradation.	High
Residential and commercial development	Habitat loss through drainage of wetlands for infrastructure development across breeding and wintering range.	Critical
Hunting and collecting	Illegal and unsustainable hunting.	High
Unintentional effects of hunting and fishing	Lead poisoning through ingestion of lead shot.	High
	Disturbance from hunting, fishing and boating activities during the breeding season.	Low
	Trapping and drowning in fishing nets.	Local
Pollution	Habitat degradation through pollution from agriculture and industry.	Medium
Problematic native species	Predation by Brown rats (*Rattus norvegicus*)	Local

Table 2. Major threats that drove White-headed duck decline and may still constrain the population [1, 10].

Table 3. Conservation actions in place for White-headed duck [1, 10, 11, 28].

Action	Description	Impact
Site/Area protection	There are 70 IBAs identified for White-headed duck in Europe, of which 43% are designated as SPAs or protected areas and 14% are not protected. In Spain, 100% of the population is included in IBAs and 90% of these are designated as SPAs.	High
	Protection of nesting sites, particularly in Spain.	High
Site/Area management	Management and restoration of key sites in Spain and France, including removal of introduced fish and control of pollution.	Low
	Control of Ruddy ducks in many countries, including Spain, the Netherlands, Belgium, France and the UK.	Critical
Species reintroduction	Planned reintroduction projects in Majorca and Italy, and reintroduction attempts in Hungary and France. Captive breeding programme and release of birds in Spain.	Low
Monitoring and planning	International Species Action Plan in place. Regular monitoring in Spain.	Medium
Legislation	Legally protected in many countries, and fully protected under European law.	Low
Education and awareness	All individuals or organisations holding Ruddy ducks in captivity in Spain were contacted to request that all reproduction and escape of the species is prevented.	Medium

reducing the population in the country by over 95% [30]. As a result, Ruddy duck observations have decreased substantially in Spain [30].

A reintroduction project conducted during the 1980s in Hungary was not successful in establishing a breeding population due to poor choice of release site (not past breeding site for the species, exposed to human disturbance, potentially poor quality habitat) and poor preparation, which did not include identification and rectification of the factors that caused extinction in the first place [31]. A reintroduction on Corsica in 2001 also failed to produce a self-sustaining population [32]. Reintroduction projects are being planned in Italy and in Spain [10], but proposals are postponed until complete eradication of Ruddy ducks has been achieved [10, 33].

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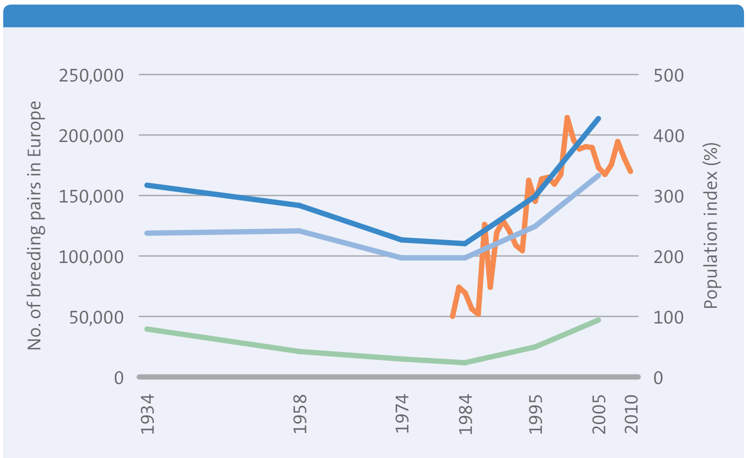
4.5. WHITE STORK

Ciconia ciconia

SUMMARY

The White stork declined until the mid-1980s due to poor feeding conditions, caused by adverse climatic conditions in the wintering areas in Africa and changing agricultural practices in Europe. The species has since increased in abundance and expanded its range. Improved food availability in both breeding and wintering areas has contributed to this ongoing recovery, while reintroduction projects have enabled recolonisation of breeding areas. Changes in migration and feeding strategies are driving the large increase in White storks in southwestern Europe. Population changes in eastern Europe are less well understood and may be more dependent on conditions in the wintering areas.

FIGURE 1. Estimated number of White Stork breeding pairs in **EUROPE**, in the **EASTERN** and **WESTERN** populations, according to International White Stork Censuses (dots), and **TREND** in the PECBMS population index since 1980 [19].



BACKGROUND

General description of the species

The White stork (*Ciconia ciconia*) is a large charismatic species with close associations to human culture, and is a flagship species for conservation in Europe [1]. It is a seasonal migrant to Europe, arriving in early spring, nesting from March to June [2], and departing for Africa in August, although some south-western breeders now winter in Iberia. White storks feed on a variety of prey including insects, amphibians, snakes, lizards, small birds, molluscs, crustaceans and small mammals [3].

Distribution in Europe

The species is widely distributed, occurring throughout continental Europe, with the majority of the breeding population concentrated in eastern Europe [4]. The present distribution of the species reflects recolonisations and reintroductions in countries where it became extinct in the past, as well as ongoing eastward expansion in eastern Europe [5, 6].

Most authorities recognise two populations [7, 8]. Most birds from eastern Europe (eastern population) migrate to Africa via the Bosphorus and winter in the eastern half of Africa, as far south as the Western Cape in South Africa. Birds from western and south-western Europe (western population), enter Africa across the Straits of Gibraltar and winter in the northern tropics of West Africa [2, 5].

Habitat preferences

In its breeding range in Europe, the White stork inhabits a variety of open habitats in the vicinity of water, including wetland margins, moist grassland, paddy fields, irrigated cropland or pasture. Nest sites are usually elevated on cliff ledges, tree tops, roofs or pylons [2, 3].

Scale	Status	Justification
Global	Least Concern (since 1994; was considered Near Threatened in 1988)	Extremely large range Increasing population trend Very large population size
Europe	Depleted (SPEC 2)	Increasing but not yet recovered from large historical decline
EU25	Depleted	

Table 1. Global IUCN Red List status [10], European population and SPEC status [11] and EU population status [12] of White stork.

Legal protection and conservation status

The White stork is listed on Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species [9], under which it is covered by the African-Eurasian Waterbird Agreement (AEWA). The eastern and western populations are currently listed in columns C (category 1) and A (category 3b) in the AEWA action plan, respectively [7].

Abundance: current status and changes

The latest International White stork Census (2004/5) estimated the current population size in Europe to be 213,690 breeding pairs (Table 2). In descending order, Poland, Spain, Ukraine, Belarus, Lithuania, Latvia, Russia and Portugal hold the largest numbers of breeding White stork, together supporting 82% of the total European population [6]. This highlights the importance of central and eastern Europe and southwestern Europe for the species.

A decreasing trend in White stork populations in Europe was noted since the early 1900s [13, 14] and international censuses of White stork breeding populations have been carried out regularly since 1934 [6]. Numbers declined up to 1984 (Figure 1), but trends varied across the breeding range [5, 15]. The western population experienced the most dramatic declines and the species went extinct in parts of its range, including Belgium in 1895 [15], Sweden in 1950 and Switzerland by 1958 [16]. The eastern population also decreased, but at a lower rate, while in some countries in eastern Europe (Poland, Slovakia, Estonia, Belarus and Ukraine) numbers were stable or increased [15, 17].

The recovery of White stork populations became apparent from the 1994/5 census [4] and the trend continued to be positive in the 2004/5 census (Figure 1, Table 2). Growth rates in the western population were higher than in the eastern population, where some populations remained stable (e.g. Belarus and Ukraine). However, in Denmark the decline was ongoing, and the species was declared extinct in 2008 [18].

Distribution: current status and changes

Evidence suggests the species was much more widespread in the past. White stork distribution historically probably included most of France [13], as well as Greece, where the species' range retreated to the north of the country in the 1800s [22]. There

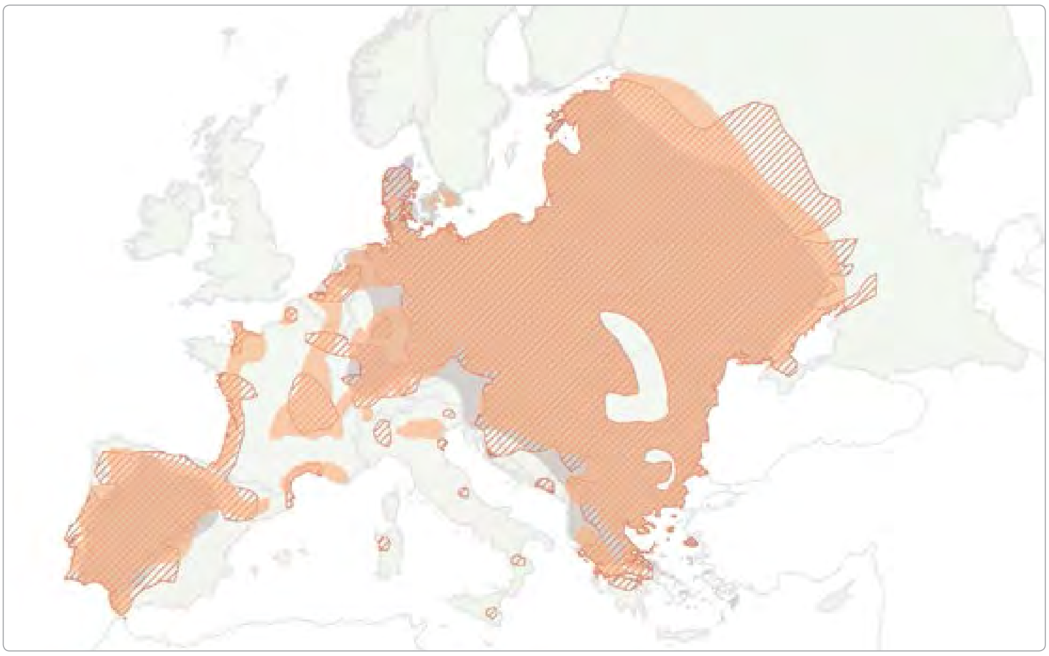


Figure 2. Current breeding distribution of White stork in Europe and historical distribution in 1949 [13] and in the 1980s [21].

Country	No. of breeding pairs	Trend	%
Albania	3	+	
Austria	395	+	
Belarus	21,362	+	10
Belgium	50	+	
Bosnia and Herzegovina	40	–	
Bulgaria	4,826	+	2
Croatia	1,700	+	1
Czech Republic	814	+	
Denmark	3	–	
Estonia	4,500	+	2
France	975	+	
Germany	4,482	+	2
Greece	2,157	+	1
Hungary	5,200	+	2
Italy	50	+	
Latvia	10,600	Stable	5
Lithuania	13,000	+	6
FYRO Macedonia	500 [20]	Stable	
Moldova	491 [20]	Stable	
Netherlands	562	+	
Poland	52,500	+	24
Portugal	7,685	+	3
Romania	5,500	+	2
Russia	10,200	+	5
Serbia	1,080 [20]	+	
Slovakia	1,331	+	1
Slovenia	240	+	
Spain	33,217	+	15
Sweden	29	+	
Switzerland	198	+	
Ukraine	30,000	+	14

Table 2. White stork population estimates in Europe according to the 2004/2005 International White Stork Census [6], indicating those countries that hold at least 1% of the European population.

is evidence that the White stork breeding distribution included Italy until the 16th century, with recolonisation recorded from 1959–60 [23].

White stork distribution in Europe increased by 28% between 1949 and 2012 (Figure 2), with substantial expansion occurring in Iberia and France. Parts of Italy and France were recolonised by the species, as well as Belgium, Switzerland and Sweden – countries from which the White stork had become extinct in the past. Areas outside the historic range have also been colonised. In particular, an eastward expansion is apparent in the eastern part of the distribution in Ukraine and Russia [24, 25].

Major threats

One of the major reasons for the decline of the western White stork population before 1984 was the prolonged drought during 1968–1984 in the western Sahel region, where this population winters [4]. The drought resulted in poor food availability in the wintering areas, and this has been shown to affect the breeding populations of White storks [14]. The climate in the eastern Sahel has also been shown to have a significant impact on the eastern population, as migrating birds stopover in this region to replenish their reserves, and droughts in the mid-1980s had negative effects on the eastern White stork population [28].

Food resources for White storks in their African wintering grounds are also negatively affected by overgrazing and the excessive use of pesticides [5]. Reduced food supplies are one of the major threats to White stork populations [4], as poor feeding conditions result in delayed migration and poor productivity [29, 30].

Declines in food availability are also important threats in the European breeding grounds. In western Europe, agricultural intensification and wetland drainage reduced food resources and were major contributing factors to the declines in the western White stork breeding population [5, 6]. The recent accession of Central and Eastern European countries to the EU will result in changes in agricultural practices, which could affect eastern White stork populations [6].

White storks are vulnerable to collision with and electrocution by overhead power lines, which were extended in Europe from the 1950s. The effects of this source of mortality may be localised [5, 31], but there is evidence that they may be severe enough to result in population-level effects [32–35].

It has been suggested that hunting of the species during the 1800s limited its distribution, e.g. in France [13] and Greece [22]. However, thanks to its special status in human culture, the White stork has benefitted from low levels of persecution across its breeding range in Europe [e.g. 36], although hunting during migration [37, 38] and in the wintering areas [2, 3, 39] is an ongoing threat.

Drivers of recovery

The large increase in White stork populations in Iberia since the mid-1980s partly reflects climatic changes in the wintering range, with less severe drought periods in West Africa [4, 6]. Climate change could also potentially be contributing to the ongoing eastward expansion of the White stork breeding distribution [6].

The increase in eastern populations since 1984 may be due to improved feeding conditions as a result of the extensification of farming practices that followed the collapse of socialist

agriculture [4, 6]. It is also possible that changing climatic conditions in eastern Europe may be driving eastward expansion in the range of the species, but this has not been confirmed as yet [41]. Conversely, expansion of irrigated agriculture in Spain resulted in an increase in food availability for the species [4, 42]. Moreover, the invasive Louisiana crayfish, *Procambarus clarkii*, which was introduced to southwestern Europe from South America, is now an important food resource for White storks in Iberia, and this has contributed to the increase in population size and range expansion of the species in this region [43–45].

White storks in Iberia and France have been utilising open landfill sites for foraging since the 1990s [46–50], a behaviour that was recently observed in the eastern population for the first time [51]. Year-round availability of food has enabled an increasing number of White storks in south-western Europe to forego migration and overwinter on their breeding grounds [6, 42, 48, 52], which may have positive effects on the population [4, 30, 53, 54]. However, open landfills will soon be closed under the EU Landfill Directive [55] and the resulting impacts on the western population of White storks are uncertain.

Targeted conservation action in the form of reintroduction projects has contributed to the recovery of White stork populations in a number of countries, including the Netherlands, France and Italy, while also enabling the recolonisation of countries in which the species became extinct, such as Belgium, Switzerland and Sweden [4, 5, 30]. However, these projects are controversial, as reintroduced storks do not demonstrate natural migration behaviour and remain on the breeding grounds

Table 3. Major threats that drove White stork decline and may still constrain the population [5, 10, 26, 27].

Threat	Description	Impact
Residential and commercial development	Loss of foraging areas and breeding sites.	Medium
Agricultural intensification	Especially loss of habitat (e.g. loss of hay meadows, grassland cultivation, crop changes, overgrazing), but also pesticide use.	High
Agricultural abandonment	Abandonment of pastoral grassland and afforestation of farmland.	High
Transportation and service corridors	Collision with and electrocution from overhead powerlines.	High
Hunting and collecting	Hunting, mainly during migration and in wintering areas.	Low
Persecution/ control	Destruction of nests on electricity pylons or other structures for maintenance.	Low
Natural system modifications	Drainage of wet meadows and inland wetlands. Flood prevention and water-level regulation.	High
Pollution from agriculture	Excessive use of pesticides, especially in wintering grounds.	High

Action	Description	Impact
Monitoring and planning	International census every 10 years.	Medium
	Established national censuses and monitoring schemes [27].	
Site/area protection	894 IBAs identified for White stork in Europe, of which 56% are designated as SPAs or other protected areas and 7% are not protected.	High
	Protection of wet grassland areas.	
Site/area management	Habitat management.	High
Species management	Artificial nest creation.	Medium
	Reintroduction programmes.	Low
Livelihood, economic and other incentives	Agro-environmental schemes.	Potentially high
Education	Education or awareness programmes [e.g. 40].	High
Legislation	Listed under a number of international conventions and agreements (see 'Legal protection and conservation status' above).	High

Table 4. Conservation actions in place for White stork.

in winter, where they are dependent on supplementary food provisioning [20].

Conservation effort in a number of countries is directed towards mitigating the threat from overhead power lines by using stork-friendly modifications, as well as erecting artificial nesting platforms [32, 40, 42, 56].

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4.6. Eurasian spoonbill

Platalea leucorodia

Summary

The Eurasian spoonbill declined dramatically after the 19th century as a result of habitat loss, caused mainly by drainage of wetlands. With the establishment of international treaties and conventions for the protection of the species and its habitat, the majority of breeding sites are now protected across its range in Europe. Habitat protection and management has been crucial in enabling the recovery of Eurasian spoonbills in Europe. Population size is increasing in most parts of Europe, along with evidence of recolonisation and range expansion.

Background

General description of the species

The Eurasian spoonbill (*Platalea leucorodia*) is a wading bird, characterised by is distinctive appearance and in particular its spoon-shaped bill. There are four or five subspecies, of which the nominate subspecies, *P. l. leucorodia*, is found in Europe [1]. This is in turn separated into two flyway populations, which differ in their breeding distribution: the Atlantic population and the and Central/Southeast European, or continental, population [2].

Both European populations are migratory. The Atlantic population migrates along the East Atlantic coast to winter in west Africa, though some overwinter in northwestern Spain and Portugal and an increasing number remain in France during the winter. The continental population uses two main migration routes, though with substantial crossover: western breeders tend to migrate south-west through Italy to North Africa, while eastern breeders usually head south-east through the Balkans, Anatolia, the Middle East and the Nile Delta to the Upper Nile [2, 3].

Table 1. Global IUCN Red List status [7], European population and SPEC status [8] and EU population status [9] of the Eurasian spoonbill.

Scale	Status	Justification
Global	Least Concern (since 1988)	Extremely large range, very large population size and not believed to be decreasing.
Europe	Rare (SPEC 2)	Small population size (<10,000 pairs).
EU25	Rare	Small population size (<5,000 pairs).

Distribution in Europe

Eurasian spoonbills are found across the Palearctic, but their distribution is fragmented. The species breeds from Europe to China. The Atlantic population breeds in western Europe, and was much more expansive in the past. The continental population breeds in the Danube river basin, northern Italy, the Carpathian Basin, Greece, the Black Sea region and Anatolia.

Habitat preferences

It inhabits tidal areas, river deltas and estuaries, alluvial wetlands, lakes and, the continental population in particular [3], artificial wetlands, such as carp fish farms or reservoirs [2]. It is a colonial breeding bird and colonies are mixed with other species, including herons, cormorants and gulls. Eurasian spoonbills nest in trees, reed beds or dunes. They forage in mudflats or other shallow open waters for small fish, shrimp or other aquatic invertebrates [2, 4].

Legal protection and conservation status

The Eurasian spoonbill is listed in Appendix II of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention, Annex II of the Convention on Migratory Species, under which it is covered by the African-Eurasian Waterbird Agreement (AEWA) [5]. Both populations in Europe are currently listed in column A (category 2) in the AEWA action plan [6].

Abundance: current status and changes

The Eurasian spoonbill continental flyway population (central and southeastern Europe/ Mediterranean) has shown an uncertain but negative trend between 1988 and 2006, declining by 2.1% per year [10] (Figure 1). This apparent decline is mostly driven by severe decreases in Russia and Turkey [3]. However, the part of the population that is included in Europe, as defined in this study, is in fact increasing [3] (Table 2). The most important populations for the European part of the continental flyway are Hungary and Romania, which together make up more than 70% of the total flyway population and both of which are increasing [11, 12] (Table 2). New colonies have also recently been established in Italy, the Czech Republic and Slovakia [3, 13].

The Atlantic flyway population (west Europe and west Mediterranean) on the other hand,

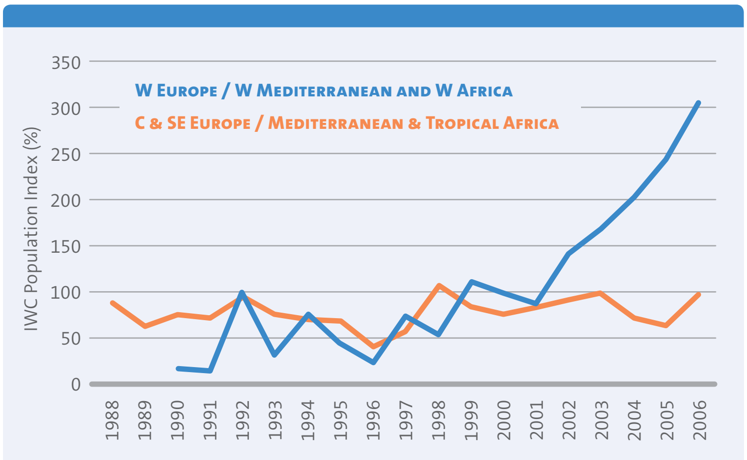

Figure 1. International Waterbird Census (IWC) Population Index [15] showing the trend between 1988/1990 and 2007 of the two flyway populations of Eurasian spoonbills found in Europe.

Country	No. of breeding pairs	No. of colonies	Year	Population trend	%
East Atlantic flyway					
Belgium	18	1	2009 [18]	+	
Denmark	57	4	2008	+	1
France	562–618	7	2012 [19]	+	11
Germany	220	9	2007	+	4
Netherlands	2,542	39	2012 [20]	+	49
Portugal	92–99	10	2002	+	2
Spain	1,631	12	2007	+	32
United Kingdom	8	1	2011 [21]	+	
Continental flyway					
Albania	0	0	2005		
Austria	38	1	2006	Stable	1
Bosnia and Herzegovina	0	0	2000		
Bulgaria	55–150	7	2007	Stable	2
Croatia	120–280	3	2013 [22]	Stable	5
Czech Republic	3	1	2007	+	
Greece	221	4	2009 [23]	Fluctuating	6
Hungary	1,200–1,400	16	2011 [24]	+	33
Italy	105–110	3–5	2007	+	3
Moldova	10–20	1	2012 [25]	-	
Montenegro	30	1	2013 [26]	+	1
Romania	1,400–1,600	17	2006	+	38
Serbia	195–280	5	2008	+	6
Slovakia	0–35	1	2012 [27]	Fluctuating	
Ukraine	200–250	14	2009 [28]	?	6

Table 2. Latest population estimates of Eurasian spoonbill breeding populations in Europe, indicating those countries holding more than 1% of the total population for each flyway. Unless otherwise stated, data from International Single Species Action Plan for the Conservation of the Eurasian Spoonbill [3].

increased by 19.4% per year during 1990–2006 [10] (Figure 2) and according to the most recent estimates numbers around 5,000 breeding pairs (Table 2). Nearly half of the population is found in the Netherlands, while Spain holds more than 30% and France more than 10% of the total flyway population (Table 2).

The Atlantic flyway population more than doubled between 1991 and 2012 (Figure 2). The key population in the Netherlands, which has been regularly monitored [14], began increasing in the 1980s and by 2012 there were more than seven times as many breeding pairs as there were in 1962 (Figure 2).

Distribution: current status and changes

Eurasian spoonbills of the Atlantic population used to breed across a much wider range in the 19th century [3, 14], but the species' distribution declined

dramatically by the 1950s, when breeding spoonbills were found only in the Netherlands and southern Spain (Figure 3). These two regions continue to dominate the Atlantic population today [3], but it is evident that substantial recovery has taken place since. Recolonisation has taken place on the west coast of France in the early 1980s, in Germany and Denmark from the mid-1990s, and in Belgium from 2000 [3, 14, 29] (Figure 3). In the UK the first breeding colony of spoonbills in more than three centuries became established in 2010 [21]. The continental population is also recovering from historical declines [3]. The colonies in the Po Delta in Italy, for example, became established around 1990 [13].

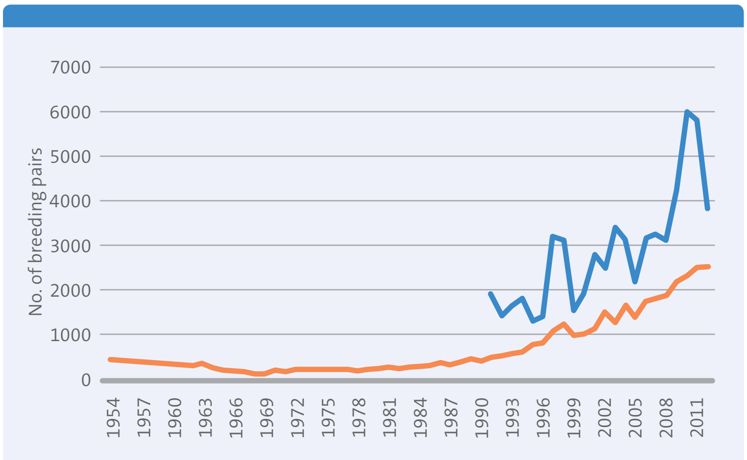

Figure 2. Number of Eurasian spoonbill breeding pairs in the **Atlantic flyway population** since 1991 and in the **Dutch population** since 1962 [16, 17].

Major threats

Loss of wetland habitat through water management was the main cause of the severe declines that Eurasian spoonbills suffered historically [3, 14, 16]. Wetlands were drained for agricultural purposes or development, converted to fish farms, or became overgrown as a result of abandonment of grazing [3].

Poaching and collisions with overhead electricity cables are the main non-natural causes of death during migration [3]. Illegal hunting is a particular problem for continental Eurasian spoonbills, especially in staging areas between wintering and breeding sites [3].

Drivers of recovery

All major breeding sites for Eurasian spoonbills in the Atlantic and most in the continental distributions have been given protected status [3]. Protection and management of wetland habitats is the major driver behind the recovery of the Atlantic Eurasian spoonbills [14].

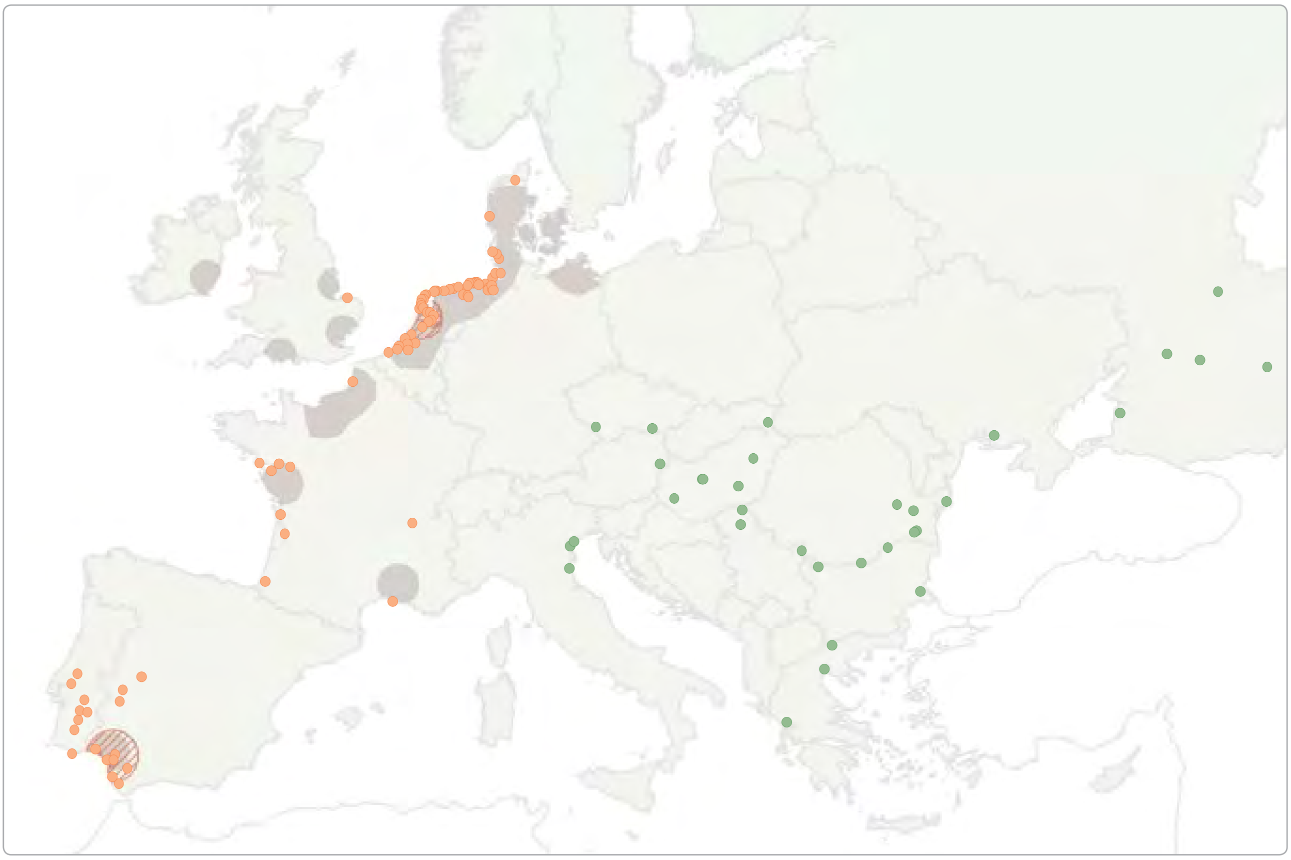

Figure 3. Current distribution of Eurasian spoonbill colonies in Europe, showing the area of breeding distribution of the Atlantic flyway population in the **1800s** and **1950s** [14]. Current **Atlantic flyway** and **Continental flyway** are also shown.

Threat	Description	Impact
Residential and commercial development	Loss of breeding and wintering habitat as a result of infrastructure development.	High
Natural system modification	Loss of wetland breeding habitat as a result of water regime intervention, mainly for intensive agriculture, or fishpond abandonment and land reclamation.	High
?	Loss of trees for nesting, especially in southern Spain (Doñana)	High
Climate change and severe weather	Extreme weather events (e.g. flooding, drought) result in suboptimal water levels in breeding and feeding habitats, and springtime storms can result in the death of eggs and chicks.	High
	Climate change will affect habitat availability.	High
Hunting and collecting	Illegal hunting in the Balkans.	High
Unintentional effects of fishing and harvesting aquatic resources	Competition for food with fisheries.	Medium
Pollution from agriculture	Pollutants from agricultural run-off results in reduced productivity and survival, especially in wintering grounds in Africa, where DDT is used.	Medium
Transportation and service corridors	Collision with powerlines, often during migration at river deltas with large ports or industry.	Medium
Problematic non-native/alien species	Habitat degradation due to alien invasive water fern species Azolla filiculoides in southern Spain.	Medium
Problematic native species/diseases	Competition for nesting sites with other species, e.g. Great cormorant (Phalacrocorax carbo) and large gulls.	Low/Local
	Natural predation by e.g. foxes, wild boars.	Medium/Low
	Disease e.g. botulism or ectoparasites can cause high mortality.	Medium
Human intrusion and disturbance	Disturbance at breeding or feeding sites from tourism, farming operations and military aircraft exercises.	Medium/Low

Table 3. Major threats that drove the Eurasian spoonbill decline and may still constrain the population [3].

Action	Description
Site/Area protection	There are 308 IBAs identified for Eurasian spoonbill in Europe, of which 58% are fully designated as SPAs or other protected areas and 7% are not protected.
	Protected areas cover most breeding sites and some sites important during migration and wintering.
Monitoring and planning	International Species Action Plan in place and national or regional Special Action Plans and/or specialist working groups are in place in some countries (Netherlands, Spain, Hungary, Romania, Serbia).
	Systematic monitoring in place in most countries in Europe, including an international colour ringing scheme.
Habitat and natural process restoration	Wetland restoration and management of breeding colonies and feeding sites (France, Spain, Croatia, Slovakia).
Ex-situ conservation	Captive breeding ongoing in Spain.
Education and awareness	Education campaigns and communication with stakeholders (Bulgaria, Hungary, Serbia).
Legislation	Full legal protection across species' range in Europe.

Table 4. Conservation actions in place for Eurasian spoonbill [3].

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4.7. Dalmatian pelican

Pelecanus crispus

Summary

The Dalmatian pelican is a globally threatened species, which suffered large declines in the last centuries due to habitat loss and degradation and persecution. In Europe the species has shown a remarkable recovery, especially in Greece, where it has benefitted from targeted conservation efforts and the most complete implementation of the European Species Action Plan. However, enforcement of protection legislation remains poor in most countries, while birds are still under threat from disturbance, overhead power lines and habitat degradation.

Background

General description of the species

The Dalmatian pelican (*Pelecanus crispus*) is the largest species of pelican and one of the largest bird species in the world [1]. It is globally threatened and listed as Vulnerable on the IUCN Red List (Table 1), with a global population of 4,000 – 5,000 breeding pairs, the majority of which breed in the former USSR, Kazakhstan in particular [2, 3]. The largest known colony of Dalmatian pelicans is in Lake Mikri Prespa in north Greece, while the Danube Delta in Romania is also a key site for the species [3] (see also Table 2).

Dalmatian pelicans feed exclusively on fish, and tend to forage up to 190km away from the breeding colony singly or in small groups [4]. Diet composition varies according to the relative abundance and distribution of prey species [4]. Communal fishing with cormorants (*Phalacrocorax*) has been recorded in Greece [5].

The breeding season begins in late January to April and each pair produces two eggs [6]. Dalmatian pelicans reach sexual maturity at 2 to 4 years [6]. They migrate short distances to the wintering areas in deltas and other coastal areas of the Mediterranean Sea, the Caspian Sea and the Persian Gulf in the autumn [4].

Table 1. Global IUCN Red List status [10], European population and SPEC status [11] and EU population status [12] of the Dalmatian pelican.

Scale	Status	Justification
Global	Vulnerable (since 2004; considered Lower Risk/Conservation Dependent in 2000, Vulnerable in 1994 and Threatened in 1988)	Rapid population declines outside the species' range in Europe are suspected to be continuing.
Europe	Rare (SPEC 1)	Small population size.
EU25	Rare	

Distribution in Europe

The Dalmatian pelican used to breed across western Europe during the Neolithic period, with fossils found as far west as Great Britain [7]. Today, the species is restricted to eastern parts of its range in Europe (from Montenegro to Greece and south and east Ukraine to south Russia)[3]. Elsewhere, Dalmatian pelican distribution includes west and northeast Turkey and extends east to Kazakhstan and west Mongolia and China[3].

Habitat preferences and general densities

Breeding colonies are found on lakes, estuaries and deltas, mostly in fresh water [4], but some colonies in Albania, Romania, Greece and Turkey are found in brackish lagoons [8]. Dalmatian pelicans prefer to breed and roost in reed beds, floating islands of vegetation or sand banks that are completely surrounded by water and are free from disturbance and inaccessible to mammalian predators such as foxes, wild boars and jackals [4, 9]. They are highly faithful to traditional breeding grounds, though colonies may relocate if a site becomes degraded or disturbed [4].

Legal protection and conservation status

The Dalmatian pelican is listed in Appendix I of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention, Annex I and II of the Convention on Migratory Species, under which it is covered by the African-Eurasian Waterbird Agreement (AEWA). The population in Europe (Black Sea and Mediterranean) is currently listed in column A (categories 1a–c) in the AEWA action plan.

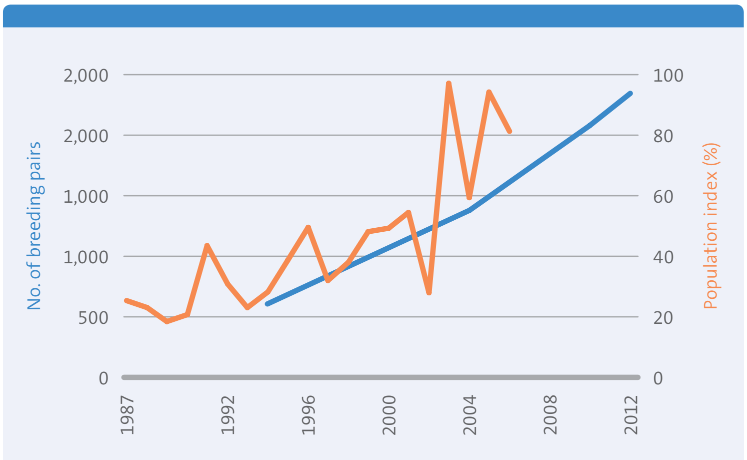
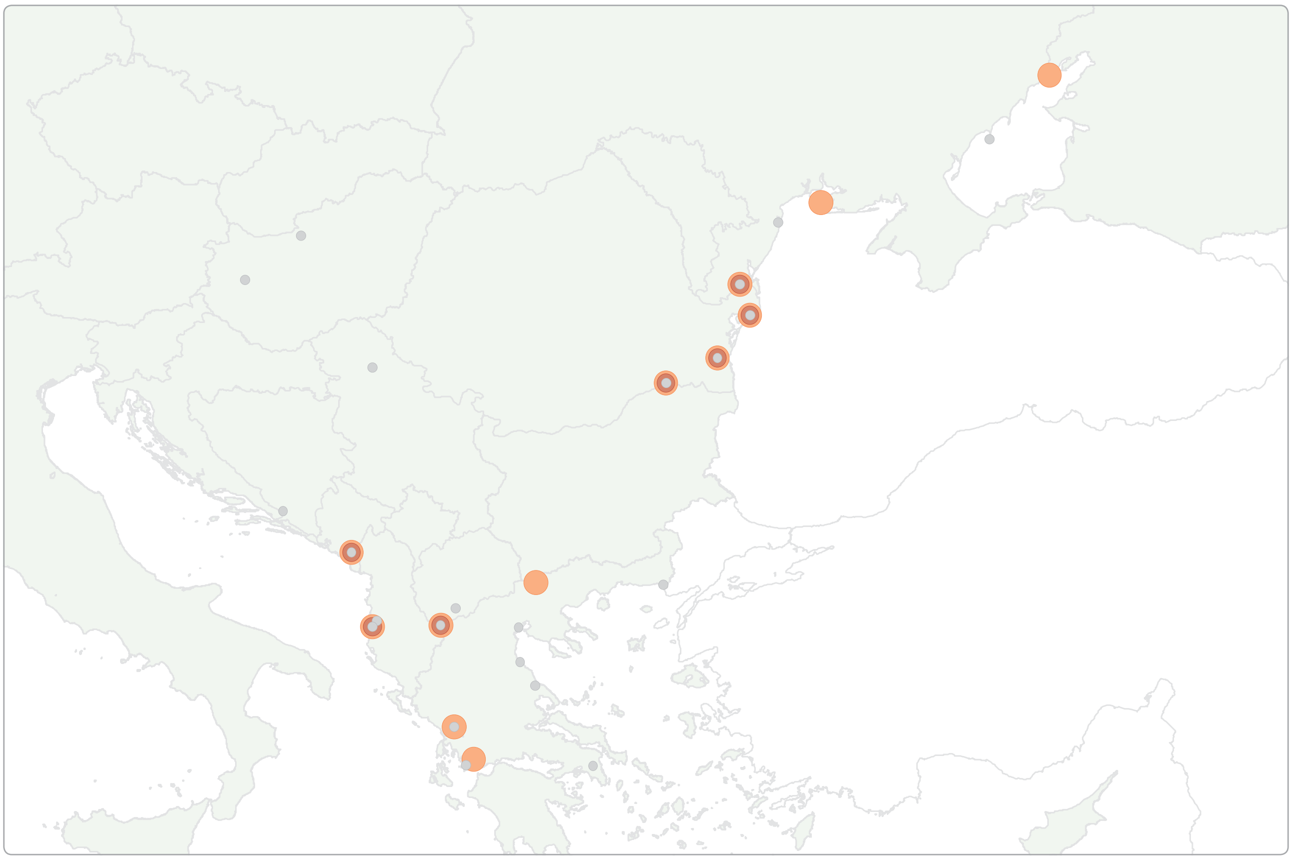


Figure 1. **Number** of Dalmatian Pelican breeding pairs in south-eastern Europe since 1994 and the International Waterbird Census population index [14] showing the **trend** of the entire population in Europe from 1987 to 2006.

Abundance: current status and changes

Dalmatian pelicans suffered a strong decline in Europe during the 19th and 20th centuries, when many colonies disappeared [2–4, 7, 9]. The decline



halted in the 1980s and most colonies have been stable or increasing since 1990 [2], with the exception of the colony in Albania, where declines were ongoing until 2006 [13] and the population in the European part of Russia, for which the trend is unknown [6]. Up-to-date information from Russia is not available [6] and so only limited discussion of this part of the population is possible.

The current estimate of Dalmatian pelican population size in southeastern Europe (excluding Russia) comes to around 1,660 breeding pairs, with 73% of the population found in Greece and 19% in Romania (Table 2). The population in Greece increased from 70–120 pairs in 1980 [7] to about 1,200 pairs in 2008 [13], while overall the total south-eastern European population increased by 245% between 1994 and 2009 (Figure 1).

Distribution: current status and changes

The Dalmatian pelican's breeding range has contracted since the 1900s, with a number of colonies in Europe becoming extinct in the last century [2, 7, 9], particularly in central Europe (Figure 2). Known colonies have been lost in former Yugoslavia, Albania, Greece, Montenegro and Romania [2, 7, 9]. The species became extinct in Hungary in 1868 and in Ukraine by the end of the 1940s [7]. Dalmatian pelicans returned to Ukraine in the 1970s [17], with some evidence of eastward expansion since [18], and two new colonies have become established in Greece in the last decade [6, 13, 19] (Figure 2).

Figure 2. **Current** distribution of known Dalmatian pelican colonies in southeastern Europe [6] and historical distribution in the **1900s** [7, 8, 15–17], and **1990s** [9, 15, 16]. NB: size of points does not correspond to colony size.

Major threats

The most important threat that drove population decline and extinction of colonies of Dalmatian pelican was loss of wetlands, which were drained or their hydrology modified for agriculture [13]. Wetlands within the species' range have already been lost (e.g. drained or dried up lakes in Greece, Albania and Montenegro), which limits the recovery of Dalmatian pelicans, as there is little remaining habitat available for new colonies to establish [2, 19].

Habitat loss and degradation remains an important threat today, caused by pollution, hydro-

Table 2. Latest population estimates of Dalmatian pelican breeding populations in Europe [13], indicating those countries holding more than 1% of the total.

Country	No. of breeding pairs	Year	Trend	%
Albania	27	2005–2007	-	1
Bulgaria	14–150	1990–2009	+	2
Greece	1,150–1,300	2008	+	55
Montenegro	5–14	2000–2010	Stable	
Romania	312–330	2009	+	14
Russia	450–710	2006	?	25
Ukraine	2–14	1994–2009	?	

Table 3 Major threats that drove the Dalmatian pelican decline and may still constrain the population [9, 13, 20].

Threat	Description	Impact
Natural systems modifications	Drainage of wetlands for agriculture and housing development.	Critical
	Burning of reed beds.	Medium
Human intrusions and disturbance	Disturbance at breeding and wintering sites by birdwatchers, photographers and recreational and fishing boats.	High
Persecution/ control	Destruction of nests by fishermen.	Medium
	Shooting.	Medium
Transportation and service corridors	Collision with and electrocution by power lines, especially during migration and wintering.	High
Pollution	Long-term eutrophication of wetlands.	Medium
	Contamination by heavy metals and pesticides.	Medium/Low
Renewable energy	Collision with wind turbines.	Potentially high
Climate change and severe weather	Drought or flood.	High
	Climate change could have important negative effects in arid and semi-arid regions.	Unknown

logical changes leading to erosion or flooding of colonies, and housing development [13,21]. For example, eutrophication drove declines in Dalmatian pelicans in Albania until 2007 [13]. The next most important threat is disturbance by human activities and illegal persecution [13,21].

Collision with and electrocution by power lines is also an ongoing threat, particularly during migration and the non-breeding season [13, 21].There is an increasing number of windfarms being developed along the main flyways used by Dalmatian pelicans and near key wetlands, and collision with wind turbines could potentially have a high impact on the species [13, 21].

Drivers of recovery

Dalmatian pelican recovery in Europe is largely the result of targeted conservation efforts, especially limiting disturbance by people [13, 22]. However, overall capacity to carry out management and enforce protection of colonies is considered to be low and improvements are necessary [13]. In Greece, where the European Species Action Plan (SAP) for Dalmatian pelican has been implemented most successfully, the breeding population of the species has increased dramatically [13] (see 'Abundance: current status and changes' above).

Habitat management and restoration has had positive effects on the Dalmatian pelican population in Europe. Provision of nesting platforms has proved valuable in large lakes, where they help limit disturbance and prevent flooding [13]. However, most suitable habitat is already utilised by the species, so there is limited scope for further provision of artificial nest platforms or encouraging the establishment of new colonies [19].

One such attempt to reintroduce the species to potentially suitable sites in Croatia was unfortunately aborted as a result of conflict with government and local people [19]. Efforts to manage conflicts with fishermen have not been particularly successful, as persecution still takes place, albeit at a low rate [13].

Knowledge regarding Dalmatian pelican ecology and demography has improved greatly since the 1980s [2, 19], but the species remains understudied and further research is necessary in order to help improve the effectiveness of conservation actions for this species [19, 21].

Action	Description
Monitoring and planning	Monitoring programmes in most countries.
	SAP in place and well implemented.
	National action plans in place in Romania, Montenegro and Ukraine.
	National working groups in Bulgaria, Greece and Romania.
Site/area protection	There are 119 IBAs identified for Dalmatian pelican in Europe, of which 48% are designated as SPAs or other protected areas and 20% are not protected.
	IBAs cover nearly the entire EU population of the species.
	Wardening and limiting disturbance by people.
Site/area management	Predator control measures (fencing, artificial platforms).
	Mitigating impacts of power lines (e.g. burying, increasing visibility, insulation).
Species management	Floating rafts and nest platforms for breeding.
	Maintenance and restoration of nest platforms.
Habitat and natural process restoration	Wetland restoration in the Lower Danube and the key breeding sites in Greece.
Education and awareness	Targeted awareness raising programmes in Greece and Romania under LIFE projects, to reduce conflicts with fishermen and limit disturbance by tourists.
Legislation	Legally protected in all countries in its European distribution.
	Covered under a number of international treaties and conventions (see 'Legal protection and conservation status' above).

Table 4. Conservation actions in place for Dalmatian pelican [13].

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4.8. Lesser kestrel

Falco naumanni

Summary

The Lesser kestrel used to be one of the most abundant birds of prey in the Western Palearctic. It suffered severe declines in the second half of the 20th century, primarily as a result of habitat loss and degradation caused by land-use changes. Lesser kestrel populations have recently increased and recovery is underway in southwest Europe, although populations elsewhere in Europe are stable or slowly declining. Provision of artificial nests and restoration of breeding colonies helped drive Lesser kestrel increase locally, but lack of suitable foraging habitat is still limiting in most areas. Targeted agri-environment schemes and habitat management are necessary to ensure adequate prey densities for Lesser kestrel in order to enable population recovery and range recolonisation.

Table 1.
Global IUCN Red List status [12], European population and SPEC status [4] and EU population status [13] of Lesser kestrel.

Scale	Status	Justification
Global	Least Concern (since 2011; considered Vulnerable in 1994–2008 and Threatened in 1988)	Stable or slightly positive population trend overall during the last three generations. No longer approaches any of the thresholds for Vulnerable under the IUCN criteria.
Europe	Depleted (SPEC 1)	Large historical decline.
EU25	Depleted	

Background

General description of the species

The Lesser kestrel (*Falco naumanni*) is a small falcon species, similar in appearance to the larger Common kestrel (*F. tinnunculus*). Lesser kestrels prey mainly on large insects, and occasionally taking small vertebrates, e.g. small birds, reptiles and mice or other rodents [1]. Lesser kestrels breed in colonies of up to 200 pairs and nest in cavities on cliffs or buildings from February to July [1]. It is a migratory species, wintering in sub-Saharan Africa [1, 2], but there are some resident populations in southern Spain and northern Africa [1]. Lesser kestrels are gregarious throughout the annual cycle, migrating in flocks and congregating at roost sites in the post-fledging pre-migratory period, as well as at the wintering grounds [2].

Distribution in Europe

The Lesser kestrel's breeding range covers the Western Palearctic south of 55°N [2]. It used to be considered one of the most abundant birds of prey in the region [3], but underwent large population declines in the second half of the 20th century throughout Europe [2, 4]. The species' range has undergone contractions in the Balkans [5], as well as in southwest Europe [6].

Habitat preferences

Colonies are often found in or near human settlements, where walls or roofs of old buildings provide suitable nesting sites, while rock cliffs, quarries and heaps of stones are also used [2]. The species requires open areas over which to forage and is found in lowland areas with steppe-like habitats, grasslands and extensively farmed land [2, 7]. Prey diversity, abundance and accessibility positively affect breeding success [2, 8], as does colony location in suitable agricultural habitats and low human disturbance levels in colonies [9].

Roost site availability and habitat quality of surrounding foraging areas are important in the post-breeding period, when large proportions of the breeding population congregate, moult and prepare for migration [2, 10, 11].

Legal protection and conservation status

The Lesser kestrel is listed in Appendix II of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention, and Annex I and II of the Convention on Migratory Species.

Abundance: current status and changes

On the basis of the most recent population estimates, the European Lesser kestrel population amounts to approximately 26,000 breeding pairs (Table 2). Spain, Italy and Greece together hold 85% of the population (Table 2).

The Lesser kestrel underwent dramatic declines by about 95% between the 1960s and the 1990s [14] but currently the breeding population in Europe is increasing overall [15]. The population in southwest Europe has increased substantially since the mid-1990s (Figure 1) [2]. Data from Spain, which holds more than half the European population, are likely to be underestimates [2, 16], but along with other countries in southwest Europe, show recovery of the species. However, in other parts of Europe, populations are stable or slowly declining [2] (Figure 1), although data from southeastern Europe are less accurate [2].

Distribution: current status and changes

Lesser kestrel currently has a mainly Mediterranean distribution, having undergone substantial range contractions in central Europe [16]. The species has recently become extinct from Austria, Hungary, Poland [6], Czech Republic [16], Croatia, Slovenia [4], and Bulgaria [2].

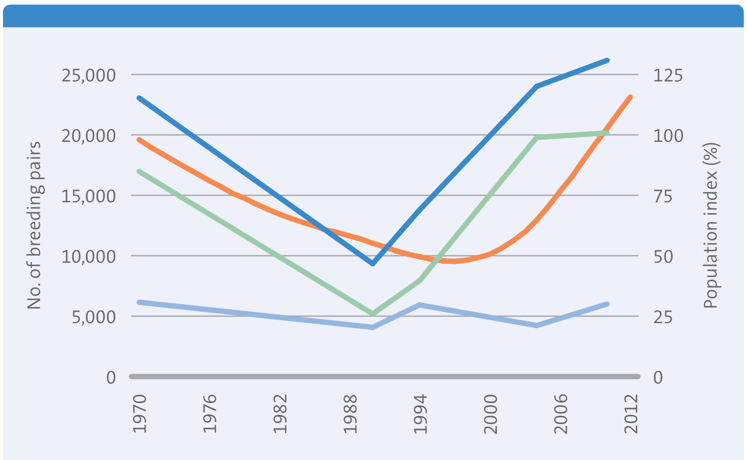

Figure 1. Number of Lesser Kestrel breeding pairs in Europe since 1970, according to the Species Action Plans [2, 6, 17] and other key sources, showing the **total** European population and **southwest** and **eastern and southeast** European populations separately. The population **trend** since 1970 is also shown (see 'Methods').

Major threats

The main cause of the Lesser kestrel decline has been habitat degradation, as a result of agricultural intensification and abandonment, driven by European agricultural policies [27]. Land-use change associated with the loss of grazed grasslands and extensive dry cereal cultivation, either to intensively farmed crops or to abandonment, scrub encroachment and afforestation, causes degradation of foraging areas by reducing availability and abundance of prey [2, 7, 27, 28] and correlates negatively with the abundance of colonies [28].

Application of pesticides on intensive farmland further diminishes the prey base available for Lesser kestrel, resulting in chick starvation, poor fledging success and direct mortality of parents feeding broods [2, 27, 29, 30]. Pesticide use in the wintering and staging areas leads to reduced juvenile survival, while habitat loss during the non-breeding season is also an important threat, e.g. conversion of grassland to arable cultivation [2].

Table 2. Latest Lesser Kestrel population estimates in Europe, indicating those countries holding more than 1% of the European population.

Country	No. of breeding pairs	Year	%
Albania	0–20	2002 [2]	
Bosnia & Herzegovina	10	2012 [18]	
Croatia	20	2010 [2]	
France	332	2012 [19]	1
Greece	2,600–3,300 (unconfirmed estimate: >6,000)	2009 [20] (2013 [21])	10
Italy	4,500–5,500	2009 [2]	19
Macedonia (FYROM)	1,500–2,500	2010 [22]	7
Moldova	3–6	2001 [23]	
Portugal	527–552	2007 [24]	2
Romania	0–2	2010 [2]	
Russia	1,100	2009 [2]	4
Spain	14,072–14,686	2005 [2]	55

Figure 2.
Current distribution of Lesser kestrel in Europe and historical distribution in the **1950s** [25] and **1980s** [26].

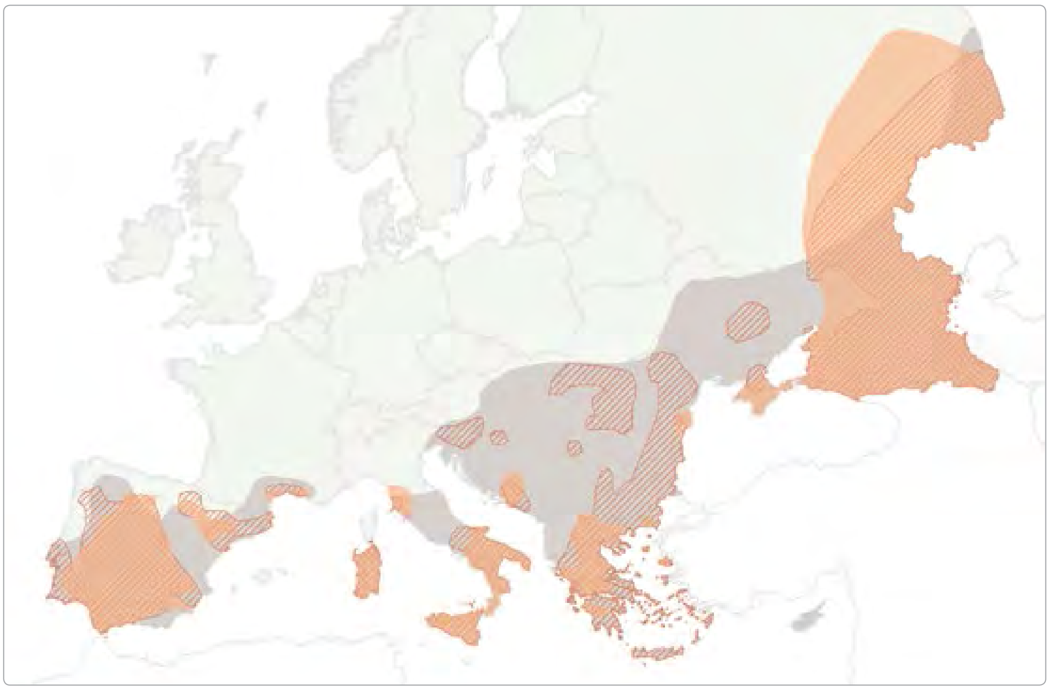

Table 3.
Major threats that drove Lesser kestrel decline and may still constrain the population [15].

Threat	Description	Impact
Agricultural intensification	Habitat loss and degradation in breeding areas – changes in agricultural practices led to reduction of food availability, e.g. conversion to intensive arable production, conversion to intensive perennial crops in the Mediterranean, overgrazing.	Critical
	Reduction in availability of prey due to pesticide use in intensified agricultural areas in breeding and wintering areas.	Critical
	Habitat loss in winter quarters, pre-migratory and stopover sites – destruction and fragmentation of grasslands caused by agricultural intensification, including pesticide use and unsuitable grazing regimes.	High
Agricultural abandonment	Abandonment, scrub encroachment, wildfires and/or afforestation reduce prey availability and accessibility.	Critical
Natural systems modifications	Drainage of wetlands for irrigation or conversion to cultivated land results in decline of prey availability and loss of foraging areas.	High
Residential and commercial development	Infrastructure and urban development results in habitat loss and fragmentation.	High
Other	Loss of nest sites due to restoration, collapse or demolition of old buildings.	Medium/High
Climate change and severe weather	Low rainfall in the wintering grounds is associated with reduced juvenile survival and recruitment, desertification in the Sahel zone reduces available habitat for passage and wintering birds.	Medium/High
	Increasing frequency of extreme temperatures due to warming climate results in overheating of nest boxes, causing chick mortality.	
Persecution	Human persecution and disturbance.	Low/Medium
	Destruction of pre-migration roosting sites due to sanitary considerations.	Unknown
Transportation and service corridors	Collision with and electrocution by power lines.	Medium
Renewable energy	Collision with wind farms.	Medium
	Habitat loss due to solar plants.	Medium
Problematic native species	Interspecific competition with Jackdaws *Corvus monedula*, Red-footed Falcons *Falco vespertinus* and other predators, which predate eggs and kleptoparasitise adults feeding young.	Medium/High
Pollution from agriculture	Pesticide toxicity, especially in wintering grounds.	Low

Reductions in nest site availability have also contributed to declines, often due to restoration, demolition or collapse of old buildings [2], and a shortage of nest sites limits population growth in several areas [10, 27, 31].

Rainfall and temperature in the breeding areas have been shown to influence Lesser kestrel population dynamics [32, 33], but climate is most important in the wintering grounds, where juvenile survival is strongly dependent on rainfall [2]. Low rainfall is negatively correlated with survival, probably as a result of decreased locust population explosions and hence lower prey availability for Lesser kestrels [34].

Drivers of recovery

The Lesser kestrel is legally protected across Europe, but the level of enforcement and on-the-ground protection of designated areas varies between countries and could be improved [15, 30].

Restoration and management of Lesser kestrel breeding colonies, as well as the provision of artificial nests, are very important factors behind the increase in some populations [10, 15, 31, 35]. Release of captive-bred Lesser kestrels to reinforce local populations in southwest Europe and the ongoing reintroduction project in Bulgaria [36] can help restore the former range of the species [15]. However, lack of suitable foraging habitat limits recolonisation [7, 15].

Agricultural and forestry policy are pivotal in the availability of habitat for Lesser kestrel and targeted measures have the potential to drive population expansion, by ensuring high prey

Action	Description	Impact
Livelihood, economic and other incentives	Targeted agri-environmental measures in Portugal and Spain.	High/Critical
	Beneficial agri-environmental measures in France and Bulgaria.	
Land/water protection	There are 231 IBAs identified for Lesser kestrel in Europe, of which 42% are fully designated as SPAs or other protected areas and 22% are not protected.	High
	Protected areas cover the majority of the populations in the Mediterranean countries.	
Monitoring and planning	International Species Action plan in place.	High
	National Species Action Plan in France.	
	Surveyed in most countries, except Slovenia, but patchily.	Medium
Species management	Artificial nests or provision of nesting opportunities, including sensitive restoration of old buildings and colony restoration, e.g. erection of Lesser kestrel 'houses' (primillares) in Spain and breeding walls and breeding towers in Portugal [35].	High, but local
	Captive breeding to reinforce populations in Spain, Portugal and France.	Low
	Reintroduction project in Bulgaria initiated.	
Education	Awareness campaigns, especially in the Mediterranean countries, including websites, information brochures and workshops.	High
Legislation	Legally protected in all countries, but enforcement should be improved (Bosnia and Herzegovina, Croatia, Greece, Italy, FYRO Macedonia, Romania and Spain).	High

Table 4. Conservation actions in place for Lesser kestrel [15].

densities through appropriate rotational cereal cultivation practices and traditional low-intensity pastoral systems [15, 27, 37]. For example, the persistence of the largest population of Lesser kestrels in Portugal (Castro Verde SPA, holding *c.* 80% of the Portuguese population) is guaranteed as a result of a ban on afforestation and support for a targeted agri-environment scheme in the area, which ensures a large area of fallow land, low pesticide and herbicide use and controlled grazing intensity [7, 35].

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4.9. Saker falcon

Falco cherrug

Summary

The Saker falcon declined in Europe as a result of persecution, nest robbing and habitat loss due to land-use change, and the current distribution of the depleted populations is fragmented. Saker falcons have benefitted from intensive conservation efforts, and as a direct result the species is increasing in the Carpathian Basin. Legal protection, nest guarding, provisioning of artificial nests, insulation of power lines, raising public awareness, stakeholder dialogue (involvement in active conservation) and habitat management (e.g. agri-environment measures) to promote the key prey species have all contributed to ongoing recovery in the region. To secure the species' status in Europe, such measures must be extended across the species' distribution.

Table 1. Global IUCN Red List status [14], European population and SPEC status [15] and EU population status [16] of Saker falcon.

Scale	Status	Justification
Global	Endangered (since 2012; considered Vulnerable in 2010, Endangered in 2004–2008, Least Concern in 1994–2000 and Near Threatened in 1988)	May be undergoing a very rapid decline of at least 50% over the last 10 years or three generations.
Europe	Endangered (SPEC 1)	Small population size (<2,500 mature individuals) and continuing decline of at least 20% within 5 years or two generations.
EU25	Vulnerable	Small population size (<1,000 mature individuals).

Background

General description of the species

The Saker falcon (*Falco cherrug*) is a large falcon species popular with falconers, especially in the Middle East [1], and similar in appearance to Lanner falcon (*Falco biarmicus*) and Gyr falcon (*Falco rusticolus*), which are smaller and larger in size, respectively [2]. It is the national bird species in Hungary, where it has cultural importance as an important agent in Magyar mythology [3]. Saker falcon flight is characterised by rapid acceleration and high manoeuvrability, to enable hunting close to the ground in open habitats [4].

Sexual maturity is reached at 2–3 years of age and breeding takes place between March and June [5, 6]. Clutch size varies from one to five eggs, with variable breeding success, particularly where rodent populations cycle [5, 6]. Saker falcon is a partial migrant throughout its range: most of the juvenile and immature birds are migratory, while most of the established adults remain in their breeding areas all year around. Adult birds breeding in the northernmost parts of the distribution may migrate southwards in autumn [7].

Distribution in Europe

Saker falcons occur in a wide range across the Palearctic, from eastern Europe to western China [4]. In Europe, the range is heavily fragmented and can be divided into three relatively separate populations: a continuous population in central Europe covering eastern Austria, Slovakia, Hungary, Serbia and western Romania (Carpathian Basin); a population in southern Ukraine, Moldova and southeast Romania; and an assumed population in Bulgaria [8], where its range has contracted since 1945 [5, 9]. The species' range used to include south-eastern European Russia, but disappeared from this region by the early 21st century [10].

Habitat preferences

The Saker falcon is a typical steppe species, preferring open landscapes, and in Europe inhabits wooded steppes, agricultural areas and mountain foothills [11]. The species specialises in hunting small to medium sized diurnal rodents, Suslik (*Spermophilus citellus*) in particular, but will also take birds, such as Starlings (*Sturnus vulgaris*) and Domestic pigeons (*Columba livia forma domestica*) [9].

Like other falcon species, Saker fuses nests constructed by other species, such as Eastern imperial eagle (*Aquila heliaca*), White-tailed eagle (*Haliaeetus albicilla*), Raven (*Corvus corax*) and Common buzzard (*Buteo buteo*) [4, 12]. Nests are traditionally in tall trees and on cliffs, but recently the species began using electricity pylons and currently the majority of pairs in Central and Eastern Europe nest on pylons [8, 9].

Legal protection and conservation status

The Saker falcon is listed in Appendix II of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species [13].

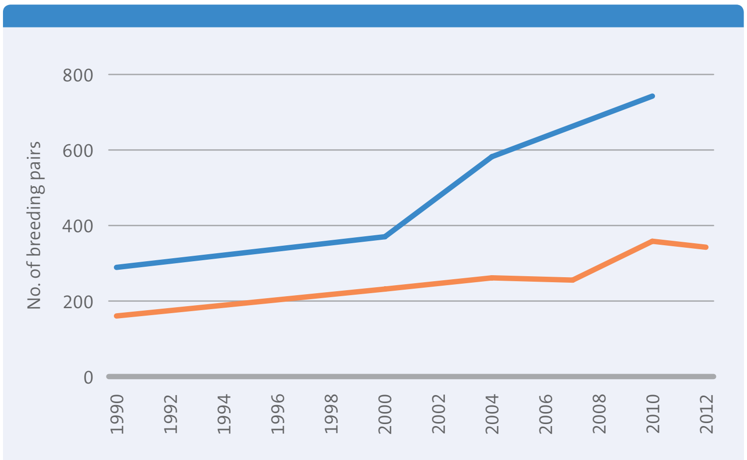

Figure 1. Number of Saker falcon breeding pairs in Europe since 1990, showing the **TOTAL** and the **CARPATHIAN BASIN** population (Austria, Hungary, Serbia, Slovakia) separately, based on the Species Action Plan [9], BirdLife International [15], and other key sources.

Abundance: current status and changes

Although reliable data are not available before the 1980s [8], it was evident that the Saker falcon experienced significant declines across its range in Europe since the mid-1900s [5, 9, 15, 26–29]. The key populations in Hungary and Ukraine, for example, were estimated at just 30 and 30–40 pairs, respectively, by 1980 [8, 28, 30–32]. According to the most recent estimates of population size (Table 2), the European population of Saker falcon numbers approximately 740 pairs and appears to be increasing.

The population in the Carpathian Basin, which makes up more than 40% of the total population in Europe, has been recovering since the 1980s, mainly driven by large increases in Hungary and Slovakia [30, 33, 34], but also in Austria where the species

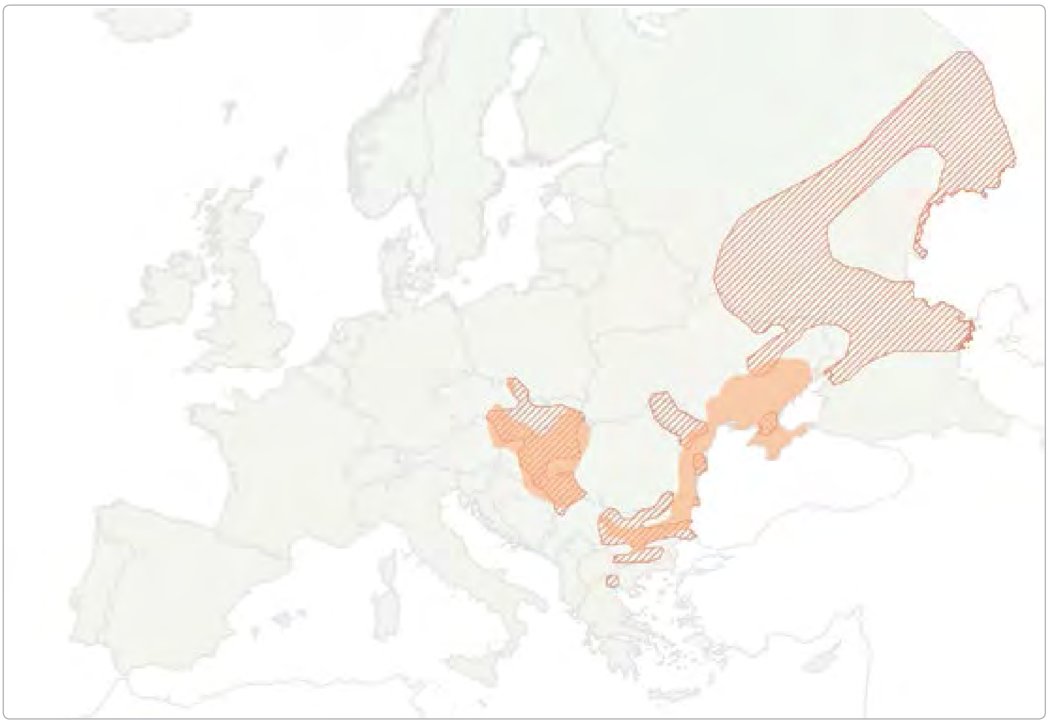

Figure 2. **CURRENT** distribution of Saker falcon in Europe and **HISTORICAL** distribution in the 1980s [30].

TABLE 2.
Latest Saker falcon population estimates in Europe, indicating those countries that hold at least 1% of the European population.

COUNTRY	NO. OF BREEDING PAIRS	YEAR	%
Austria	25–30	2010 [17]	4
Bulgaria	0–8	2012 [18]	
Croatia	3–5	2010 [19]	1
Czech Republic	20–25	2013 [20]	3
Germany	0–1	2006 [9]	
Hungary	241–245	2012 [21]	33
FYRO Macedonia	0–3	2013 [22]	
Moldova	10–12	2010 [19]	2
Poland	0–2	2007 [23]	
Romania	10	2010 [8]	1
Serbia	25–35	2013 [24]	4
Slovakia	40–45	2012 [25]	6
Ukraine	315–345	2010 [19]	45

TABLE 3.
Major threats that drove Saker falcon decline and may still constrain the population [9].

THREAT	DESCRIPTION	IMPACT
Agricultural intensification	Conversion of grasslands into arable land, or into vine-yards in Bulgaria, leads to a reduction in prey availability.	High locally
	Disturbance at nest sites from agricultural operations.	Medium
	Poisoning by pesticides or other chemicals, resulting in low productivity.	Unknown
	Tree felling in steppe and pseudo-steppe may limit nest availability.	Local
Agricultural abandonment	Decrease in grazing animal stock results in lower prey availability.	High
	Loss of foraging habitat through afforestation of agricultural land.	Local
Wood and pulp plantations	Disturbance at nest sites from forestry activities.	Low
Other	Nest collapse when old or weak nests are occupied.	High
Hunting and collecting	Trapping for use in falconry, especially in the Middle East, Pakistan and North Africa.	Potentially high
	Nest robbing was critical in the Czech Republic, Slovakia and possibly Bulgaria, Ukraine and Russia.	Potentially high locally
	Illegal shooting, especially in the migratory Asian populations.	Medium
Persecution/ control	Destruction of artificial nests where considered a threat by game keepers, particularly in the Czech Republic.	Local
	Persecution by pigeon-fanciers (poisoning, shooting, destruction of nest) in Serbia, Hungary, Slovakia	Low
Unintentional effects of hunting and collecting	Suslik eradication – considered a pest or competitor with livestock.	Low
	Unintentional poisoning from bait intended for foxes and other vermin.	High
Transportation and service corridors	Electrocution by power lines.	High
Renewable energy	Collisions with wind turbines.	Low
	Wind farm development has resulted in loss of breeding and foraging areas in east Austria, west Hungary, north Serbia, west and southeast Romania	Medium to locally high
Residential and commercial development	Infrastructure development results in loss of Suslik colonies.	Medium
Mining and quarrying	Quarrying in some parts of the species' range results in loss of nest-sites.	Local
Invasive non-native/alien species	Hybridisation with escaped hybrid falcons.	Unknown
Problematic native species	Nest predation by natural predators.	Low
Climate change and severe weather	Extreme weather can cause nest collapse or death of eggs or small chicks.	Low

was on the brink of extinction in the 1970s [35]. In Ukraine, which also holds 45% of the Saker falcon population in Europe, the population suffered significant declines since the 1950/60s, but is now considered to be relatively stable [10, 28, 36]. In Bulgaria, Saker falcons used to be common and widespread before the 1930s [37], but are now close to extinction (Table 2), and the last documented successful breeding attempt was in 1997 [38].

DISTRIBUTION: CURRENT STATUS AND CHANGES

Since the mid-1900s, Saker falcon distribution has become fragmented as a result of population declines and range contractions, especially in southeast Europe [5, 9], and the species became extinct from the European part of Russia in the early 21st century. In the late 20th century, populations have undergone shifts within their regional distribution, as a result of changing habitat occupancy [38]. In central Europe, following the abandonment of grazing in the foothills and mountains after 1990 and the end of the communist regime, Saker falcon territories in mountains and hills were abandoned in favour of lowland agricultural areas, where the species continues to expand, occupying new (but probably historically used) areas [8, 30]. Similarly, in eastern Europe, Saker falcons declined in the forest steppe, but remained and possibly increased in the southern steppe zone [28, 33, 38]. Most nest sites for the species in central and eastern Europe are now electricity pylons [38] and artificial nests are used extensively by Saker falcons in the Carpathian Basin [8, 30, 35].

MAJOR THREATS

The Saker falcon suffered declines in central and eastern Europe in the 19th and 20th centuries [9, 38]. The main reasons include persecution, and habitat loss and degradation, due to declines in key prey species, as a result of abandonment of pastoralism after the end of the communist regime, while ongoing nest robbing for falconry had important negative effects on already declining populations [8, 9, 27, 38]. Agricultural intensification has also had negative impacts on Saker falcons, resulting in habitat loss for the species' prey (Suslik) [8, 9, 30, 38]. However, it is important to note that intensive agricultural areas currently hold some of the highest Saker falcon breeding pair densities in Hungary [8], indicating that the species can utilise such habitats given adequate prey and (artificial) nest site availability.

Action	Description	Impact
Planning and monitoring	International Species Action Plan in place and national plans exist in some countries (Czech Republic, Hungary, and Serbia).	Medium
	Systematic monitoring carried out in a number of countries.	Medium
Site/area protection	There are 134 IBAs identified for Saker falcon, of which 53% are fully designated as SPAs or other protected areas and 13% are not protected.	Medium
Site/area management	Power line mitigation.	High
	Nest protection.	Historically high
Habitat and natural process restoration	Prey population management (Suslik translocation).	Medium
Species recovery	Provision of artificial nests.	High
Ex-situ conservation	Captive breeding.	Low
Education and awareness	Awareness raising campaigns towards gamekeepers.	High
Legislation	Protected by law in all countries.	Medium

Table 4. Conservation actions in place for Saker falcon [9].

Habitat loss remains an important problem today [3, 9] and nest robbing, which is no longer a significant problem in most of central Europe, may still be a considerable threat in Ukraine and eastern Europe [40]. New threats have also come about, including electrocution [3, 30]. It is likely that nest site availability limits Saker falcon populations [41], as a result of removal of trees in agricultural areas [3, 9]. Illegal poisoning is another critical threat, as it appears that use of poison bait is increasing in the Carpathian Basin [3, 4].

Drivers of recovery

Conservation measures mostly include nest protection, provision of artificial nests, insulating power lines, habitat management (e.g. through agri-environment schemes), population management of key prey species, and education campaigns [27, 30, 33, 38, 42].

The Saker falcon has shown evidence of recovery in the Carpathian Basin, as a direct result of active conservation effort [27, 30, 33, 42]. With effective protection of the species and appropriate management of its habitats, there is scope for further recovery and recolonisation in other parts of Europe [43].

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4.10. Peregrine falcon

Falco peregrinus

Summary

The Peregrine falcon is one of the most widespread raptor species in the world. In the 1960s and 1970s, the species suffered dramatic declines as a result of the effects of organochlorine chemicals used in agriculture. Following the ban on these toxic chemicals, and with improved protection from persecution and nest robbing, Peregrines have recovered worldwide, including in many parts of Europe, largely thanks to intensive reintroduction. The species is also increasingly utilising man-made habitats and has colonised cities in Europe and elsewhere. However, Peregrine falcons are still under threat from illegal persecution. In addition, the tree-nesting population of the species in central and eastern Europe has not recovered and currently consists entirely of reintroduced birds.

Background

General description of the species

The Peregrine falcon (*Falco peregrinus*) is one of the most widespread raptor species in the world, known for its flight speed and importance for falconry [1].There are 19 sub-species recognised, of which three are found in Europe: the nominate (*F. p. peregrinus*), northern (*F. p. calidus*) and the Mediterranean or Maltese falcon (*F. p. brookei*) [1, 2].

Peregrine falcons are partial migrants: those that breed in northern latitudes migrate southwards during the winter, while those that breed at lower latitudes are mostly resident throughout the year [1].

Table 1. Global IUCN Red List status [7], European population and SPEC status [8] and EU population status [9] of Peregrine falcon.

Scale	Status	Justification
Global	Least Concern (since 1988)	Extremely large range and population size, with a stable population trend.
Europe	Secure (Non-SPEC)	Large population that increased during 1970–1990 and during 1990–2000.
EU25	Secure	

Distribution in Europe

The Peregrine falcon is one of the most widely distributed bird species worldwide, occupying all continents except Antarctica [3]. *F. p. peregrinus* is found in temperate Eurasia between the tundra in the north, and the Pyrenees, Balkans and Himalayas in the south, and from the British Isles in the west to the Russian Far East [1]. *F. p. calidus* is found in the north, from the Kola Peninsula to the Russian Far East and winters in the Mediterranean or southern India [2]. *F. p. brookei* is found in the south, from the Iberian Peninsula in the west to the Caucasus in the east [1].

Habitat preferences

Peregrine falcon habitat is extremely variable, but they prefer to forage over open habitats, though they are increasingly inhabiting urban areas [1, 3, 4].

Traditionally, Peregrine falcons lay their eggs in scrapes on cliffs, or may use disused nests of other species, but buildings and other man-made structures are increasingly being utilised [1]. Some Peregrine falcons in central and eastern Europe nest in trees, although this population became extinct and is now limited to a small, but growing, number of reintroduced pairs [4], while nesting on the ground appears to be relatively common in bog habitats in the Baltic region and tundra [2, 5].

Peregrine falcons prey almost exclusively on birds, often killed in flight by 'stooping', i.e. diving at the target from above at great speed [1, 4]. Many species are taken, including ducks, gamebirds, waders, seabirds, and especially pigeons and doves, feral pigeons in particular [1].

The species displays reverse sexual dimorphism, with females being 15–20% larger than males, especially in *F. p. calidus* [1]. Sexual maturity is reached at 1–3 years and breeding takes place between February and June [1, 3].

Legal protection and conservation status

The Peregrine falcon is listed in Appendix I of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species [6].

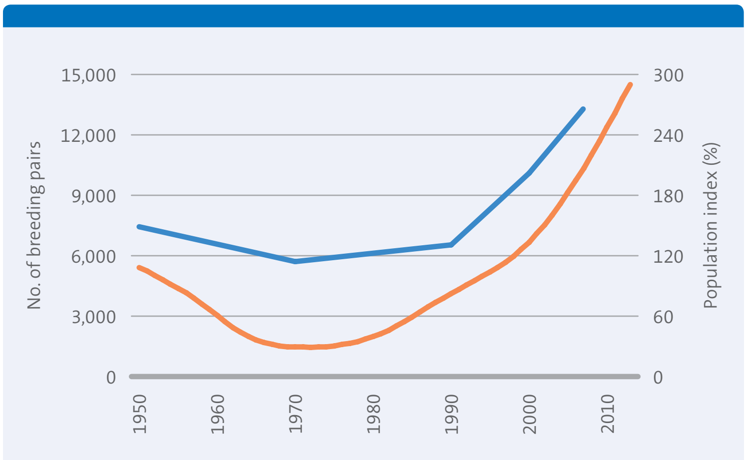


Figure 1. **Number** of Peregrine falcon breeding pairs in Europe since 1970, based on data from BirdLife International [8, 36] and other key sources, including proceedings of regular international conferences [37–39]. The population **trend** since 1950 is also shown (see 'Methods').

Abundance: current status and changes

The current Peregrine falcon population in Europe is estimated at around 13,900 pairs (Table 2). However, data from some populations are out of date, including Greece, Portugal, Albania and FYRO Macedonia (Table 2). Key populations are found in Spain, Russia, the UK, France, Italy, Norway and Germany, which together hold 75% of the European population (Table 2).

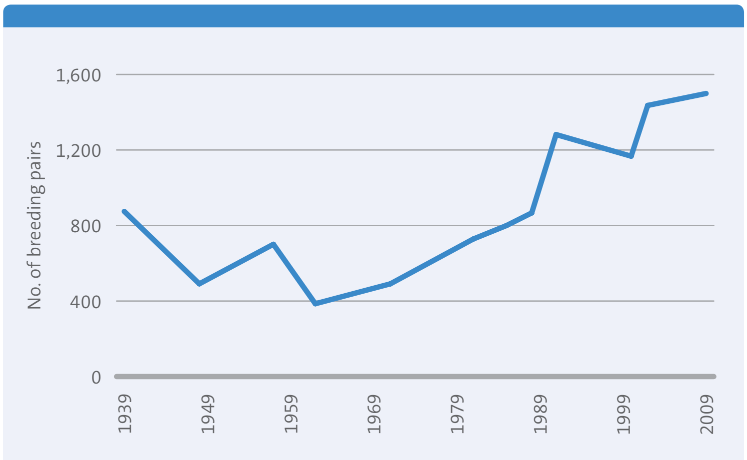


Figure 2.
Number of Peregrine falcon breeding pairs in the UK since the 1930s [10, 12, 34, 40–45].

Historically, populations in Europe were stable, but serious declines occurred from the mid-1960s to the mid-1970s [10]. In Fennoscandia, for example, a possible reduction of 95% of the population size at the start of the 20th century occurred by the1970s [11] and dramatic declines also occurred in the UK [12], Czech Republic [13], Germany [14, 15], France [16, 17] and Bulgaria [18]. During the 1970s, the species became extinct from the former German Democratic Republic [15], Belgium [10], Denmark [10, 19], Estonia [20], Latvia [21], Slovakia [22], Hungary [23, 24] and Poland [25], while the population in Switzerland was reduced to a single breeding pair [26]. The tree nesting population, which used to number 4,000 pairs [27], was extirpated during this period [28].

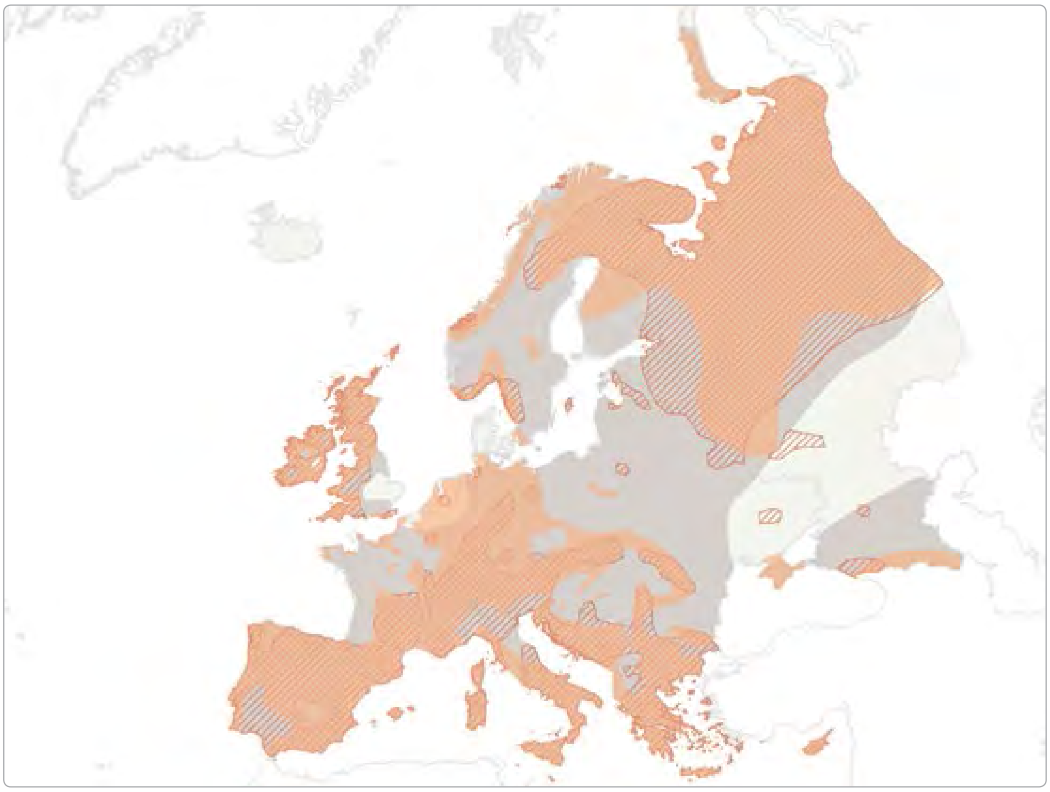
Following this period of decline, the population in Europe and elsewhere recovered to pre-decline levels [10], recolonising for example the former German Democratic Republic in the early 1980s [15], and later on the Netherlands [29], Belgium [10], Poland [25, 30], Hungary [23], Slovakia [22] and Lithuania [31]. In some cases, such as in Britain, Ireland and the Netherlands, Peregrine falcons are currently more numerous than they have ever been [29, 32]. However, the tree nesting population in central Europe remains very small, at around 40 pairs [2, 27, 33].

Peregrine falcons in the UK have been surveyed regularly since the 1930s, with censuses carried out every ten years or so [34], documenting the population development of the species in this key country (Figure 2). The population was stable in the early 1900s, but declined during World War 2 (1939–1945) [35]. This was followed by a period of recovery and populations in most of Britain were considered to be stable by the early 1950s [35]. A second period of decline began in 1955 and the UK population reached its lowest point in 1963 [32]. By the mid-1980s, the population had recovered to its pre-World War 2 levels and then continued to increase [12, 32].

Distribution: current status and changes

Peregrine falcon distribution in Europe declined in the 1960s and 1970s, and the species went extinct in a number of regions (Figure 3). Evidence of the

Figure 3.
Current distribution of Peregrine falcon in Europe and historical distribution in the **1950s** [72] and **1980s** [73].



contraction of the species' range is most prevalent in central and eastern Europe, but also in parts of the UK and France (Figure 3). However, recolonisations of numerous areas are apparent, and within the species' distribution in Europe and elsewhere, Peregrine falcons are increasingly expanding their habitat use to include urban areas [4, 12].

Major threats

The most important cause of the worldwide decline in Peregrine falcon populations was the use of organochlorine chemicals in agriculture [10]. Biomagnification of these pollutants in Peregrine falcons resulted in reduced productivity, through embryo mortality and eggshell breakage [74, 75]. In the UK, the pattern of the decline matched geographical variation in the intensity of pesticide use [35], while declines were also more pronounced in agricultural areas in France [76], Germany and Fennoscandia [10].

Illegal nest robbing was also an important limiting factor, acting on an already declining population, especially in Germany and Switzerland [10], but also in Italy [77] , Spain [78, 79] and Britain, where it is an ongoing threat [4]. Peregrine falcons have long been persecuted by humans, as a result of conflicts with game keeping, such as grouse moors in the UK [35]. This remains a threat today, despite the full legal protection of the species [80]. Persecution to protect Domestic pigeons has also had in impact on Peregrine falcons [4, 41, 78, 81], and in the UK the decline suffered by the species during World War 2 was the result of direct persecution by the military to prevent predation of messenger pigeons [12]. Peregrines are also shot illegally by recreational hunters, particularly in the Mediterranean [16, 77].

Drivers of recovery

The ban on the use of organochlorines in agriculture and the increased protection of the species enabled substantial recovery of Peregrine falcons in Europe from the 1980s [10]. Reintroduction efforts, initiated thanks to artificial breeding techniques developed by falconers [2], enabled the recolonisation and recovery in Switzerland [26], Sweden [11], Poland [25, 30], as well as colonisation of Moscow by reintroduced birds [2]. The reintroductions in Germany [15, 83] resulted in recovery in southern and eastern Germany, but also of the Austrian, Slovakian, Czech and Hungarian populations [13, 23]. Reintroduced Peregrine falcons form the remaining tree-nesting population in Germany

Country	No. of breeding pairs	Year	%
Albania	100	2000 [8]	1
Andorra	4	2000 [8]	
Austria	224–324	2009 [46]	2
Belgium	80	2013 [47]	1
Bosnia & Herzegovina	Regular breeder, but no population size estimate	2012 [48]	
Bulgaria	200	2009 [18]	1
Croatia	160–200	2009 [49]	1
Cyprus	50–60	2013 [50]	
Czech Republic	60–70	2013 [51]	
Denmark	3	2007 [19]	
Finland	260	2010 [52]	2
France	1,160–1,500	2008 [53]	9
Germany	1,000	2009 [54]	7
Greece	316	2000 [8]	2
Hungary	30–40	2013 [23]	
Republic of Ireland	450–500	2011 [55]	3
Italy	1,100–1,400	2009 [56]	9
Liechtenstein	1–2	2013 [57]	
Luxembourg	1–2	2010 [58]	
FYRO Macedonia	87	2000 [8]	1
Malta	1	2000 [8]	
Netherlands	112	2012 [59]	1
Norway	800–1,000	2006 [60]	6
Poland	20	2013 [2]	
Portugal	75–110	2008 [61]	1
Romania	150–300	2013 [62]	2
Russia	1,500–2,000	2009 [63]	12
Serbia	50–70	2013 [64]	
Slovakia	150–180	2012 [65]	1
Slovenia	90–115	2010 [66]	1
Spain	2,462–2,804	2008 [67]	19
Sweden	232–332	2012 [68]	2
Switzerland	300–400	2010 [69]	2
UK	1,500	2009 [44]	11
Ukraine	120–130	2009 [70, 71]	1

Table 2. Latest Peregrine falcon population estimates in Europe, indicating those countries that hold at least 1% of the European population.

Table 3. Major threats that drove Peregrine falcon decline and may still constrain the population.

Threat	Description	Impact
Pollution from agriculture	Organochlorine pesticides reduced productivity.	Historically critical
Hunting and collecting	Persecution due to conflict with game and pigeon keeping.	High
	Nest robbing for egg collecting.	Historically high
	Nest robbing for falconry.	Historically medium
	Illegal shooting by hunters for recreation.	Medium
Human intrusions and disturbance	Disturbance by recreational activities, e.g. rock climbing.	Medium
Climate change and severe weather	Poor weather conditions can result in poor productivity [41].	Low

Action	Description	Impact
Legislation	Use of organochlorine chemicals is banned in most countries.	Critical
	Legally protected in most countries and included in various international treaties and conventions (see 'Legal protection and conservation status').	High
Monitoring and planning	Many populations across Europe are monitored regularly [10].	Medium
Site/area protection	There are 1004 IBAs identified for the Peregrine falcon in Europe, of which 51% are fully designated as SPAs and 9% are not protected.	Medium
Site/area management	Nest wardening [26, 77, 82].	Local
Species recovery	Artificial nest platforms.	Medium
Species re-introduction	Reintroduction programmes in Sweden, Switzerland, Germany, Czech Republic, Poland and Russia.	High
Education and awareness	Awareness raising programmes to mitigate conflicts [41].	Low

Table 4. Conservation actions in place for Peregrine falcon [2, 37–39].

and Poland [28, 54, 82, 84]. The size of many populations in Europe is now higher than it was before the organochlorine crisis.

It is important to note that contamination by toxic chemicals still occurs, but the current effects on Peregrine falcons remain unknown [27]. In order to help fill gaps in research, consolidate knowledge, and enable improvements in the effectiveness of conservation actions for this species, the European Peregrine Falcon Working Group was recently established [27].

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4.11. Red kite

Milvus milvus

Summary

Red kites suffered severe declines in the 19th and early 20th centuries, resulting in a restricted and highly fragmented distribution. After an increase in some countries between 1970 and 1990, the species suffered considerable declines in its strongholds in Germany, France and Spain, caused by mortality due to poisoning, and habitat loss.

These declines were partly offset by ongoing positive trends in other countries, including Sweden, Switzerland, and the UK. Legal protection and targeted conservation efforts, including ongoing reintroduction projects, have been instrumental in enabling the observed recovery of this species. However, poisoning remains a critical threat, particularly in Spain and France, which hold important populations of both breeding and wintering birds.

Table 1. Global IUCN Red List status [8], European population and SPEC status [5] and EU population status [9] of Red kite.

Scale	Status	Justification
Global	Near Threatened (since 2005; considered Least Concern in 1994–2004 and Threatened in 1988)	Moderately rapid population decline, owing mostly to poisoning from pesticides and persecution, and changes in land-use amongst other threats.
Europe	Declining (SPEC 2)	Moderate recent decline (>10%).
EU25	Declining	

Background

General description of the species

The Red kite (*Milvus milvus*) is a truly European bird of prey, with nearly the entire range of species found in Europe. Unlike its congener, the Black kite (*Milvus migrans*), which is probably the most abundant raptor in the world [1], the Red kite has a small global population. It is a medium-large raptor, with chestnut-red plumage, characteristic white patches under the wings and a long forked tail [1]. They are very agile and elegant in flight and spend long periods soaring over the landscape [2].

Red kites first breed at 2–4 years of age and lay 1–3 eggs in March–April. They are migratory in most of northern, central and eastern Europe, spending the winter mainly in Spain [3], but in some areas only young adults migrate, while in Britain the population is resident. Increasingly, many Red kites in northern and central Europe remain in their breeding areas in winter [4].

Distribution in Europe

The Red kite is endemic to the Western Palearctic and more than 95% of its global range is within Europe [4, 5]. The species is distributed from southern Portugal and Spain to Denmark, Sweden and Poland, with isolated populations in Italy and the United Kingdom. There may also be a small population in Morocco [1].

Habitat preferences

Red kite habitat is variable, but open, often farmed landscapes are generally preferred [1, 6]. Red kites are mostly scavengers, feeding on carcasses, including livestock and road kill, but will also take small birds, rodents and invertebrates [1, 6]. They nest in patches of woodland or isolated trees and form loose breeding aggregations [1, 6].

Legal protection and conservation status

The Red kite is listed on Appendix II of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species [7].

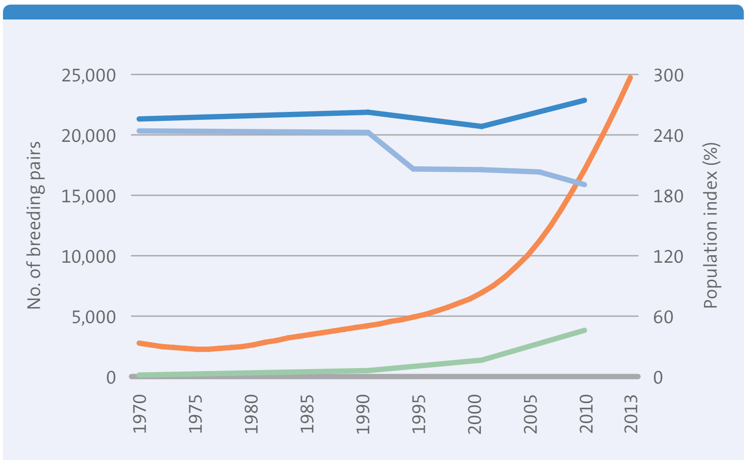

Figure 1. **Number** of Red kite breeding pairs in Europe since 1970, showing the decline in the key populations in **Spain, France and Germany** and increase in **northwest Europe**, based on BirdLife International [5, 12], the Species Action Plan [14] and other key sources. The overall population **trend** is also shown.

Abundance: current status and changes

The current population of Red kites in Europe comprises around 23,600 pairs, nearly half of which are found in Germany (Table A1). Germany, along with France and Spain form the core of the breeding population in Europe, together accounting for 67% of the total. Important populations are also found in the UK and Sweden, each holding 9% of the total population (Table A1).

Red kites declined globally until the 1970s, but some populations recovered during 1970–1990 [2, 4, 10, 11] and the overall trend was stable [12]. Declines have been documented in the core breeding areas since 1990, amounting to an overall population decline of 16% in the past three Red kite generations [5, 6, 13] (Figure 1). These declines have been partly offset by rapid increases in northwest Europe and other parts of the species' range, including the UK, Sweden, Switzerland and Poland [11, 13, 14].

Distribution: current status and changes

It is clear that the distribution of the species before the 20th century used to be much larger, as the remaining distribution is highly fragmented and discontinuous [2, 30, 31] (Figure 2). By the end of the 19th century, Red kites had become extinct in

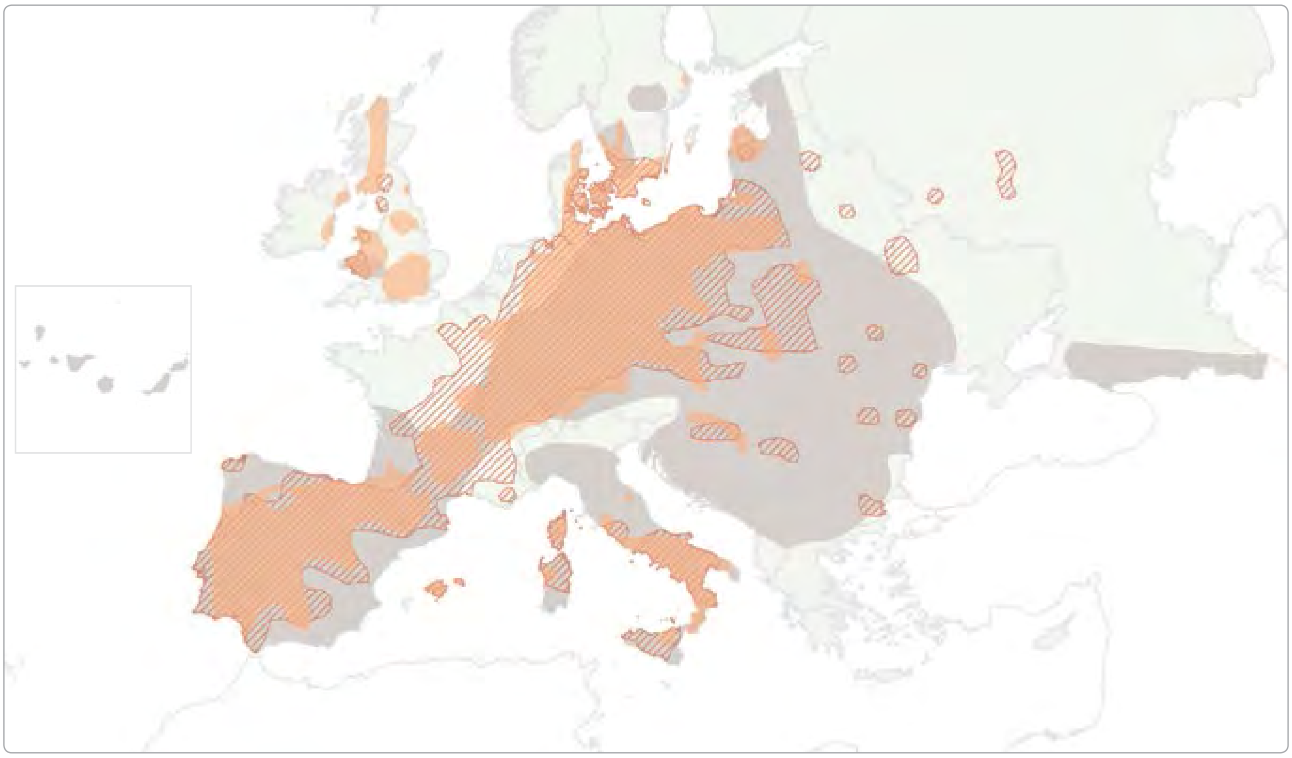

Figure 2. **Current** distribution of Red kite in Europe and historical distribution in the **1950s** [29] and **1980s** [30].

Country	No. of breeding pairs	Trend	Year	%
Austria	12–19	Stable	2008	
Belarus	1–5	Stable [14]	2008	
Belgium	150	+	2008	1
Bulgaria	0–1	?	2008	
Czech Republic	100–120	+	2007	
Denmark	75–80	+	2008	
France	2,656	Stable	2009 [15]	11
Germany	10,100–12,300	Stable	2009 [16]	47
Hungary	5–10	Stable	2010 [17]	
Republic of Ireland	25–35	+ [18]	2013 [18]	
Italy	314–426	+	2008	2
Latvia	1	+	2010 [19]	
Liechtenstein	0–1	?	2008	
Lithuania	10–20	+	2013 [20]	
Luxembourg	40	Stable	2009 [21]	
Netherlands	1	?	2012 [22]	
Poland	1,000–1,500	+ [14]	2009 [23]	5
Portugal	36–67	- [14]	2001	
Russia	5–10	?	2003	
Serbia	4–6	?	2008 [24]	
Slovakia	10–15	-	2012 [25]	
Spain	2,000–2,200	- [14]	2005	9
Sweden	1,933–2,181	+	2012 [26]	9
Switzerland	1,200–1,500	+	2009 [27]	6
UK	2,200	+	2013 [28]	9

Table 2. Latest Red kite population estimates in Europe, indicating those countries with more than 1% of the total population. Unless otherwise stated, data are from Aebischer (2009) [4].

Table 3. Major threats that drove Red kite decline and may still constrain the population [14].

Threat	Description	Impact
Unintentional effects of hunting and collecting	Poisoning from illegal baits.	Critical
	Secondary poisoning from consumption of rodents poisoned with rodenticides in managed grasslands.	High
	Secondary lead poisoning.	Low
Hunting and collecting	Illegal shooting and trapping.	Medium/high
Agricultural intensification	Habitat degradation and loss due to agricultural intensification, especially ploughing of permanent grasslands and homogenisation of the farmed landscape. Loss of non-farmed elements, e.g. hedgerows, trees, uncultivated field edges, results in loss of nesting and feeding sites. Farming activities also cause disturbance of nesting or roosting sites.	Medium/high
Livestock farming and ranching	EU sanitary legislation prohibited leaving livestock carcasses, which resulted in a decrease in food availability.	Medium
Renewable energy	Collision with wind turbines, particularly during the breeding season.	Medium, potentially growing
Transportation and service corridors	Electrocution on power cables.	Low
Wood and pulp plantations	Disturbance from forestry operations, particularly in some areas of eastern Europe.	Low (local)

Norway and Denmark [2]. More recently, severe range contractions took place in the Baltic States, the Balkans, central and eastern Europe and south-western Russia [2, 31] (Figure 2).

From the 1970s, Red kites began recolonizing parts of their range, including Denmark and Belgium [2, 12, 31], while reintroduction projects resulted in the recolonisation of the British Isles [14, 18].

Major threats

Until the mid-1950s, major declines in Red kite populations were caused by intensive persecution, especially during 1850–1900 [2, 30–32]. From the 1960s, habitat degradation due to agricultural intensification, but also the decline in grazing livestock, negatively affected Red kites in southern and eastern Europe [14, 30]. In Germany, land-use change and the intensification of agriculture following reunification of the country in 1989 resulted in habitat degradation and was the main cause for the decline in the German Red kite population in the 1990s [4, 33].

The main driver for the modern decline of the species is mortality through poisoning [6, 14]. As facultative scavengers, Red kites are particularly sensitive to the illegal use of poison for control of foxes, wolves, corvids, etc. Recent cases include 43% of known causes of mortality in France between 2002 and 2007 [34], 40% in Scotland between 1989 and 2006 [35], and possibly four birds in Northern Ireland so far in 2013 [36]. Red kites are also highly susceptible to secondary poisoning from consumption of poisoned rodents. Rodenticides are used to control vole outbreaks in agricultural areas and scavengers feed on the poisoned carcasses [6, 14]. This is a major threat, particularly in Spain and France, where the migratory population of Red kites winters [13].

Mortality of wintering birds caused by secondary poisoning following rodent control campaigns could partially explain the declines suffered by the breeding populations of France and Germany [6]. It is interesting to note that in several of the populations that are stable or increasing, such as UK, Sweden, Italy, Czech Republic, and the region of Auvergne in France, many birds are sedentary, and lack of exposure to poisoning in the wintering grounds has been suggested as a factor behind the positive trends in these populations [3, 6, 33].

Other threats include illegal persecution of the species, prey declines and loss of breeding and foraging habitat due to agricultural intensification, expansion of windfarms and electrocution by power cables [10, 13, 14, 37].

Action	Description	Impact
Monitoring and planning	Systematic monitoring in most countries.	Medium
	International Species Action Plan in place and national or regional Action Plans in place or in preparation in some countries (Denmark, France, Germany, Italy, Portugal and the UK).	High
Site/Area protection	There are 641 IBAs identified for Red kite in Europe, of which 52% are fully designated as SPAs or other protected areas and 4% are not protected.	Medium
Site/Area management	Mitigation of the most dangerous powerlines.	Low
	Buffer zones around nests.	High
Species recovery	Supplementary feeding.	Medium
Species reintroduction	Reintroduction projects in Italy (Tuscany and the Marche), Britain and Ireland.	High
Education and awareness	Awareness raising for foresters, landowners and public.	Medium
Legislation	Legally protected in all countries in Europe.	High

Table 4. Conservation actions in place for Red kite [14].

Drivers of recovery

Red kites have benefitted from legal protection, monitoring and targeted conservation actions across most of their distribution, including reintroduction projects in Britain and Ireland and in Italy [13]. In order to ensure the survival of Red kite populations, it is critical that the illegal use of poison baits is halted, while the risk of secondary poisoning following rodent control campaigns must also be reduced [13, 14]. Red kite habitat should also be preserved by maintaining low intensity grassland management and ensuring that sanitary regulations do not prevent the availability of livestock carcasses [13, 14].

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Peer reviewers

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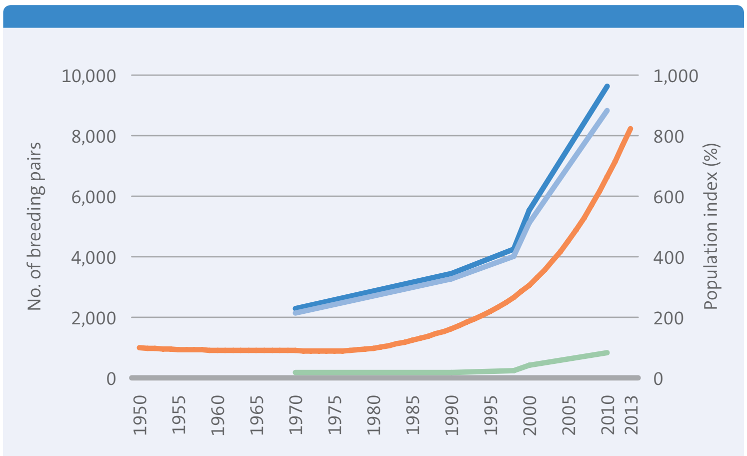
4.12. White-tailed eagle

Haliaeetus albicilla

Figure 1. Estimated **number** of White-tailed eagle breeding pairs in Europe, in the large population in **Northern Europe** and the smaller **south-eastern** population, including the Danube and the Balkans since 1970, based on BirdLife International [10, 18], the Species Actions Plans [2, 6] and other key sources. The population **trend** since 1950 is also shown (see 'Methods').



Summary

The White-tailed eagle declined dramatically across Europe between the 1800s and the 1970s, owing to direct persecution and the adverse effect of environmental pollutants on reproductive success. With the introduction of protection legislation and the ban of harmful chemicals, the species has shown a spectacular recovery.

Population size has increased and White-tailed eagles have recolonised areas from which they became extinct, in some cases with the help of reintroduction programmes, while range expansion in Europe is also apparent.

Background

General description of the species

The White-tailed eagle or Sea eagle (*Haliaeetus albicilla*) is a large, long-lived, slow-reproducing raptor [1]. Territorial pairs are sedentary, normally occupying the same breeding territory throughout their life [2], although birds in some northern populations migrate south in winter [3].

Distribution in Europe

The species is widely distributed across the Palearctic, from Greenland and Iceland in the west, to the Pacific coast and Japan in the east [4]. Historically, the White-tailed eagle was present throughout Europe, and its distribution extended across western and southern Europe, reaching as far south as North Africa [5].

White-tailed eagles in Europe can be divided into two sub-populations: northern Europe, which includes Norway and the Baltic Sea riparian states, and southern-eastern Europe, which includes the Danube countries and the Balkans [6].

Habitat preferences

White-tailed eagles nest preferably on trees or cliffs, and more rarely on pylons or towers and in some areas rather regularly on the ground. The species is usually closely associated with water and inhabits a range of habitats near lakes, river valleys and coastal waters [2, 7]. White-tailed eagles mainly feed on fish and aquatic birds, and carrion is an important source of food, especially during winter [2]. A sufficient prey base is necessary, as well as suitable nesting trees in forested areas and low levels of human disturbance [2].

Legal protection and conservation status

White-tailed eagle is listed in Annex I of the EU Birds Directive, Appendix I of CITES, Annex I and II of the Convention on Migratory Species, and Annex II of the Bern Convention [8].

ABUNDANCE: CURRENT STATUS AND CHANGES

According to the latest White-tailed eagle population estimates, the European population numbers 8,600 – 10,900 breeding pairs (Table 2). In descending order, Norway, European Russia, Poland, Germany and Sweden hold the largest numbers of breeding White-tailed eagles, together supporting 81% of the total European population. This highlights the importance of Norway, which holds 39% of the European population (Table 2), and the countries surrounding the Baltic Sea (northern European population) [12], while most of the remaining population in Europe is found in the countries along the river Danube [6].

During the period 1800 – 1970, White-tailed eagle populations across Europe suffered dramatic declines. The species became extinct in a number of countries, including the Czech Republic (1880s [13]), the United Kingdom (1911 [14]), Denmark (1912 [15]), Austria (1950s [16]), and Slovakia (1964 [17]). During the last few decades, White-tailed eagles have undergone a large increase (Figure 1) and population trends continue to be positive in nearly all countries in Europe (Table 2).

Scale	Status	Justification
Global	Least Concern (since 2005; was considered Near Threatened in 2004 and Threatened in 1988)	Extremely large range, moderately small to large global population size (>10,000 mature individuals) and increasing population trend.
Europe	Rare (SPEC 1)	Small European breeding population (< 10,000 pairs).
EU25	Rare	

Table 1. Global IUCN Red List status [9], European population and SPEC status [10] and EU population status [11] of White-tailed eagle.

Country	No. of breeding pairs	Year	Trend	%
Austria	14–17 [19]	2012	+	
Belarus	85–105 [20]	2002	?	1
Bosnia and Herzegovina	5–10 [21]	2012	–	
Bulgaria	15 [6]	2010	+	
Croatia	150 [6]	2008	+	2
Czech Republic	95–100 [22]	2013	+	1
Denmark	31 [15]	2010	+	
Estonia	220–250 [23]	2012	+	2
Finland	294 [12]	2007	+	3
Germany	630–660 [6]	2010	+	7
Greece	6 [24]	2009	Stable	
Hungary	250 [25]	2012	+	3
Iceland	53 [26]	2002	?	1
Republic of Ireland	10 [27]	2011	+	
Latvia	80–100 [28]	2012	+	1
Lithuania	100–150 [29]	2012	+	1
Moldova	2–3 [30]	2010	?	
Netherlands	4 [31]	2013	+	
Norway	3,500–4,000 [32]	2010	+	39
Poland	1,250–1,700 [33]	2012	+	15
Romania	37–42 [6]	2010	+	
Russia	500 [2]	2000	?	15
Serbia	115 [34]	2009	+	1
Slovakia	9 [35]	2012	+	
Slovenia	8–11 [36]	2012	+	
Sweden	533–600 [37]	2012	+	6
Ukraine	100–120 [38]	2009	+	1
United Kingdom	59 [39]	2012	+	1

Table 2.
Latest White-tailed eagle population estimates in Europe, indicating those countries that hold at least 1% of the European population.

Distribution: current status and changes

White-tailed eagle distribution underwent severe range contractions from mid-19th until mid- to late 20th century [2, 6, 42, 43]. Recovery is evident in a number of countries [44], including the Czech Republic [13], Denmark [45], Finland [46], Germany [47], Norway [32], Poland [48, 49] and Sweden [50, 51] and there is evidence of a westward range expansion. However, a retraction is apparent in the Balkan Peninsula and Russia (Figure 2), although the species range in these regions may have been overestimated in the past [52].

Major threats

The declines experienced by the European population of White-tailed eagles during the 19th and early 20th centuries were caused mainly by persecution [1, 2, 12, 16, 44]. Severe crashes in White-tailed eagle populations took place until the 1970s, attributed to bioaccumulation of organochlorine pesticides, such as DDT and PCB [2, 12, 55, 56]. Pollution caused by these chemicals resulted in breeding failure [51, 55, 57]. The populations surrounding the Baltic Sea were most severely affected, as pollution levels were very high in the region. In contrast, the Norwegian population, which utilises food resources from the northern Atlantic, was not as badly affected [57].

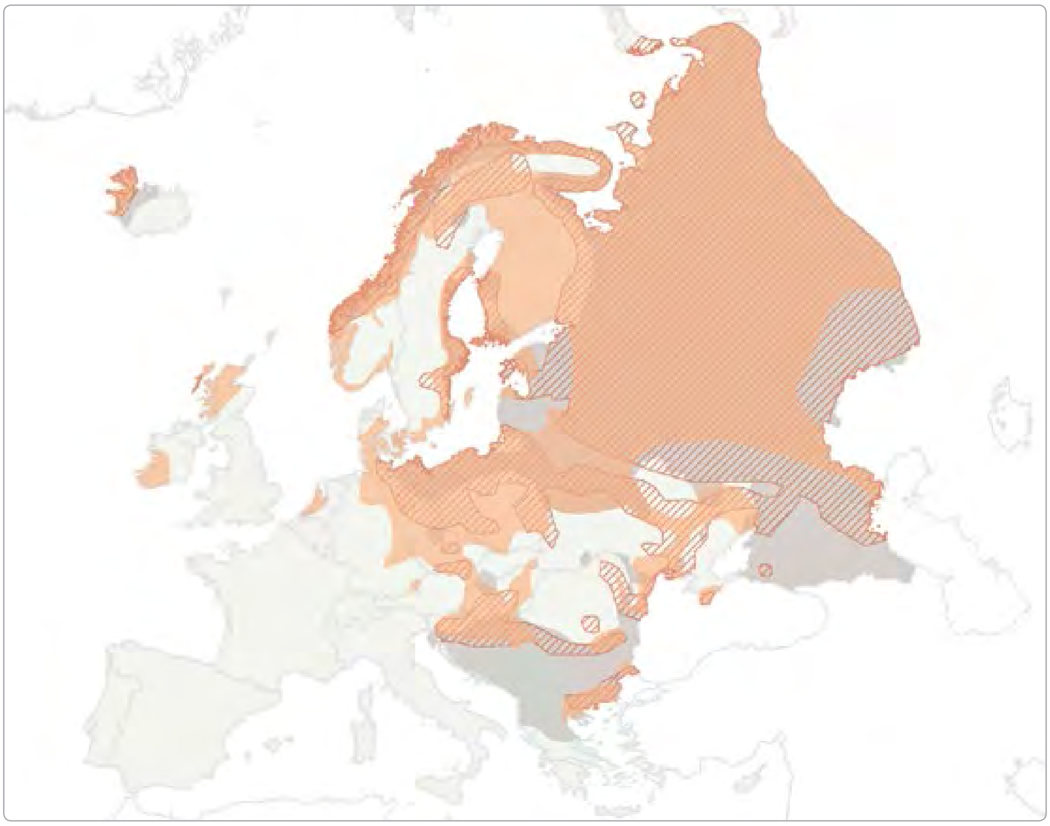


Figure 2.
Current distribution of White-tailed eagle in Europe and historical distribution in the **1950s** [40] and **1980s** [41].

Ongoing threats include habitat loss and degradation [2, 6, 17, 58–60], human disturbance, especially as a result of forestry operations and access [2, 6, 42, 60, 61], and persecution [2, 6], accidental poisoning [2, 6, 54, 62–65] and collision with wind turbines and overhead cables [2, 63, 66–68] (Table 3). Collision with and electrocution by overhead cables is the most important cause of unnatural mortality in juvenile and sub-adult White-tailed eagles in Norway [32, 69], while collision with wind turbines at the Smøla wind power plant in Norway is a significant cause of mortality of adult birds [66, 67]. Although the effects of collisions are local, the mortality and habitat displacement caused by the wind power plant have resulted in reduced White-tailed eagle breeding success [70]. Future development of wind power plants may have potentially high impact on White-tailed eagle populations over the long term [32].

Drivers of recovery

Legal protection of White-tailed eagles and their nests and the ban of DDT and other harmful chemicals since the 1970s have resulted in recovery, recolonisation and expansion, contributing to the comeback of the species in Europe [2, 6, 42–44]. Other management interventions include reintroductions, as well as winter feeding, artificial nest construction, monitoring and public awareness campaigns.

The exclusion of DDT from agriculture and forestry in the early 1970s was followed by successful reproduction and an increase in White-tailed eagle numbers [e.g. 55, 72]. Supplementary feeding contributes to increased juvenile overwinter survival [46, 65, 73–75], resulting in population-level benefits. Protection of nests from disturbance has also proved important for breeding success [44, 76].

Reintroduction programmes have contributed to increases in the Czech Republic [13] and Scotland [14, 77, 78], while the success of the programme in Ireland [79, 80] remains to be seen. Many White-tailed eagles reintroduced to Ireland have been lost to illegal persecution [81], but the first eaglets since the species became nationally extinct in the early 1900s fledged in 2013 [82]. Plans for a reintroduction of the species to Suffolk, England, were withdrawn in 2010 due to financial cut backs [83].

Natural recolonisation and expansion has also taken place in a number of countries, including Germany [84], Denmark [15] and the Netherlands, where a pair of White-tailed eagles began breeding in Oostvaardersplassen in 2006 [85] and by 2013 there were seven pairs in the country [31, 86].

Threat	Description	Impact
Wood and pulp plantations	Ecosystem conversion and degradation reduces availability of suitable nesting habitat. Disturbance of nesting birds by forestry operations. Forestry roads cause habitat fragmentation and disturbance, especially in the Danube region.	Medium to high
Residential and commercial development	Ecosystem conversion and degradation. Increased disturbance, resulting in reduced productivity.	Medium to high
Natural systems modifications	Ecosystem conversion and degradation through river regulations and drainage of wetlands.	Potentially medium to high
Hunting and collecting of terrestrial animals	Persecution and illegal hunting, especially in central and southern Europe and parts of Asia.	Medium
Unintentional effects of hunting and collecting	Unintentional effects of poisoned baits put out to kill foxes and other vermin. Unintentional effects of lead poisoning from ingested ammunition.	Medium
Pollution	Ecosystem conversion and degradation through secondary poisoning from pesticides and pollutants, causing mortality and impaired reproduction.	Medium
Human intrusions and disturbance	Disturbance of nests through increased tourism and recreation.	Medium to low
Transportation and service corridors	Accidental mortality by collision with and electrocution by overhead cables.	High
	Accidental mortality by collision with trains and cars.	Low to medium
Renewable energy	Accidental mortality due to collisions with wind turbines.	Potentially high
Unintentional effects of Fishing and harvesting aquatic resources	Reduction of prey base through overfishing.	Low
Agricultural intensification	Ecosystem conversion and degradation of wetlands.	Low
Climate change and severe weather	Increasing precipitation in Greenland has probably had a negative effect on breeding success.	Low

Table 3. Major threats that drove White-tailed eagle decline and may still constrain the population [2, 6, 32, 52–54].

Table 4. Conservation actions in place for White-tailed eagle.

Action	Description
Monitoring and planning	International Species Action Plan [2]. Species Action Plan for the Danube region [6]. Systematic monitoring schemes in some countries, e.g. Finland, Germany, Hungary, Iceland, Norway, Poland, Slovakia, Sweden, United Kingdom [2], as well as transnational surveys and an ongoing international colour ringing programme [54].
Site/area protection	There are 760 IBAs identified for White-tailed eagle in Europe, of which 56% are fully designated as SPAs or other protected areas and 15% not protected.
Site/area management	Nest protection [2, 6].
Species reintroduction	Reintroduction programmes in place in Scotland and Ireland.
Species recovery	Supplementary winter feeding.
	Artificial nest platform creation [e.g. 65, 71].
Legislation	Listed under a number of international conventions and agreements (see 'Legal protection and conservation status').
Education and awareness	Public awareness campaigns [e.g. 19].

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Peer reviewers

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4.13. Bearded vulture

Gypaetus barbatus

Summary

The Bearded vulture is a specialised scavenger which inhabits mountain areas in southern Europe. The species was widespread across most Eurasian mountain ranges until the 19th century, when direct persecution and the use of poison against wildlife led to its disappearance from most of its former distribution range. During most of the last century, within western and southern Europe, Bearded vultures survived only in the Pyrenees and on two Mediterranean islands (Corsica and Crete). At the end of the 20th century, the Pyrenean population started to increase. Reintroduction projects are ongoing in the Alps, the Grands Causses (Cevennes) and the mountains of Andalucía, with others to northern Spain and central France planned in the coming decade. Captive bred birds released in the Alps have led to the reestablishment of a wild population there. Although the Bearded vulture is making a comeback in Western and Central Europe (increase of 40% in the last few years), its population is still small and fragile (200 pairs).

Table 1. Global IUCN Red List status [12], European population and SPEC status [13] and EU population status [14] of Bearded vulture.

Scale	Status	Justification
Global	Least Concern (since 1994; was considered Near Threatened in 1988)	Extremely large range. Although the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion.
Europe	Vulnerable (SPEC 3)	Small population size (<10,000 mature individuals) and a continuing decline of at least 10% within 10 years or three generations, and no subpopulation estimated to contain more than 1,000 mature individuals.
EU25	Vulnerable	Small population size (<1,000 mature individuals)

Background

General description of the species

The Bearded vulture, or Lammergeier (*Gypaetus barbatus*) is a highly distinctive bird-of-prey and one of the largest Old World vultures [1]. Reproductive rate is low, as sexual maturity is reached at about seven years or later [2], and usually just one chick is fledged per nest. It is largely a resident species, but the young may disperse widely – birds released in the Alps have been recorded in the Baltics and in Western France and the Netherlands [3].

The species is usually monogamous, but polyandrous trios, normally two males and one female, first recorded in the Pyrenees in 1979, have increased ever since – in 1996, 14% of the breeding territories in the Pyrenees were occupied by trios. The formation of trios has been attributed to biased sex ratios, low food availability, high breeding density or genetic relatedness between males, but as yet there is no proof of which is the key factor [4, 5]. This phenomenon could have important implications for the conservation of the species.

Distribution in Europe

The Bearded vulture is widely distributed in mountainous regions in Eurasia and Africa, with a small proportion of its global range in Europe. Although the global population of the species is not concentrated in Europe [6], the Bearded vulture is one of the most emblematic species of the large Eurasian mountain ranges. The species currently breeds in Austria, France, Greece (Crete), Italy, Spain, and Switzerland [7], and it also occurs in Turkey and the Caucasus.

Habitat preferences

The Bearded vulture nests on cliffs in mountain ranges at 400–2000 m above sea level and has a rather large territory – between 100 and 500 square kilometres [8]. It forages over montane and sub-alpine vegetation, mostly above 1000 m, where both domestic and wild ungulates occur. Where available, the species may also visit feeding stations.

The diet of the Bearded vulture consists mostly of bone marrow (up to 85% of diet), especially from the extremities of sheep and goat, but flesh is also taken from dead animals including chamois, marmot, sheep, goat, moufflon, ibex, rabbit and pigs (domestic and wild) [9, 10]. If bones are too big to swallow in one piece, Bearded vultures carry them into the air and let them drop onto rocks below, to break them. Small animals (birds and rodents), or meat of larger ones, are fed to chicks, forming an important part of their diet. As bones contain almost no water, Bearded vultures feeding mainly on marrow need to have access to water.

Legal protection and conservation status

The species is listed in Annex I of the EU Birds Directive, in Annex III of the Bern Convention, in Annex II of the Convention on Migratory Species and in Appendix II of CITES [11].

Abundance: current status and changes

The current European breeding population of Bearded vulture is quite small (200 pairs; Table 2) and was mostly stable during 1970–1990. Since 1999, the European populations show a recovery (Figure 1). The population in the Pyrenees (Spain and France) is increasing [15, 16], as is the reintroduced population in the Alps (Austria, France, Italy and Switzerland), which comprised 22 breeding pairs in 2013 [17, 18]. The two small island populations have contrasting trends, with the population in Crete (Greece) slightly increasing in the last decade [19] and that in Corsica (France) slowly decreasing [20] – it now numbers only 10 individuals.

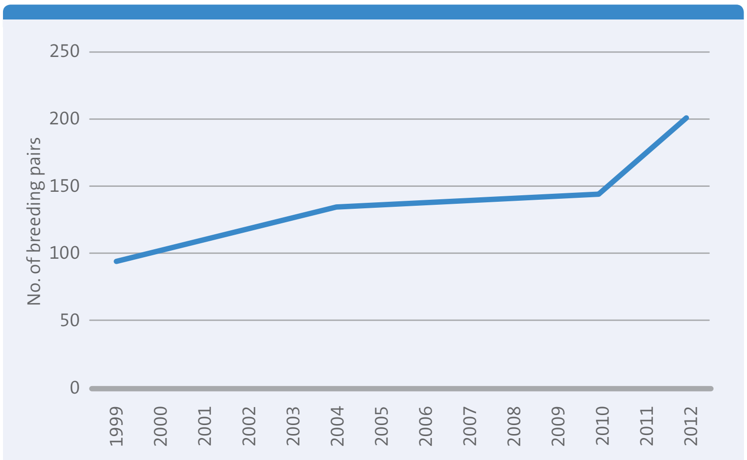

Figure 1. Estimated number of Bearded vulture breeding pairs in Europe.

Distribution: current status and changes

Human persecution and poisoning caused a reduction in numbers or extinction of the species across most of Europe at the end of the 19th and beginning of the 20th centuries [23, 24]. After its extirpation from the Alps at the beginning of the 20th century [25, 26], extinction continued in other regions. The species was exterminated from Germany (1855), Switzerland (1884), Bosnia and Herzegovina (1893), Austria (1906), Italy (1913) [27], Romania (1935), Czechoslovakia (1942), Yugoslavia (Serbia, Montenegro) (1956) [28], Bulgaria (1966) [29], Andalucía (1980s) [30] and the Former Yugoslav Republic of Macedonia (1990) [31, 32]. It disappeared from mainland Greece in the early 2000s [19, 33].

The distribution of the species in western and southern Europe was reduced to the mountains of the Pyrenees (France and Spain), Crete (Greece) and Corsica [34]. The species now breeds only in Andorra (regions of Navarra, Aragón and Cataluña, all in the Pyrenees) and Andalucía in Spain, in France (Pyrenees, Corsica and the Alps), Switzerland, Austria and Italy (Alps only) and Greece (Crete).

Table 2. Numbers of Bearded vulture breeding pairs in each country in Europe in 2010–2012 according to recent data [13, 15, 21].

Countries	No. of breeding pairs	Trend	%
Austria	2	+	1
France	46	+	23
Greece	6–7	Stable	3
Italy	6	+	3
Spain	134	+	67
Switzerland	5	+	3

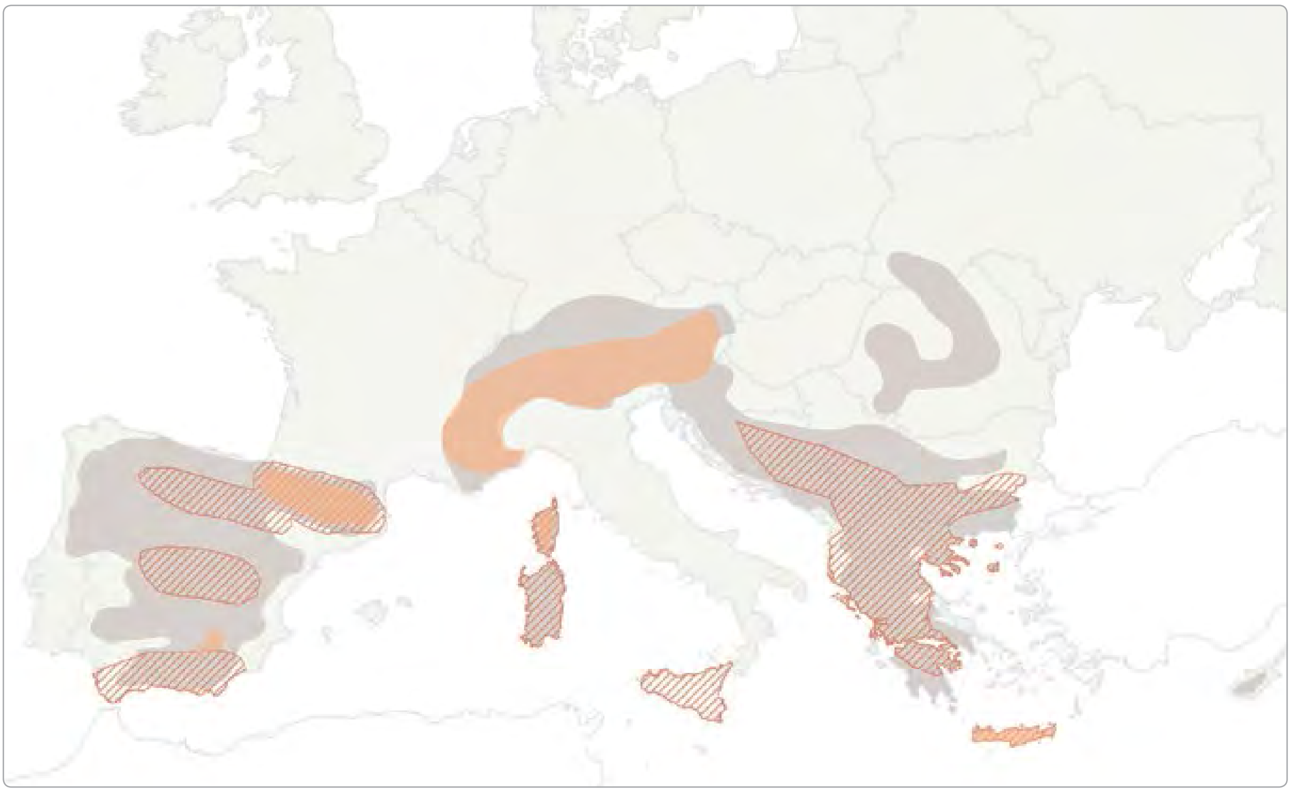

Figure 2.
Current distribution of Bearded vulture in Europe and historic distribution in the **1850s** and **1950s** [22].

Table 3.
Major threats that drove the Bearded vulture decline and may still constrain the population.

Threat	Description	Impact
Unintentional effects of hunting and collecting	Poisoning and intoxication as a result of consumption of poison baits against predators, or lead poisoning from feeding on carcasses with lead shot.	Critical
Pollution from agriculture	Poisoning and intoxication as a result of consumption of livestock carcasses with antibiotics.	
Agricultural abandonment	Reduction of carrion availability due to declines in extensive livestock management in the mountains.	High
Livestock farming and ranching	Less carrion available because of modernisation of agriculture.	High
Renewable energy	Collision with wind turbines.	High
Transportation and service corridors	Collision with and electrocution by overhead power lines.	High
Human intrusions and disturbance	Human outdoor activities near breeding cliffs (e.g. rock climbing).	Medium
Hunting and collecting	Main reason for the extinction in Alps in the past.	Medium (historically high)

Major threats

This species experienced a massive decline in Europe in the 19th and 20th centuries due to persecution (mostly shooting), use of poisoned baits, habitat loss, and reduction in extensive livestock farming in many mountain ranges [34].

The main causes of ongoing declines appear to be non-target poisoning, direct persecution, habitat degradation, disturbance of breeding birds, inadequate food availability, changes in livestock-rearing practices and collisions with power-lines and wind farms. Human persecution and poisoning continue to be the main factors contributing to unnatural mortality for European Bearded vultures [34], as evidenced by recent studies, which show that shooting (31%), intentional poisoning (26%), collision (18%) and unintentional poisoning (12%) were the most important threats.

Drivers of recovery

The Bearded vulture is still vulnerable in Europe, as its population size is small and includes some isolated, fragile, relict island populations (Crete and Corsica). A number of Bearded vulture conservation projects are in place, including the highly successful reintroduction programme in the European Alps (Austria, France, Italy and Switzerland), which has been in operation since the 1980s under the coordination of the Vulture Conservation Foundation (formerly the Foundation for the Conservation of the Bearded Vulture) [21]. To date, 197 birds have been released and 22 breeding pairs are currently established as a direct result of this project [17].

Since 2010, new release sites in the western Alps (Parc Regional du Vercors) and the Grands Causses (France) have been chosen with the aim to bridge and connect the Alpine and Pyrenean populations. A reintroduction project has also been initiated in Andalucía by the regional government.

These projects employ best practice for captive breeding, monitoring and releasing methodologies and standards, based on the European Endangered Species Breeding Program (EEP). Annual conferences of the Alpine reintroduction project partners (International Bearded Vulture Monitoring, IBM) facilitate exchange of information and experience, including discussion on the situation in Spain and other countries within the distribution of the Bearded vulture.

Action	Description	Impact
Site/area protection	There are 125 IBAs identified for Bearded vulture in Europe, of which 34% are fully designated as SPAs or protected areas and 22% are not protected.	High
Monitoring and planning	Intensive monitoring in the Alps (by International Bearded vulture Monitoring, IBM), Corsica, Crete, Pyrenees.	Medium
Species reintroduction	Reintroduction programmes in the Alps, Cevennes and Andalucía. Based on captive breeding of Bearded vultures through the species EEP (Endangered Species Programme).	High
Education and awareness	Reintroduction projects work with local and national stakeholders and the public at large, especially during the release season.	Medium
Compliance and enforcement of legislation	Campaigns against the use of poison are implemented in Andalucia, some regions of the Pyrenees and France. Also there are specific activities against lead poisoning in some areas (e.g. Italian Alps).	High

Table 4. Conservation actions in place for Bearded vulture.

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Peer reviewers

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4.14. Griffon vulture

Gyps fulvus

Summary

The Griffon vulture declined throughout its European range until the second half of the 20th century, when legal protection came into force and the use of the most lethal poisons against wildlife was prohibited. By then it had disappeared from many European countries. In the last forty years, the species has staged a remarkable comeback, and its European populations have increased significantly, mainly in the Iberian Peninsula and France. There are recent signs that the populations in the Balkans and in Italy are also now slowly recovering, but the species has gone extinct or is still declining in some countries (e.g. Albania and Greece). This significant population increase (c. 200% in the last 12 years) is mainly due to the successful implementation of a series of conservation measures, notably campaigns to minimise poisoning and provide safe food at 'vulture restaurants'. Its range has also expanded, in most part thanks to a number of reintroduction projects in France, Italy and the Balkans.

Table 1. Global IUCN Red List status [13], European population and SPEC status [14] and EU population status [15] of Griffon vulture.

Scale	Status	Justification
Global	Least Concern (since 1988)	Extremely large range, large population size and increasing population trend.
Europe	Secure (Non-SPEC since 2004; previously considered Rare and SPEC 3)	The species underwent a large increase overall in Europe.
EU25	Secure	

Background

General description of the species

Like other vultures, the Griffon vulture (*Gyps fulvus*) is a scavenger, feeding mostly from carcasses of medium-to-large sized dead animals, which it finds by soaring over open areas, often moving in flocks. In areas with healthy populations, a dead animal can attract large numbers of vultures within a short time [1].

Griffon vultures are a very long-lived species, and the maximum lifespan recorded in captivity is 55 years [2]. Griffons first breed when they are 4 or 5 years, laying a single egg per nesting attempt. Most adults are sedentary, but young and immature birds often disperse over longer distances, reaching Africa and the Middle East. Dispersal follows a southwesterly direction in western Europe (through the Straits of Gibraltar) and a southeasterly direction in the Balkans, through Turkey, towards the Middle East and northeast Africa [1, 3].

In recent years, Griffon vultures have been seen with more frequency in central Europe, including in Belgium, the Netherlands and Germany, probably related to the recent increase in Griffon vulture populations in Spain and France, but these observations may also be driven by local food shortages. Immature and non-breeding Griffons from Spain and France have also been recorded moving increasingly north or northeast towards the Alps from April to September. Similar movements also happen in the Croatian (and Balkan) population, with about 100–150 birds summering in the Alpine area of northeastern Italy, Austria and Slovenia [4].

Distribution in Europe

The Griffon vulture has an extremely large range, extending over Europe, the Middle East and North Africa. It occurs from India, west to Portugal and Spain, including some island populations in the Mediterranean (Crete, Naxos, Cyprus and recently established in Mallorca) [5]. It also occurs in Turkey, the Crimea (Ukraine) and the Caucasus, and then from there to the Middle East and into Central Asia. In North Africa it is probably extinct as a breeding species [6], even though it occurs in large numbers during migration in Morocco [7].

Habitat preferences

Griffon vultures are most common in countries bordering the Mediterranean and usually occur at low densities. They breed in colonies in cliffs, at sites that are undisturbed by humans, and that are within a few dozen kilometres to open areas with good availability of dead animals [8–10]. Griffon vultures roost and rest on large cliffs and soar over surrounding open countryside in search of food, but they avoid woodlands. They forage over a wide range of habitats, mainly over hills with low vegetation and rocky escarpments, usually at moderate altitudes (200–2,500 m), but also over lower areas, including river deltas, provided there are large numbers of grazing animals and cliffs. Satellite telemetry has revealed that Griffon vultures fly, on average, at 300m above ground, but can reach heights of 2,500 m [11].

Legal Protection and conservation status

The Griffon vulture is listed on Annex I of the EU Birds Directive, Annex II of the Bern Convention, Annex II of the Convention on Migratory Species, and Appendix II of CITES [12].

Abundance:
current status and changes

There are approximately 27,000–28,000 breeding pairs of Griffon vulture in Europe (Table 2). The largest numbers of Griffon vultures are found in Spain, which holds 90% of the European population and where the population has been increasing. There are also significant populations in France, Portugal, Croatia and Greece (Table 2). The number of Griffon vulture breeding pairs has increased substantially in most of the species' European range, including in the Iberian Peninsula, in France (from 75 pairs in 1999 to 1,443 pairs in 2012), and in some countries in Eastern Europe (Croatia, Serbia, Bulgaria). However, populations are declining in continental Greece and in Cyprus. Small, decreasing or fluctuating populations are also reported from Macedonia and Ukraine, while the species has disappeared from Albania, Bosnia and Herzegovina, Montenegro and Romania [16].

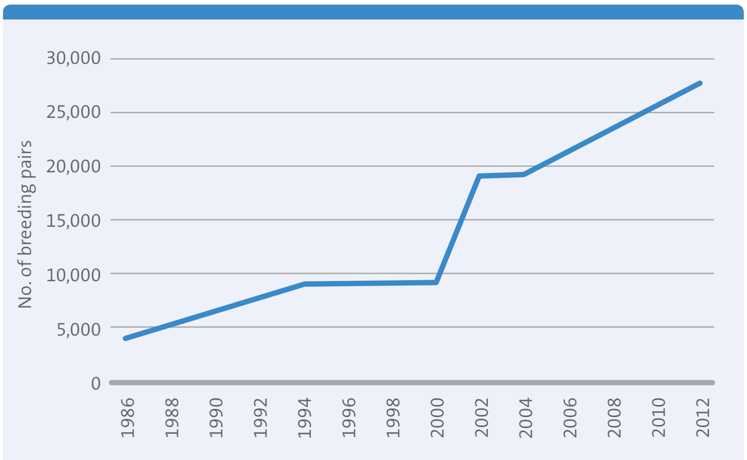

Figure 1. Estimated number of Griffon vulture breeding pairs in Europe.

Distribution:
current status and changes

The Griffon vulture has a patchy distribution in most parts of its range. The population in the western European portion of the range (Iberian Peninsula and France) has increased greatly during the last three decades, but in some areas in southeastern Europe populations the range is still shrinking and populations have recently become extinct [16].

In the past it reached the southwest of Germany (up to the end of the Middle Ages), south Poland (up to the early 19th century), and more recently it occurred in Romania, Moldova, Ukraine, and south

Table 2. Latest population estimates of Griffon vulture in each European country, according to the latest Balkan Vulture Action Plan summary [17] and recent data, indicating those countries holding more than 1% of the European population.

Country	No. of breeding pairs	Year	Trend	%
Austria	?		?	
Bulgaria	67 [18]	2013	+	
Croatia	141 [19]	2013	+	
Cyprus	2 [20]	2013	-	
France	1,443 [21]	2012	+	5
Greece	270 19	2012	-	1
Italy	92 [22]	2012	+	
FYRO Macedonia	16 [17]	2012	-	
Portugal	197–361 [23]	2008	+	1
Serbia	130 [17]	2012	+	
Spain	24,609–25,541 [24]	2008	+	91
Ukraine	23–25 [25]	2008	+	

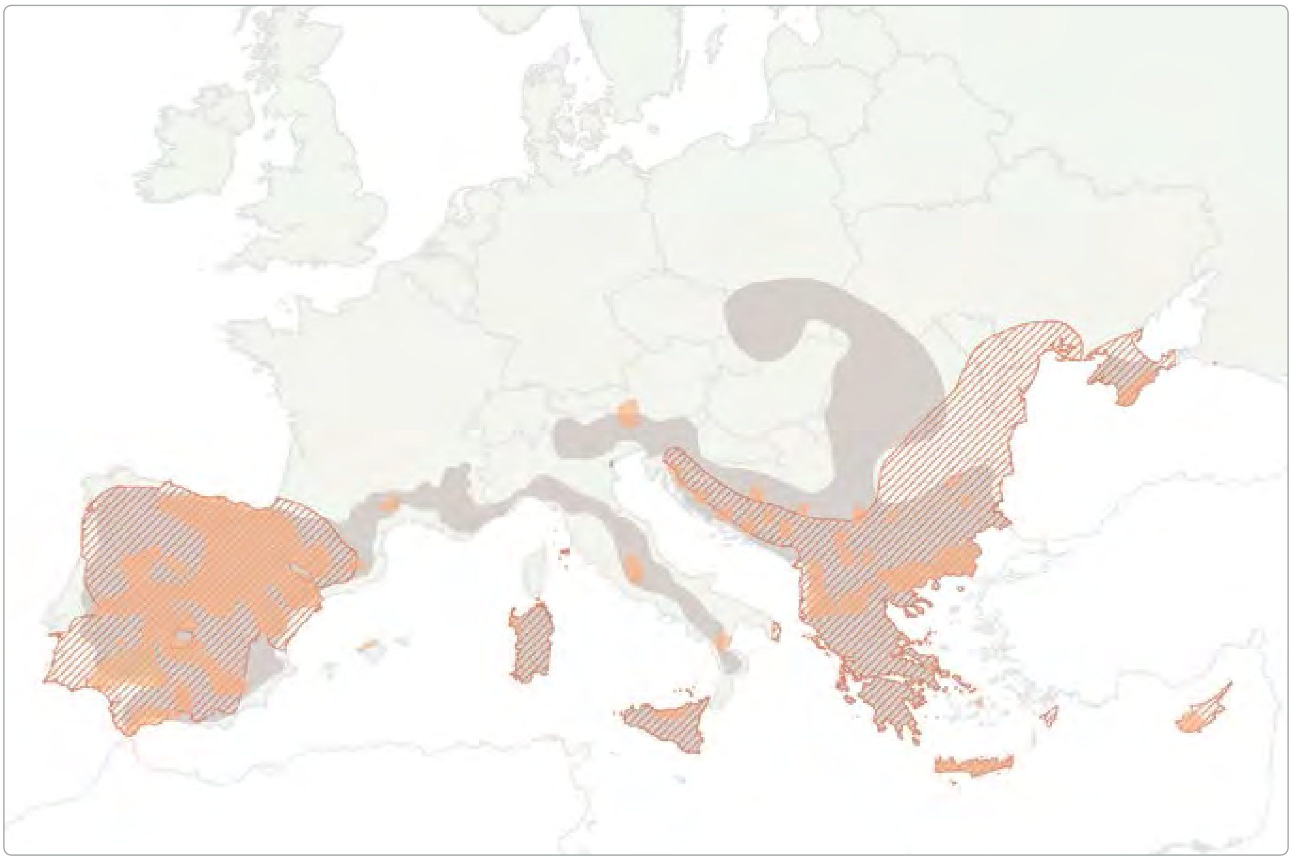

Figure 2.
Current distribution of Griffon vulture in Europe and historical distribution in the **1850s**, and **1950s** [26].

of the Urals. Today it occurs in Portugal, Spain, France, Italy, and down the Balkans to Greece.

In the last few years, Griffon vultures have recolonised Mallorca, as a group that appeared on the island in 2008 is now resident and breeding well [27].

Major threats

The main threats to Griffon vulture populations are similar throughout their range [28]. The principal threats are poisoning, lack of food, and mortality due to collision with wind turbines and electrocution from powerlines [29–31]. Poisoning is the most important threat affecting all vulture species in Europe. Food abundance is considered a critical factor in the population dynamics of vultures [32–35] and availability of food is driven by EU sanitary regulations on carcass disposal, as well as by changes in land-use that influence the number of domestic ungulate populations and thus the availability of carcasses [36–40]. More locally, disturbance to Griffon vulture nesting cliffs and direct persecution, through shooting and egg robbing, can be important [41].

These threats caused a widespread decline in Griffon vulture numbers between the end of the 19th century and beginning of 20th century, and resulted in its extinction in some areas such as the French Alps and the Carpathians [42].

Table 2.
Major threats that drove the Griffon vulture decline and may still constrain the population [16].

Threat	Description	Impact
Unintentional effects of hunting and collecting	Poisoning from consumption of poison baits used against predators, or of carcasses with contaminated with lead from shot.	Critical
Pollution from agriculture	Poisoning from consumption of carcasses with non-steroidal anti-inflammatory drugs (NSAIDs).	
Livestock farming and ranching	Less carrion disposal because of modernisation of agriculture and the new EU sanitary regulations.	Critical
Renewable energy	Mortality by collision with wind turbines.	High
Transportation and service corridors	Collision with and electrocution by overhead power lines.	High
Human intrusions and disturbance	Human disturbance near breeding sites.	Low
Persecution	Intentional shooting and egg robbing for collections.	Low

Drivers of recovery

European populations of the Griffon vulture have increased in recent decades thanks to a number of conservation measures. These include a ban on poisoning carcasses, established in the 1970s. The relaxation of laws that prohibited farmers from leaving dead animals on their farmland, the creation of feeding stations, and a number of reintroduction projects [44] contributed to the successful recovery and increase of the populations in Europe.

Action	Description	Impact
Monitoring and planning	Well implemented national monitoring programmes in most of the countries with breeding populations.	High
Compliance and enforcement of legislation	Campaign against the use of poison: great achievements in Spain; almost no progress in the Balkans.	Critical
Site/area protection	There are 289 IBAs identified for Griffon vulture in Europe, of which 40% are fully designated as SPAs or other protected areas and 12% are not protected.	High
Species reintroduction	Finalized programs in France and ongoing projects in Italy, Bulgaria and Cyprus [43]. Planned projects for Romania.	High
Habitat and natural process restoration	Artificial feeding sites, reintroduction of wild ungulates, free disposal of carcasses in the field, work with local livestock breeders.	Critical
Legislation	National legislation protecting the species exists in all range countries.	High
	National regulations on the establishment of feeding stations exists in some countries, need to be developed in others.	
Education and awareness	The main focus of public awareness raising activities are connected with the poisoning threat or the food availability.	High

Table 3. Conservation actions in place for Griffon vulture.

In Spain, the Griffon vulture became legally protected in 1966, and as a result, population recovery started in the mid-seventies [45]. Reintroduction programs have taken place in southern France since the 1980s. The first of these began in 1981 in the Grands Causses region (Massif Central), leading to a population of >400 pairs in 2013, followed by three other programs in the southern French Alps, leading to >300 pairs in 2013 [46]. Four reintroduction projects have also established populations in north-eastern, central and southern Italy and in Sicily [4]. A reintroduction project is also underway since 2010 in Stara Planina Mountain, Bulgaria (Vultures Return in Bulgaria LIFE08 NATY/BG/278 Project) [47].

It is forecast that the species will continue to increase, mostly in southeastern Europe, and has the potential to recolonize parts of its former European range where it is still absent. However, this is dependent on the implementation of effective anti-poison work throughout the Griffon vulture range, and the continuing establishment of more feeding stations.

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Peer reviewers

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4.15. Cinereous vulture

Aegypius monachus

Summary

The Cinereous vulture is one of the largest and most spectacular birds of prey in the world. It used to occur in great numbers many places in southern and central Europe, but habitat changes, poisoning and changes in food availability due to modern farming techniques caused populations to decrease and/or disappear (notably from most of the Balkan peninsula) during the 20th century. Although the species' only remaining foothold in the Balkans is very fragile, the key population in Spain is increasing (2,068 breeding pairs in 2012, an increase of 48% in the last decade), while the species is also increasing in France, due to a very successful ongoing reintroduction project. The rate of increase of the Spanish, but also of the French and Greek populations, seems to have accelerated in the last decade, offering good prospects for the re-colonisation of some part of its former range in the near future.

Table 1. Global IUCN Red List status [6], European population and SPEC status [7] and EU population status [8] of Cinereous vulture.

Scale	Status	Justification
Global	Near Threatened (since 1994)	This species has a moderately small population, which appears to be suffering an ongoing decline in its Asian strongholds, despite the fact that in parts of Europe numbers are now increasing.
Europe	Rare (SPEC 1)	Small population size.
EU25	Rare	

Background

General description of the species

The Cinereous vulture, or European Black vulture (*Aegypius monachus*) breeds in loose colonies. In Europe, their huge nests are nearly always in trees (usually evergreen oaks and pines), but in Asia they may also nest on rocks. With very rare exceptions, clutch size is one egg [1]. While hatching success is generally high, many pairs do not breed every year, so the species has a slow recovery potential. It can live 20–30 years in the wild and up to 39 years in captivity [2].

Distribution in Europe

Currently the species has a discontinuous distribution in Europe, divided between the large western European populations (Portugal, Spain and France), and the isolated and fragile nucleus in Dadia (Greece) and Ukraine. It also occurs in Turkey and the Caucasus.

Habitat preferences

The species prefers hilly landscapes with Mediterranean habitats [3,4]. In Spain, Cinereous vultures occur mostly in dehesa-type habitats (open, grazed areas with relatively few large trees, predominantly Holm oaks (*Quercus ilex*). Open pine forests around large granite mountains have also been identified as Cinereous vulture habitat in Spain and Greece. On Mallorca, the vultures breed on solitary pine trees growing on sea cliffs scarcely covered with other vegetation.

Legal protection and conservation status

The species is listed in Annex I of the EU Birds Directive, in Appendix II of the Bern convention, and in Appendix I of CITES [5].

Abundance: current status and changes

Its global population is estimated to number 7,200–10,000 pairs, with 1,700–1,900 pairs in Europe *sensu lato* (in the early 2000s) and 5,500–8,000 pairs in Asia [7]. In Europe as defined for this study, the species occurs in Spain [9, 10] (2,068 breeding pairs in 2012 and increasing [11]), Portugal (where up to 5 pairs have been trying to breed in the last decade) and France (28 pairs in 2012). In Greece, the population is located at a single colony (28 breeding pairs, slightly increasing) [12].

Spain is the species' global stronghold (even though most of the distribution range occurs outside Europe), and the population here has increased dramatically from 206 pairs in 1973 to 1,600 pairs in 2006 [10, 13] and over 2,000 breeding pairs currently (97% of the European Cinereous vulture population). Most of these birds breed in approximately 35 colonies, half of which are in the Caceres province [10]. There is also a small island population in Mallorca.

Overall therefore, the European population increased between 1996 and 2004, and the rate of increase has accelerated in the last decade. Numbers increased from 1,074–1,178 pairs in 1996 to 2,128–2,147 breeding pairs currently (Figure 1). Populations are considered to be increasing in Spain, France and Greece, and declining in Ukraine [7, 14].

Distribution: current status and changes

The significant increase of Cinereous vultures in Spain has allowed for the recolonisation of some of its former range (e.g. Portugal and France, where recolonisation was also aided by a reintroduction project using Spanish birds).

Moreover, individuals have started to be seen more frequently in the Alps (including the Italian eastern Alps), probably accompanying the many Griffon vultures that now summer in the alpine chain, from Iberia and France [19]. Some stray individuals, presumably from the Dadia colony, have also reached Crete and Bulgaria in the last few years, offering hope for a potential recolonisation of the species' former range in southeastern Europe too.

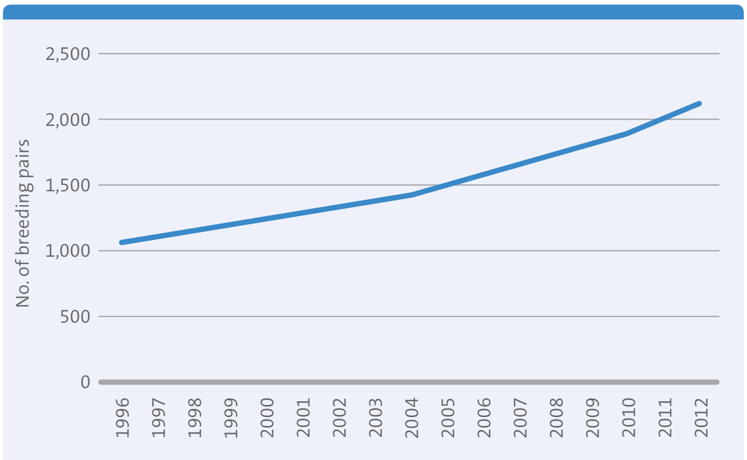

Figure 1. Estimated number of Cinereous vulture breeding pairs in Europe.

Major threats

Historically, the most important threats were related to the decline of herbivores, impacting on food availability. During the 20th century, the loss of nest sites due to forestry operations (notably plantations of eucalyptus trees in western Spain) and disturbance became a major threat.

The reduction of animal carcasses in the wild due to modernisation of agriculture also became a big problem. Persecution and especially poisoning played a critical role, leading to extinction in some

Table 2. Numbers of Cinereous vulture breeding pairs according to the Species Action Plan [14], the latest review of the implementation of Species Action Plans [13] and recent data.

Country	No. of breeding pairs	Year	Trend	%
France	28 [15]	2012	+	1
Greece	28 [16]	2012	+	1
Portugal	2–3 [17]	2012	+	
Spain	2,068 [11]	2012	+	97
Ukraine	2–20 [13]	2011	+	1

Table 3. Major threats that drove the Cinereous vulture decline and may still constrain the population.

Threats	Description	Impact
Wood and pulp plantations	Habitat loss due to forestry operations.	High
Residential and commercial development	Habitat loss due to building development.	High
Increase in fire frequency/ intensity	Habitat loss due to forest fires.	High
Livestock farming and ranching	Less carrion available because of modernisation of agriculture and new EU sanitary regulations.	High
Indirect effects of hunting and collecting	Use of poison baits for predators.	Critical
Renewable energy	Collision with wind turbines.	High
Transport and service corridors	Collision with and electrocution by overhead power lines.	High
Human intrusions and disturbance	Disturbance caused by tourists during the breeding season.	Low

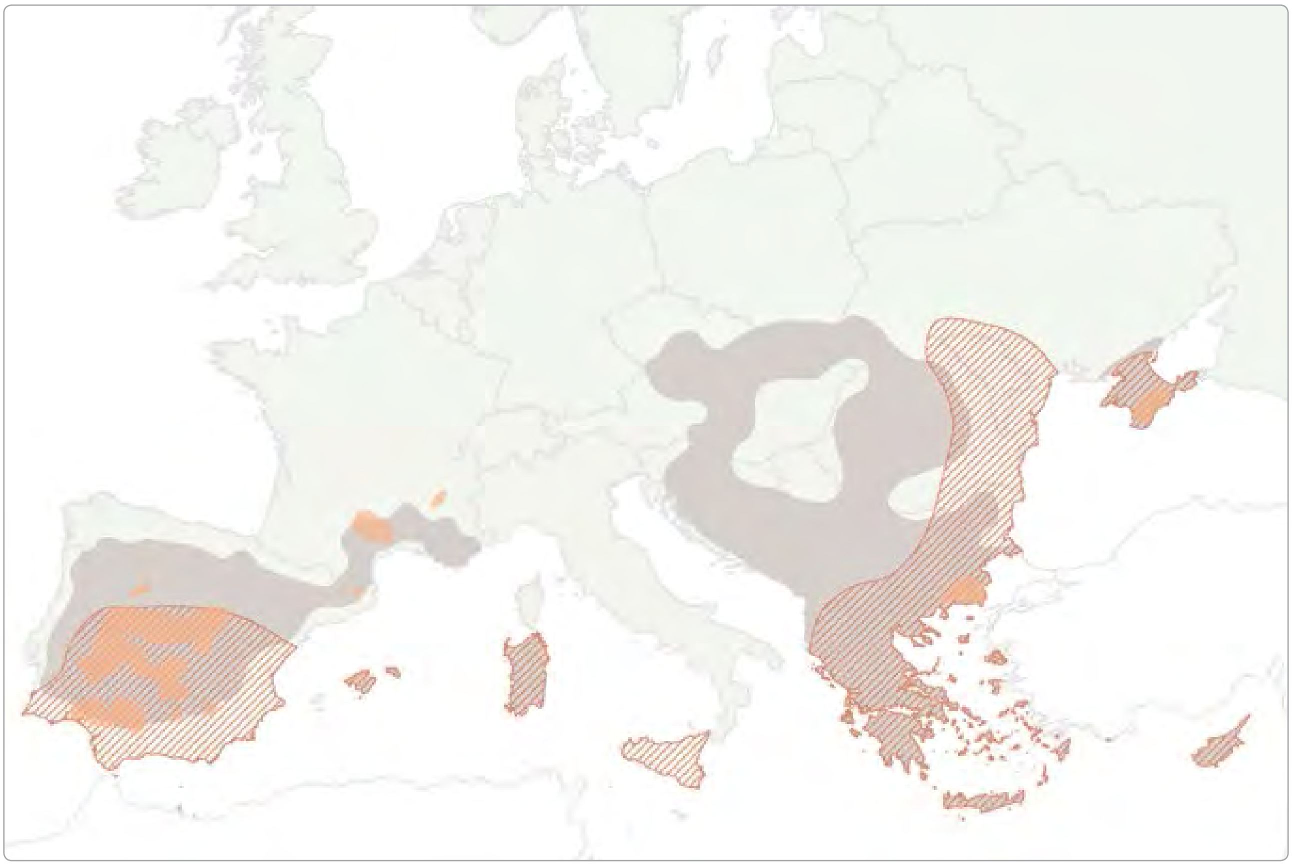

Figure 2.
Current distribution of Cinereous vulture in Europe and historical distribution in the **1850s** and **1950s** [18].

Table 4.
Conservation actions in place for Cinereous vulture.

countries/regions [14, 20]. The illegal use of poisons is the most important threat to the species at present, followed by mortality at windfarms, food shortage and increasingly forest fires. Since 1990, about 500 poisoned Cinereous vultures have been found in Spain alone [20]. The poisoning of wolves and other large carnivores in the Balkans has led to the near extinction of the Cinereous vulture population there.

Action	Description	Impact
Monitoring and planning	National monitoring programs in Portugal, Spain, France and Greece (Dadia).	High
Compliance and enforcement of legislation	Campaign against the illegal use of poison, mostly in Spain, and to a lesser extent Portugal and France.	Critical
Species reintroduction	Ongoing reintroduction programme in France (Verdon and Baronnies, led by LPO) and Spain (Catalonia, led by GREFA).	Critical
Species recovery	Provisioning of safe food through a network of feeding stations (Portugal, Spain, France, Dadia).	Critical
Site/area management	Management of protected areas to protect the foraging and nesting habitats required by this species (e.g. Dadia).	High
	The species breeding habitats are generally protected from forestry operations through restrictions and zoning for forestry operations and management plans in protected areas (France and Greece).	High
Site/area protection	There are 90 IBAs identified for Cinereous vulture in Europe, of which 24% are fully designated and 26% are not protected.	High
Education and awareness	The main focus of public awareness raising activities has been the poisoning threat.	High

Drivers of recovery

The significant increase in Cinereous vultures in Spain (and also in Greece) has largely been due to the conservation measures implemented in those two countries. The progress of the implementation of the Species Action Plan of the Cinereous vulture in the last review was evaluated as good overall, and very good in Greece, France and Spain [13]. The most important conservation actions include anti-poisoning campaigns, adequate management of breeding sites, and provision of food through a network of vulture feeding stations.

The ongoing reintroduction projects in France and Catalonia have also been successful in driving recolonisation and increases of Cinereous vulture range and numbers. The project in the Grands Causses (Cevennes), Southern France, has resulted in the establishment of a small breeding population (28 pairs in 2012 [15]), with good prospects for further increases. The ongoing reintroduction programs elsewhere in France (Verdon and Baronnies) and in Catalonia (6 breeding pairs in 2012 [21]) are beginning to give positive results.

The EU Birds Directive and the EU LIFE programme have undoubtedly contributed to the recovery and conservation of the species in Europe, particularly in Spain. An effective campaign against illegal poisoning, particularly in Andalucia, also appears to have been crucial [13].

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This species account was prepared by José Tavares and Jovan Andevski, Vulture Conservation Foundation.

4.16. Spanish imperial eagle

Aquila adalberti

Summary

The Spanish imperial eagle was close to extinction by the 1960s. Since implementation of concerted conservation efforts, the species is in the process of recovery. Population size has increased and there is evidence of recolonisation of parts of its former range. The major threats include electrocution from electricity towers, habitat degradation and poisoning. Conservation efforts focus on legal protection, habitat management, modification of electricity structures, supplementary feeding and private land support.

Background

General description of the species

The Spanish imperial eagle (*Aquila adalberti*) is a large, long-lived and sedentary raptor with a moderate reproductive rate. It is endemic to the western Mediterranean region and at present occurs exclusively in the Iberian Peninsula [1]. It is the most endangered raptor in Europe and one of the rarest birds of prey globally [2]. The Spanish imperial eagle was traditionally considered a subspecies of the Eastern imperial eagle (*Aquila heliaca*), but is currently considered a separate species [3, 4]. The first evidence of Spanish imperial eagle appears in late Pleistocene deposits in the southeast Iberian Peninsula [4].

Table 1. Global IUCN Red List status [14], European population and SPEC status [15] and EU population status [16] of Spanish imperial eagle.

Scale	Status	Justification
Global	Vulnerable (since 2005; was considered Endangered in 2004, Vulnerable during 1994–2000 and Threatened in 1988)	Small population, which is dependent on ongoing intensive management measures.
Europe	Endangered (SPEC 1)	Small population size (<2,500 mature individuals) and a continuing decline of at least 20% within 5 years or two generations, and no subpopulation estimated to contain more than 250 mature individuals.
EU25	Endangered	

Distribution in Europe

Nearly the entire population breeds in central and southern Spain and a few breeding pairs have recently recolonised Portugal. During the 19th century, Spanish imperial eagle was common throughout Spain [5–7] and its range spread westward into Portugal and to the south into Morocco [4, 6, 7]. However, by the mid-20th century, the species range had declined considerably, and the species was close to extinction, with only 30 breeding pairs remaining in the wild [1].

Habitat preferences

Spanish imperial eagle habitat is variable, but the majority of the breeding population occupies areas with patches of Mediterranean forest and dehesas, open forest of Holm oak *Quercus rotundifolia* and

Cork oak *Q. suber* of anthropogenic origin [8]. The species nests in trees, usually Cork oak and Stone pine *Pinus pinea*, and occasionally on electricity pylons [1, 9]. European rabbits (*Oryctolagus cuniculus*) account for 50–70% of Spanish imperial eagle diet [5], complemented by pigeon, reptiles, carrion of wild ungulates and water birds [10]. Territory size is *c.* 2,800 ha during the breeding season and *c.* 10,500 ha in the non-breeding season and varies depending on prey density and human presence [1, 11]. Mean breeding density is 1.93 pairs per 100 km² [12].

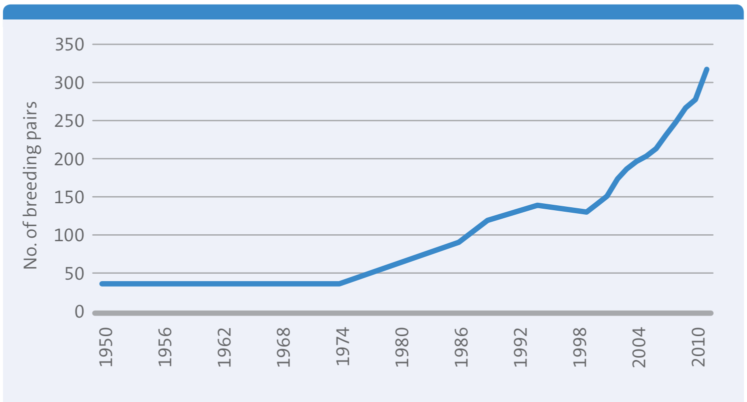

Figure 1. Number of Spanish imperial eagle breeding pairs in Spain since 1950.

Legal protection and conservation status

The Spanish imperial eagle is listed on Appendix I of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention, and Annex I and II of the Convention on Migratory Species [13]. The species receives full legal protection in Spain and Portugal, with national and regional legislation in place [1].

Abundance: current status and changes

The Spanish imperial eagle was close to extinction in 1960 [5] and the subsequent population change shows recovery from a severely depleted state. The number of Spanish imperial eagle breeding pairs in Spain, which holds nearly the entire global population of the species, increased from 38 in 1974 to 317 in 2012 [17]. Population size had an upward trend from the 1970s, followed by a period of stability from mid to late 1990s and a sharp increase since 2000 [18] (Figure 1).

In 2002, the first confirmed breeding in Portugal was recorded and the current population size is estimated at 2–5 breeding pairs [1, 19]. The species has always occurred in small numbers in Portugal, and patterns of sporadic occupation have been recorded over time [20].

Distribution: current status and changes

In past centuries, the Spanish imperial eagle experienced a dramatic reduction in its range. Between 1850 and 1974, the species lost nearly 90% of its range in Iberia, retracting to the central and southern parts of its distribution (Figure 2). By 2012, the species occupied less than 20% of its 1850 range, mainly in mountainous forest areas

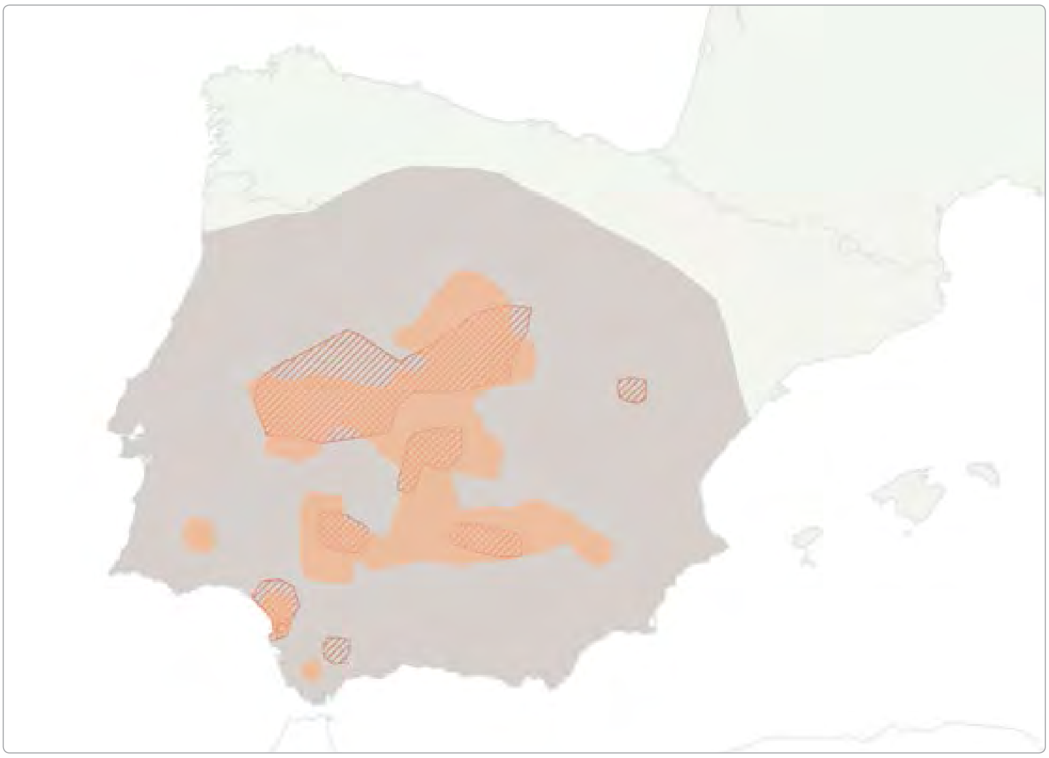

Figure 2. Current distribution of Spanish imperial eagle in Europe and historical distribution in 1850 [6, 18] and 1974 [21].

Threat	Description	Impact
Transportation and service corridors	Accidental mortality by electrocution by overhead cables and pylons.	Critical
	Infrastructure development causes habitat fragmentation.	Critical
Invasive and other problematic species and diseases	Shortage of key prey species due to myxomatosis and viral haemorrhagic disease in rabbits.	Critical
Unintentional effects of hunting and collecting	Illegal poisoned baits for predator control.	Critical
	Unintentional effects of lead poisoning from ingested ammunition.	Low
Wood and pulp plantations	Disturbance during nesting.	Medium
Agricultural intensification	Ecosystem conversion and degradation.	Unknown
Pollution from agriculture	Ecosystem conversion and degradation through secondary poisoning from pesticides and pollutants, especially heavy metals and organochlorines, causing impaired reproduction, e.g. in Doñana.	Low

Table 2. Major threats that drove Spanish imperial eagle decline and may still constrain the population [1].

Table 3. Conservation actions in place for Spanish imperial eagle.

Action	Description
Monitoring and planning	International Species Action Plan [1].
	National and regional Species Action Plans for Spain [1].
	Systematic monitoring schemes in place across the species' range, including annual census and tracking [34].
Site/Area protection and management	There are 53 IBAs identified for Spanish imperial eagle in Europe, of which 17% are fully designated as SPAs or other protected areas and 4% are not protected.
	Correction of dangerous power lines [1, 19, 30].
	Strategies for prevention of poisoning in place, including increased surveillance [34].
Habitat and natural process restoration	Habitat management to increase rabbit populations [1].
	Restocking of rabbits [1].
Species management	Regional Rural Development Programmes in Castilla-La Mancha and Extremadura include specific measures for Spanish imperial eagle [34].
	Land stewardship programme established under 'Alzando el vuelo' programme (SEO/BirdLife) and Fundación de Amigos del Aguila Imperial (FAAI) [35].
	Supplementary feeding in territories with shortage of food during the nestling period [36, 37].
	Reintroduction programme in Cádiz province, Spain [26].
	Release of individuals to strengthen Doñana population [33].
	Restricting human activities during nesting [23, 34].
	Reinforcement or replacement of collapsed nests [34].
Legislation	Listed under a number of international conventions and agreements (see 'Legal protection and conservation status').
	Full legal protection in Spain and Portugal [34].
Education	Public awareness campaigns in place [34].

and some protected private land areas in the plains [1].

In spite of the spectacular increase in Spanish imperial eagle population size, the species' range has not greatly increased, except in Cádiz, where a reintroduction programme is ongoing. However, the breeding distribution has expanded in most areas since the mid-1970s, with the exception of the extreme south-western part of the range (Doñana) [7], and many territories in plains and river valleys have been recolonised [1].

Major threats

The greatest population decline, which took place at the end of the 19th century, was probably due to the use of poison, shooting for predator control and the demand for museum specimens [1, 7]. Persecution continued until Spanish imperial eagle became legally protected in 1973, but some evidence suggests that its breeding range contracted as a result of habitat loss through land-use change and deforestation [1, 7]. However, the importance of habitat degradation as a cause of decline may have been low, as habitat availability today remains greater than the area occupied by Spanish imperial eagles [22].

Ongoing fragmentation of Spanish imperial eagle habitat, resulting from infrastructure development, not only increases human disturbance, which has been shown to negatively affect breeding success [23], but also impacts on dispersal, potentially limiting recolonisation of the species' historic range [1, 24]. Recolonisation is limited by the philopatric tendencies of the species and its attraction to conspecifics [25, 26], despite good availability of habitat in unoccupied areas [24].

The crash in rabbit populations due to myxomatosis in the 1950s and viral haemorrhagic disease in the 1990s greatly contributed to the decline of Spanish imperial eagle, as the diminished prey base had a negative impact on breeding success, particularly in habitats where alternative prey species were not available [1, 7, 27]. The large scale rabbit decline across Spain resulted in a reduction in the proportion of high quality territories with abundant prey [27].

Electrocution on power lines is the main cause of non-natural mortality for the Spanish imperial eagle, affecting dispersing juveniles especially [2, 28–30], closely followed by poisoning [1, 28, 31]. The decline in the rate of increase of the Spanish imperial eagle population between 1994 and 1999 (Figure 1) coincided with and was probably caused by an increase in illegal use of poison for predator control in game breeding areas [28, 32]. The Doñana population of Spanish imperial eagles was most affected, and severe declines took place during 1991–2002, when food shortages due to viral haemorrhagic disease in rabbits caused eagles to forage outside protected areas and come into contact with poisoned baits [33].

Drivers of recovery

The spectacular recovery of the Spanish imperial eagle has been to a great degree the result of active conservation effort and legal protection. The species benefits from protection under international and national legislation and protected areas encompass more than 70% of the total breeding population [1, 34].

Habitat management has been an important driver of recovery for the species, including management to improve food availability and modification of power cables to prevent electrocution [1, 29, 34, 37]. The 'Alzando el Vuelo' (Flying High) programme of SEO/BirdLife (BirdLife in Spain) and the private land protection of Fundación de Amigos del Aguila Imperial (FAAI), engages national authorities, local communities and private landowners in conserving and protecting Spanish imperial eagle habitat, forming a large land stewardship network. Agreements are signed with landowners who manage their land sympathetically to Spanish imperial eagle conservation [29, 35, 38, 39].

In Doñana, drastic measures were taken to mitigate declining trends, including the release of individual eagles to reinforce the population [33]. Spanish imperial eagle is a good candidate for reintroduction, as dispersal is limiting and not habitat availability [22, 24–26]. The ongoing reintroduction of Spanish imperial eagles in Cádiz province was initiated in 2002, first breeding occurred in 2010 [26, 33] and today there are seven territories are occupied [22].

Although attitudes towards the Spanish imperial eagle have improved (see 'Alzando el Vuelo' programme [35]), persecution remains an issue. For example, in Portugal, the sole breeding male was shot in 2009 [40]. Poisoning is also a critical threat to the species, as enforcement of anti-poisoning legislation is not currently effective [28, 31, 34]. At present, the recovery of the Spanish imperial eagle is still dependent on intensive management.

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4.17. Eastern imperial eagle

Aquila heliaca

Summary

Formerly more abundant and widespread, the Eastern imperial eagle declined dramatically in Europe during the 20^{th} century as a result of persecution, poisoning and habitat loss. Since the 1990s, population increases as well as range expansions have taken place, as a direct result of targeted conservation efforts. Protection of nesting sites and habitat management have been effective in driving the increase in the Eastern imperial eagle population in the Carpathian Basin.

Background

General description of the species

The Eastern imperial eagle (*Aquila heliaca*) is a large bird of prey, which was formerly believed to comprise two races: adalberti in Iberia and heliaca in central and eastern Europe and Asia. However the Spanish imperial eagle (*A. adalberti*) is now considered a separate species [1–4] and treated elsewhere in this report.

Table 1. Global IUCN Red List status [20], European population and SPEC status [21] and EU population status [22] of Eastern imperial eagle.

Scale	Status	Justification
Global	Vulnerable	Small global population, and is likely to be undergoing continuing declines, primarily as a result of habitat loss and degradation, adult mortality through persecution and collision with power lines, nest robbing and prey depletion.
Europe	Rare (SPEC 1)	Small population size (<10,000 pairs).
EU25	Rare	Small population size (<5,000 pairs).

Adult birds of the Central European, Balkan and Anatolian populations are usually resident [5], although some birds move southwards during winter. Juveniles and immatures are partially migratory, dispersing in their natal geographic region (mostly in central Europe), or migrating various distances southwards up to Anatolia (mostly from the Balkan), and occasionally reaching the Middle East or northeast Africa [2, 3, 6–8].

Distribution in Europe

The Eastern imperial eagle is sparsely distributed from the Carpathians in the west to Lake Baikal, Russia, in the east [6]. A possible expansion of the breeding range has been observed over the last decade with breeding records at latitudes of 59° N. [9] and 60° N. [10] extending the known range by some 400 km to the north. In Europe, the species occurs in a patchy distribution in the Carpathian Basin, in the Balkan peninsula, and through southern Ukraine to southern Russia [5, 11].

In the 19^{th} century the species was distributed more widely across Europe, occurring at high densities in the Balkans [7]. The central and south-eastern populations suffered dramatic declines during the 20^{th} century, when the species' range contracted to the Carpathian Basin and some parts of the Balkan Peninsula. This was followed by expansion of the Carpathian distribution during the 1990s [12], but the Balkan population remained small and scattered, albeit stable [13].

Habitat preferences

Although essentially a lowland species, the Eastern imperial eagle occupies higher altitudes today as a result of persecution and habitat loss [5, 6]. Eastern imperial eagles breed in open landscapes and agricultural areas as well as mountain forests, hills and along rivers [14, 15], foraging in open areas and wetlands [6].

The Eastern imperial eagle builds its stick nests in the tops of trees, and occasionally on electricity pylons [6]. It lays 1–4 eggs in late March to early April, with an average breeding success of 1.5 young per successful pair, which is relatively high for a raptor of its size [6, 14, 16]. Sexual maturity is reached at 3–5 years, and maximum lifespan in the wild is 26 years [14].

The species preys on mammals and its diet mostly comprises Suslik (*Spermophilus citellus*), Hamster (*Cricetus cricetus*), Hare (*Lepus spp.*), and Hedgehogs (*Erinaceus roumanicus*), but may include small rodents, reptiles and carrion [6, 17, 18]. Birds are also included in its diet, including Pheasant (*Phasianus colchicus*), Quail (*Coturnix coturnix*), Partridge (*Perdix perdix*), White stork (*Ciconia ciconia*) passerines and domestic chickens [17–19].

Legal protection and conservation status

The Eastern imperial eagle is listed in Appendix I of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention, and Annex I and II of the Convention on Migratory Species.

Abundance: current status and changes

According to the most recent estimates of Eastern imperial eagle population size, the European population numbers approximately 1,400 pairs (Table 2). This is similar to the Figure estimated in 2010 (1,178–1,387) [7]. Previous estimates are likely to be underestimates, as the quality of population monitoring in Russia, which currently holds >70% of the European population (Table 2), has improved significantly in recent years [7]. Outside Russia, key populations are found in Hungary, Ukraine, Slovakia, FYRO Macedonia and Bulgaria, which together hold nearly a quarter of the European population (Table 2).

The seemingly spectacular increase in the population size of Eastern imperial eagle in eastern Europe (Figure 1) is in fact a reflection of the quality of monitoring surveys [7, 19] and the population here is believed to be stable [7]. Many parts of south-eastern Europe, with the exceptions of Bulgaria [23], FYRO Macedonia [24] and Serbia [25], still lack good quality data [7, 12], and the Balkan population appears to be small and fragmented [13]. By contrast, the near trebling of the population in the Carpathian Basin since the early 1990s (Figure 1) has been well documented [16, 26–28].

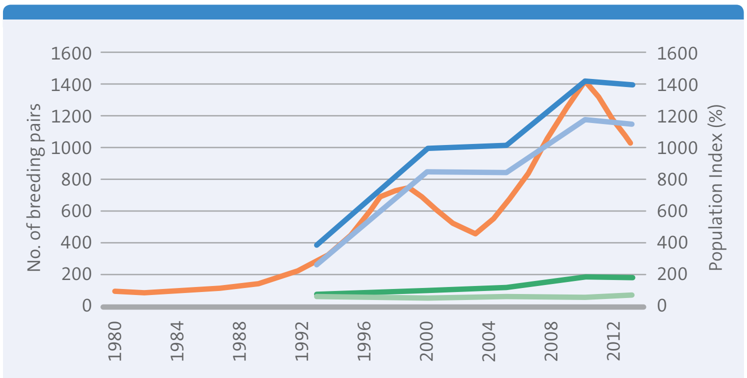

Figure 1. Population development of Eastern imperial eagle in Europe, based on the Species Action Plan [6], relevant reviews [7, 13, 29] and other key sources, showing **total**, **Eastern European** (Moldova, Russia and Ukraine), **Carpathian** (Hungary, Slovakia, Czech Republic and Austria) and **Balkan** populations separately. The population **trend** since 1980 is also shown (see 'Methods').

Distribution: current status and changes

The historical limits of the species' distribution in Europe are not known, but it is certain that Eastern imperial eagle ranged over a much larger part of Europe in the 19th century [13]. By 1960, the species' distribution contracted eastwards (Figure 2). Since that time, further contractions took place in the Balkans, resulting in a fragmented distribution in central Europe [13], and in areas in the southeastern Europe, including in Bulgaria, Romania and Greece. The species went extinct in Cyprus in the mid-1980s [7, 40] (Figure 2).

However, westwards and northwards expansions have taken place recently, with new breeding

Table 2. Latest Eastern imperial eagle population estimates in Europe, indicating those countries with more than 1% of the total European population.

Country	No. of breeding pairs	Year	%
Albania	0–5	2013 [8, 30]	
Austria	11	2012 [31]	1
Bulgaria	24	2013 [18]	2
Czech Republic	3	2013 [32]	
Greece	0–3	2010 [7, 33]	
Hungary	150–160	2013 [8]	11
FYRO Macedonia	31–35	2012 [34]	2
Moldova	0–3	2000 [13]	
Romania	0–3	2010 [7]	
Russia	883–1196	2013 [35]	72
Serbia	6–7	2013 [36]	
Slovakia	35–40	2012 [37]	3
Ukraine	110–130	2010 [29]	8

Figure 2.
Current distribution of Eastern imperial eagle and historical distribution in the **1950s** [38], and **1980s** [39].

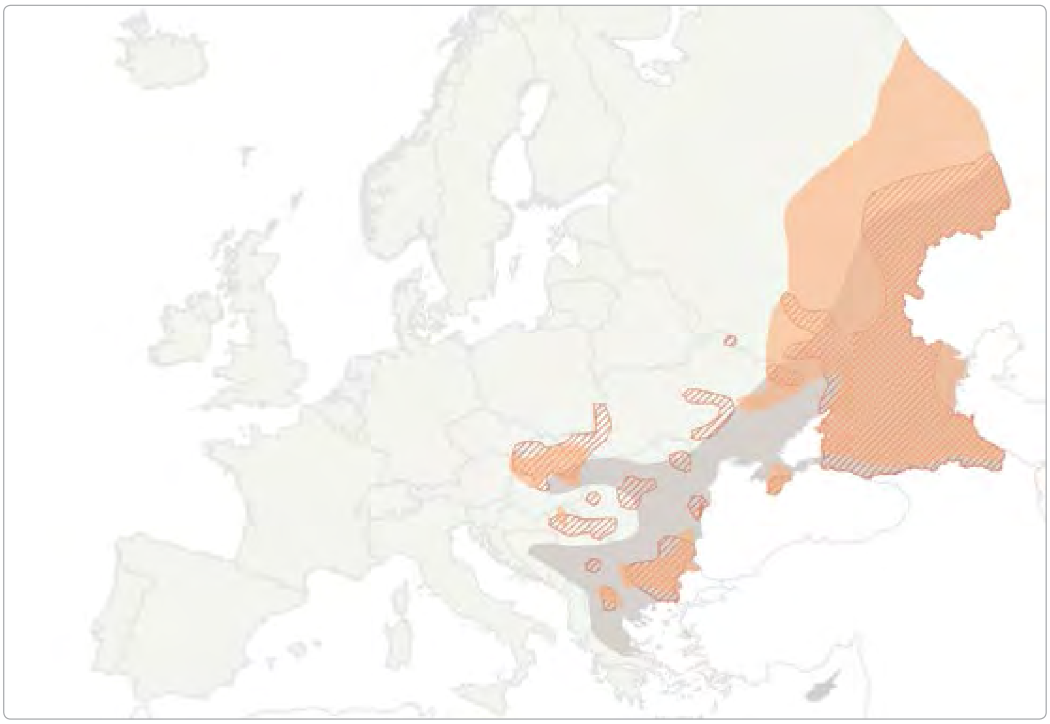

Table 3.
Major threats that drove imperial eagle decline and may still constrain the population [6, 29].

Threat	Description	Impact
Agro-industry wood and pulp plantations	Degradation of breeding habitats through deforestation, clearance and reafforestation with alien species, and cutting down of large old trees.	Medium/High
	Disturbance by logging activities during breeding season. Accessibility and disturbance along logging tracks.	
Agricultural intensification	Degradation of foraging habitats through agricultural intensification (conversion of pastures to cropland).	High
	Depletion of prey base through habitat degradation caused by overgrazing. Near extinction of Susliks in Hungary due to habitat loss.	Medium
	Very sensitive to disturbance by farming operations in agricultural areas.	High
Agricultural abandonment	Abandonment of grasslands results in foraging habitat degradation.	High
Transportation & service corridors	Collision with and electrocution by power lines is one of the most important mortality factor in Central Europe and the Balkans.	Critical
Residential & commercial development	Habitat loss and fragmentation.	High
Renewable energy	Potential threat of collision with wind turbines, with increasing establishment of wind farms.	Potential
Hunting & collection of terrestrial animals	Secondary or unintentional ingestion of poisons intended for control of foxes, wolves and other predators, especially in Hungary (main mortality factor), Greece, Bulgaria and FYRO Macedonia.	Critical
	Persecution (shooting and intentional poisoning) in Hungary and Greece.	Medium
	Nest robbing and illegal trade, especially from former USSR. Lack of enforcement of laws and CITES regulations in Bulgaria and the former USSR since disintegration of Soviet Union.	Medium
	Unintentional effects of persecution of rodents for crop protection and for their fur. Near extinction of Susliks in Bulgaria due to overhunting.	High
	Unintentional trapping as a result of mammal trapping outside European range.	Low

areas identified in the Czech Republic (since 1998) [27], Austria (since 1999) [26] and Siberia (since 2009) [9, 10]. The observed expansions may point to a recovery of Eastern imperial eagles in central Europe, but the apparent increase in range in Russia and Ukraine may be attributable to increasing survey effort [7].

Major threats

The severe decline in the 20th century was the result of anthropogenic pressures, including persecution and unintentional poisoning, particularly in central and southeast Europe [7]. Illegal hunting and poisoning (both intentional persecution and unintentional effects) is still the main problem in the key countries in the Carpathian Basin [16, 25, 29]. The most important threats today are loss of nesting sites and habitat degradation caused by forestry practices and the removal of trees from farmland [29]. Further major threats include electrocution by power lines and disturbance of nesting birds by farming operations [29]. Farmland is the most important foraging habitat for Eastern imperial eagle and conversion of pastures to intensive agriculture or, conversely, their abandonment, are critical threats to the species [29].

Drivers of recovery

Targeted conservation actions, in Hungary [12, 16] and Bulgaria [23] especially, have enabled the recovery of populations, leading to the Hungarian population

becoming the species' European stronghold outside of Russia (Table 2) and to the steady increase of population size and range across the entire Carpathian Basin since 2000 [7, 16, 29].

Key threats are being addressed through a variety of efforts, including anti-poison campaigns and a ban on use of poisoned baits, insulation of power lines, nest surveillance and protection, agri-environment schemes for maintenance of pastures and appropriate grazing regimes, protection of non-arable features in agricultural land, reintroduction and restocking of prey species such as Suslik, supplementary feeding, construction of artificial nests and rehabilitation and release of birds confiscated from illegal trade [29].

In order to ensure the continued recovery and long-term survival of the Eastern imperial eagle, such conservation actions, along with appropriate management of farmland, must be put in place across the European range of the species, while law enforcement, and public awareness efforts must improve, especially relating to the use of poisons [29].

Table 4. Conservation actions in place for Eastern imperial eagle [6, 29].

Action	Description
Monitoring and planning	Working Group established in 1990.
	International Species Action Plan in place, national management guidelines exist for Hungary and Slovakia, regional Species Action Plan in place for the Balkan Peninsula.
	Systematic monitoring carried out in most countries in Europe, including satellite tracking in Hungary, Slovakia and Bulgaria.
Site/Area Protection	There are 247 IBAs identified for Eastern imperial eagle in Europe, of which 39% are fully designated as SPAs and 32% are not protected.
	Protected areas cover 50–70% of the population. All IBAs identified for the species in the EU have been designated as SPAs.
Site/Area Management	Guidelines for appropriate forest management and agreements with forest owners in Hungary.
	Modification of power lines and pylons (Hungary, Slovakia and Bulgaria).
Species recovery	Supplementary feeding (Bulgaria, Hungary).
	Construction of artificial nests and securing unstable nests (Hungary, Slovakia, Bulgaria).
	Repatriation of confiscated or rehabilitated birds (Hungary).
Habitat and natural process restoration	Suslik reintroduction and restocking (Hungary and Bulgaria).
Livelihood, economic and other incentives	Agri-environment measures for pasture maintenance in Hungary and Slovakia, and piloted in Bulgaria.
	Agri-environment measure for "Eastern imperial eagle fallow" in Austria to increase abundance of prey species.
Education	Awareness campaigns included in LIFE projects in Hungary, Slovakia and Bulgaria for protection from destruction and disturbance by farmers, shepherds and foresters.
	Hunters' attitudes in Austria are very positive.
Legislation	Full legal protection, except in Czech Republic and Austria.
	Poisoned baits banned or strictly regulated in all countries, but enforcement is not effective.
	Leg-hold traps prohibited in all countries.

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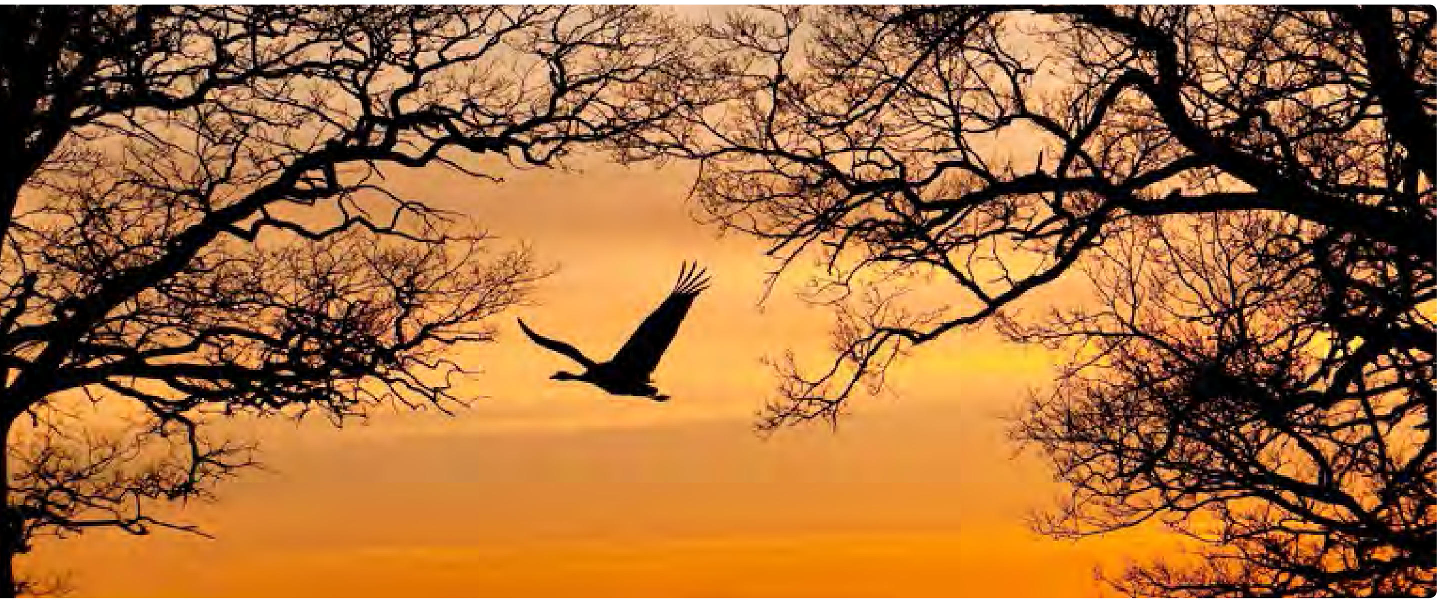


4.18. Common crane

Grus grus

Summary

The Common crane declined substantially in Europe and contracted in range until the 19th century due to loss of wetland habitat and hunting, but has shown a remarkable recovery since the 1960s. Improved feeding conditions, thanks to the expansion of agriculture, more effective protection of the species, and milder winters have enabled the Common crane population in Europe to increase and have also driven beneficial changes in migration patterns. The species has recolonised breeding areas in a number of countries, including the Czech Republic, France, the Netherlands, the UK, Denmark and western and southern Germany, while wintering areas have expanded northwards, in France and Germany, as well as in Hungary. The Common crane has adapted to utilise farmland and as a result a conflict has developed with agriculture, due to the damage caused to crops. Mitigation of the conflict has been effective in many countries, with management plans in place, including agri-environment schemes and compensation payments.

Background

General description of the species

The Common or Eurasian crane (*Grus grus*) is one of the most abundant species of crane in the world [1]. It is a large bird with grey plumage, a bare red crown and a white streak extending from behind the eyes to the upper back [2]. The innermost greater coverts on the tail are elongated and drooping [2]. Courtship involves a spectacular dancing display, which includes bowing, jumping, running, stick or grass tossing, and wing flapping, and pairs engage in unison calling, a series of coordinated calls of both partners [2].

The age of maturity is thought to be around 3–5 years [2]. Breeding begins between late March and early May, depending on the latitude [3] and usually two eggs are laid. Although breeding pairs are solitary, Common cranes are gregarious in the non-breeding season. They migrate to the wintering grounds between September and December and return to the breeding areas between February and late April, depending on latitude [2–4].

Distribution in Europe

The Common crane is the most widely distributed species of crane in the world [5]. Its breeding range in Europe extends across Eurasia from northern and western Europe to the Far East of Russia [1]. During the winter, Common cranes of Europe (West European flyway) are found mainly in France and the Iberian Peninsula [1].

There are three main flyways in Europe. The

West European flyway is used by birds from northern (Scandinavia) and central (Germany, Poland etc.) Europe, as well as a proportion of birds from Finland and the Baltic countries, which migrate to wintering grounds mainly in France and the Iberian Peninsula, with some birds wintering in Morocco [6]. The Baltic-Hungarian flyway is used by birds mainly from the Baltic countries and Finland [6]. Eastern Hungary are key stopover areas used by Baltic-Hungarian cranes, which go on to winter in North Africa [6]. The Russian-Ukrainian flyway is used by birds from the European part of Russia, Ukraine and Belarus, which winter in Turkey, the Middle East and East Africa [6].

Habitat preferences

The Common crane nests in bogs, sedge meadows and other boreal and temperate forest wetlands [6]. In the last few decades, they have adapted to utilise intensively farmed areas [6, 7]. During migration, they forage in fields, pastures and meadows and roost in wetland habitats, including shallow lakes and ponds, rivers, and along the edges of reservoirs [1]. Winter feeding and roosting habitats vary across the wintering range, and include shallow wetlands, newly seeded and stubble grain and maize fields and, in Iberia, open oak woodlands [1, 5]. Common cranes are omnivorous and feed on plant material, such as berries, seeds and cereals, as well as invertebrates and occasionally take amphibians and reptiles [2, 4].

Legal protection and conservation status

The Common crane is listed in Appendix II of CITES, Annex I of the EU Birds Directive, Annex II of the Bern Convention and Annex II of the Convention on Migratory Species, under which the three flyway populations found in Europe are covered by the African-Eurasian Waterbird Agreement (AEWA). In the AEWA Action Plan, the West European population is listed in Column C (category 1), the Baltic-Hungarian population is listed in Column B (category 1), and the Russian-Ukrainian population is listed in Column A (category 3c) [8].

Scale	Status	Justification
Global	Least Concern (since 1988)	Extremely large range, very large population size and although the population trend is unknown, it is not believed to be declining sufficiently rapidly to approach the threshold for Threatened.
Europe	Depleted (SPEC 2)	Moderate historical decline.
EU25	Depleted	

Table 1. Global IUCN Red List status [9], European population and SPEC status [10] and EU population status [11] of Common crane.

The increase is evident in the breeding as well as the wintering population. For example, since the 1960s the breeding population in Germany increased from an estimated <1,000 to 8,000 pairs in 2012 [6]. In the main wintering area in Spain, the number of cranes increased from fewer than 15,000 individuals in 1980 to more than 150,000 individuals in 2007 [14]. In France, the number of wintering cranes increased from <1,000 individuals in the mid-1970s to 80,000–100,000 individuals currently [6].

The Baltic-Hungarian population has also increased since the 1980s [6], but not as at high a rate as the West European population (Figure 1). The entire flyway population is estimated to have increased from 40,000 individuals in the mid-1980s to 130,000 individuals in 2012 [6]. The breeding population in Finland increased from 4,200–5,000 pairs in the late 1980s to 18,000–20,000 pairs in 2012, while in Estonia the number of breeding pairs increased from 300 in 1970 to 7,000 in 2009 [6]. The number of cranes using the staging areas in eastern Slovakia and Hungary increased from 5,000 in 1960s to more than 120,000 by the 2012 [6].

The Russian-Ukrainian flyway population was estimated to number 80,000 individuals in 2012, but it is not as well researched as the West European and Baltic-Hungarian populations [6]. There are indications of some positive trends in population size in the European part of Russia, although this may be in part due to improved knowledge [15] and overall the population has been classified as declining [5].

Abundance: current status and changes

Common cranes suffered considerable declines during the 17th–19th centuries, but began recovering from the 1960s [12, 13]. The West European population has undergone a large increase since the late 1980s [6] (Figure 1), from around 45,000 individuals in 1985 to around 300,000 in 2012 [6].

Figure 1. Estimated population size of Common cranes in the **West-European** and **Baltic-Hungarian** flyway populations [6, 16–18] and the population **trend**, shown by the PECBMS population index [19].

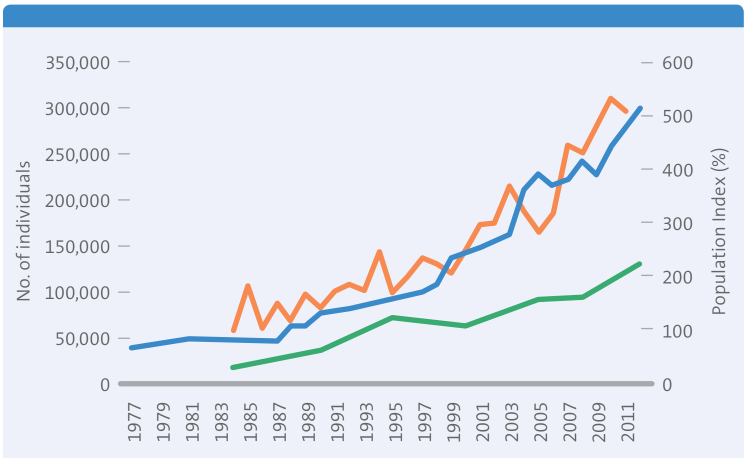
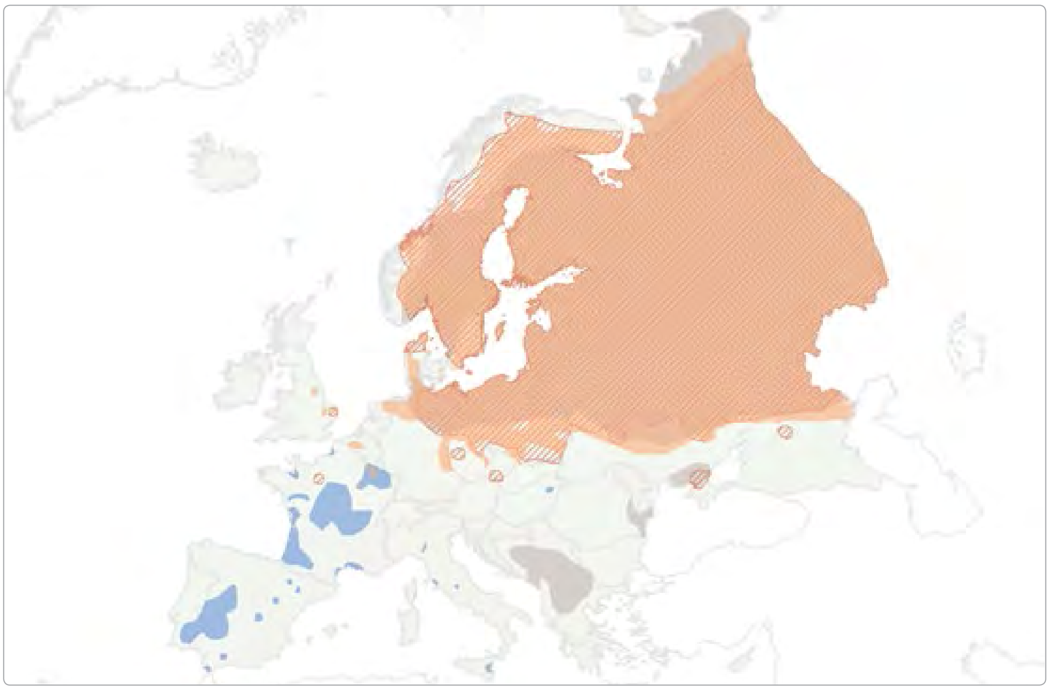


Figure 2.
Current **breeding** and **wintering** distribution of the Common crane in Europe, showing historical breeding distribution in the 1950s [28] and 1980s [29].



Distribution: current status and changes

During the 18th and 19th centuries, the species disappeared as a breeding species from much of southern and western Europe, the Balkan Peninsula and southern Ukraine [1, 12, 30]. Common cranes became extinct around the middle of the 17th century in the UK, around the middle of the 19th century in southern Germany, in the 1920s in Bulgaria and Slovakia, the 1940s in Hungary and Austria, the 1950s in Spain and Denmark, and the 1960s in the Balkan Peninsula [12]. More recently the species has recolonised western and southern Germany [12], and Denmark [20]. In the UK, a small population has been established in Norfolk since the 1970s [6, 31], while breeding has also been recorded in France, the Netherlands and the Czech Republic [12, 21].

Migration patterns have changed since the mid-1990s, with an increasing proportion of birds from the east (Finland, the Baltic States and maybe northwest Russia) using the West European flyway [6]. New important stopover sites have become established in France and Germany [32, 33] and an increasing proportion of birds spend the winter farther north along the flyway [6, 16]. Although Spain is the main wintering region [14], Common cranes now also winter in France [18] and Germany [16, 32, 34]. The first observation of wintering in France took place in the late 1970s. In Germany, Common cranes only wintered sporadically and in low numbers before 1995, but up to 15,000 have been recorded there recently [6, 16]. Some cranes have also begun to winter in Hungary since the 1980s [6].

Table 2.
Latest Common Crane population estimates in Europe, indicating those countries with more than 1% of the total European population. An estimate for the European part of Russia was not available, so it was excluded from this table.

Country	No. of breeding pairs	Year	%
Belarus	850	1979 [6]	1
Czech Republic	30	2012 [6]	
Denmark	120	2010 [20]	
Estonia	7000	2009 [6]	8
Finland	18,000–20,000	2012 [6]	21
France	12–15	2010 [21]	
Germany	8,000	2012 [6]	9
Latvia	1,513–2,268	2004 [22]	2
Lithuania	650	1998 [6]	1
Netherlands	8	2012 [6]	2
Norway	1,500	2012 [6]	2
Poland	14,300–23,100	2000–2010 [23]	20
Slovakia	1	2012 [24]	
Sweden	30,000	2012 [25]	34
Ukraine	500–850	2009 [26]	1
United Kingdom	16–18	2013 [27]	

Major threats

The main threat to Common cranes was habitat loss and degradation, due to drainage of wetlands and development [5, 13]. Habitat loss has occurred throughout the species' breeding and wintering range as well as at staging areas along migration [12]. In Europe, two-thirds of wetlands have been lost in the last century [37] and the historical contraction of the breeding range in southern and western Europe, the Balkans and southern Ukraine was partly due to drainage of wetlands [30]. An estimated 37% of wetlands have been lost in central European Russia, resulting in the decrease of the Common crane population by one-sixth [38].

Some changes in land-use have had negative impacts on the Common crane population in Europe. Specifically, some of the species' wintering grounds in Iberia are threatened by the conversion of traditionally managed open holm oak pastoral woodlands and extensive cereal fields to irrigated agriculture [39–42]. Decreased food resources in northwest Russia after the break-up of the Soviet Union [6, 43] may have driven more cranes from the east to use the West-European flyway [44].

Owing to the loss of habitat, Common cranes are increasingly concentrated in large flocks at foraging and roosting sites during migration, particularly in the West European population [12]. This results in a conflict with agriculture, as the birds cause damage to crops [5]. This is likely to continue, as populations recover in areas in which they had previously declined, but where the suitable habitat has decreased [41, 45]. This puts the species at risk of persecution in some parts of its range [30].

Historically, hunting probably contributed to the extirpation of breeding populations in the UK, Hungary and southern Europe [5] and illegal shooting is still a problem in southeastern Europe [42, 46], but it is mainly a problem outside the species' range in Europe [6].

Drivers of recovery

In western Europe, conservation actions for Common crane include legal protection, systematic research and monitoring programmes, creation and restoration of wetlands, and protection of important staging areas, roosting sites and wintering grounds [1]. The extension of international collaborative effort into eastern Europe has been particularly important, as there

Table 3. Major threats that drove Common crane decline and may still constrain the population [1, 5, 6, 35].

Threat	Description	Impact
Natural systems modification	Loss and degradation of breeding habitat due to wetland drainage, dam building, expansion of agriculture and building development.	High
Agricultural intensification	Agricultural intensification results in the loss of traditional low-intensity farming in wintering grounds in Iberia.	High
Hunting and collecting	Illegal hunting on wintering grounds and during migration in the Balkans.	Medium
Persecution/ control	Persecution due to crop depredation.	Potentially high
Human intrusions and disturbance	Disturbance at staging and winter roosting sites.	Low-Medium
Transportation and service corridors	Collision with and electrocution by overhead power lines [36].	Low
Climate change and severe weather	Climate change is expected to have adverse effects on wetland habitat.	Potentially high

Action	Description
Monitoring and planning	The European Crane Working Group (ECWG) coordinates monitoring, research and conservation activities.
Site/area protection	There are 927 IBAs identified for Common crane in Europe, of which 52% are fully designated as SPAs or other protected areas and 13% are not protected.
	Protected areas at key breeding, staging and wintering areas, but many other sites are found outside protected areas.
Site/area management	Wetland creation and restoration.
	Mitigation of dangerous powerlines.
Species reintroduction	A reintroduction project has begun in the UK to assist recolonisation and first breeding of reintroduced cranes occurred this year [31, 47].
Livelihood, economic and other incentives	Agreements with private land owners to protect key resting and wintering habitats, including agri-environment measures.
	Efforts to address conflict caused by crop depredation e.g. compensation for crop damage and artificial feeding stations to lure cranes away from fields.
Education and awareness	Education and information programmes for the public.
Legislation	Common cranes are legally protected across their range in Europe.
	The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) has been adopted by all countries within the species' range in Europe.

Table 4. Conservation actions in place for Common cranes [1, 5, 6, 35].

is some interchange between West European and Baltic-Hungarian flyways, and further research is necessary on the Russian-Ukrainian flyway [1, 48].

Improved foraging conditions in western Europe, more effective protection of Common cranes and also milder winters drove the changes observed in migration and stopover patterns in the West European and Baltic-Hungarian flyways [6, 44]. Habitat restoration of bogs and fens has resulted in the return of Common cranes to parts of Germany, where old breeding sites are currently used on migration as stopover areas and as wintering areas by some birds, following cessation of peat production and flooding of moors [32, 33, 44]. Intensive agriculture has also had a resulted in enhanced food availability. For example, the expansion of maize cultivation in Germany encouraged migrating birds to stay longer at roosting areas [44].

The recovery and range expansion of Common cranes in Europe can be attributed to a great degree to the increased abundance of food that is provided by intensive agriculture [6, 13, 49, 50]. Milder winters have also benefitted the species, as the improved winter conditions allow the birds to migrate shorter distances and being breeding earlier, which in turn enables a second clutch to be produced should the first one fail [13, 44, 51, 52].

The increasing abundance of the Common crane and the increasing concentration of large flocks during migration, combined with the lack of natural wetland habitat, have resulted in the development of a conflict with agriculture, due to the damage that the birds cause to agricultural crops. Management of this conflict varies across the species range, and measures include compensation payments and diversionary feeding with artificial feeding stations [6]. Targeted management plans have been effective at mitigating the conflict with agriculture at some of the key staging sites in Europe, including in Sweden, Estonia, Germany, France and Spain [6, 48].

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4.19. Roseate tern

Sterna dougallii

Summary

The Roseate tern was nearly driven to extinction in Europe in the 19th century due to the millinery trade, but legal protection allowed the species to recover. However, a second period of decline occurred between the late 1960s and the mid-1970s, as a result of a combination of persecution in the species' wintering grounds and increased predation and human disturbance at the breeding sites in Europe. Conservation efforts, including increased protection of colonies from disturbance, control of predators, habitat management and nest box provisioning, have enabled the key population in Ireland to increase. Positive trends in Ireland, and in particular the key colony at Rockabill, is driving the recovery of the total population in Europe. However the populations in the UK and France have not recovered appreciably following the decline, while the separate population in the Azores is fluctuating with no overall trend.

Table 1. Global IUCN Red List status [7], European population and SPEC status [8] and EU population status [9] of Roseate tern.

Scale	Status	Justification
Global	Least Concern (since 1994; was considered Near Threatened in 1988)	Extremely large range, and large population size, which is not believed to be decreasing sufficiently rapidly to approach the thresholds for Vulnerable.
Europe	Rare (SPEC 3)	Small population size.
EU25	Rare	

Background

General description of the species

The Roseate tern (*Sterna dougallii*) is a migratory coastal seabird, which feeds by plunge diving [1]. It breeds in colonies, which in Europe are almost always mixed with other species of tern [2]. Age of first breeding is 3–4 years and eggs are laid between mid-May and late July [2]. Roseate terns in Europe spend at least four months on their breeding grounds and post-breeding staging areas before migrating to West Africa to winter [1].

Distribution in Europe

The species breeds on all continents except Antarctica. In Europe there are two breeding populations: the population in the Azores (Portugal) and that in Ireland, the UK and France [3, 4]. Roseate terns used to be found at other sites in northwest Europe, as well as in Tunisia [2].

Habitat preferences

Colonies are on small rocky islands offshore or in brackish lagoons and Roseate terns usually nest under the cover of vegetation, rock crevices or man-made nest boxes [1]. Roseate terns forage in small mixed groups of terns, but will also feed in association with other seabirds, cetaceans and large predatory fish, such as tuna and mackerel. They feed on small shoaling fish, such as sandeels and sprats in northwest Europe or trumpet fish and horse mackerel in the Azores [2].

Legal protection and conservation status

The species is listed under Annex I of the EU Birds Directive, Annex II of the Bern Convention and it is included on the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) list of threatened and/or declining species [5]. The population that breeds in Europe is listed in Annex II of the Convention on Migratory Species, under which it is covered by the African-Eurasian Waterbird Agreement (AEWA), listed in column A (category 1c) in the AEWA Action Plan [5, 6].

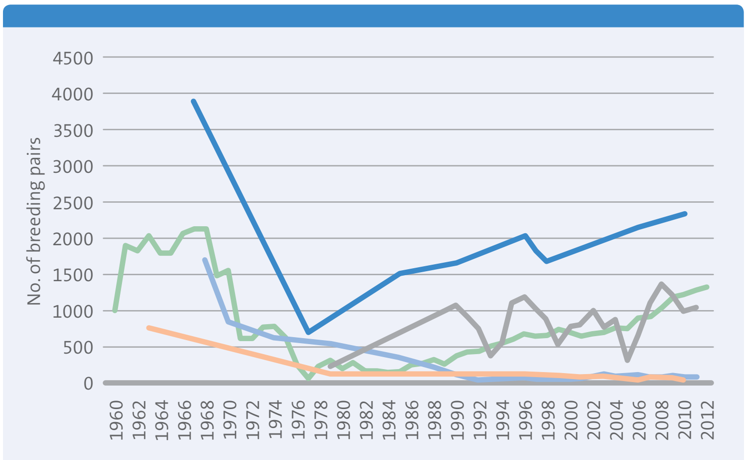

Figure 1. **Total** number of Roseate tern breeding pairs in Europe since 1967 [2, 3, 10], showing population development in **Ireland** [11], the **UK** and **France** [2–4, 10, 13, 14, 18], and the **Azores** from 1979 [3, 12].

Abundance: current status and changes

In the 19th century, Roseate terns declined to very small numbers in Europe, and in North America, but the species recovered [4]. More recently, the Roseate tern population in Europe declined very rapidly from the late 1960s to the mid-1970s, from 3,900 pairs in 1967 to 700 in 1977 (82% decline) [4, 10]. This was followed by a gradual increase in total numbers, but the current population is still less than 60% of its size in 1967 (Figure 1).

Ireland holds the largest population of Roseate terns (1,334 pairs in 2012 [11]) and accounts for about half the total population in Europe, closely followed by the Azores (1,050 pairs in 2011 [12]). The UK and France host much smaller numbers: in 2010 there were 133 breeding pairs in the UK and in France there were 32–37 pairs in 2012 [13–15].

It is evident that the observed increase in the total population is driven by the positive trend of Roseate terns breeding in Ireland (Figure 1) where, in turn, the population is dominated by the Rockabill colony [10]. In France and the UK the Roseate tern populations remain small (Figure 1), with some evidence of recovery beginning in the UK [2, 3, 16]. However, it is important to note that there is significant interchange of birds between the Irish, UK and French sites [17]. The Azores population has fluctuated and the population cycles over a 5–6 year period, with no overall trend (Figure 1) [3, 10, 12].

Distribution: current status and changes

Roseate terns currently breed only in Britain, Ireland, Brittany and adjacent coasts of northern France, and the Azores (Figure 2). Breeding has also been reported in the past in the Canary Islands and Madeira, but there have been no

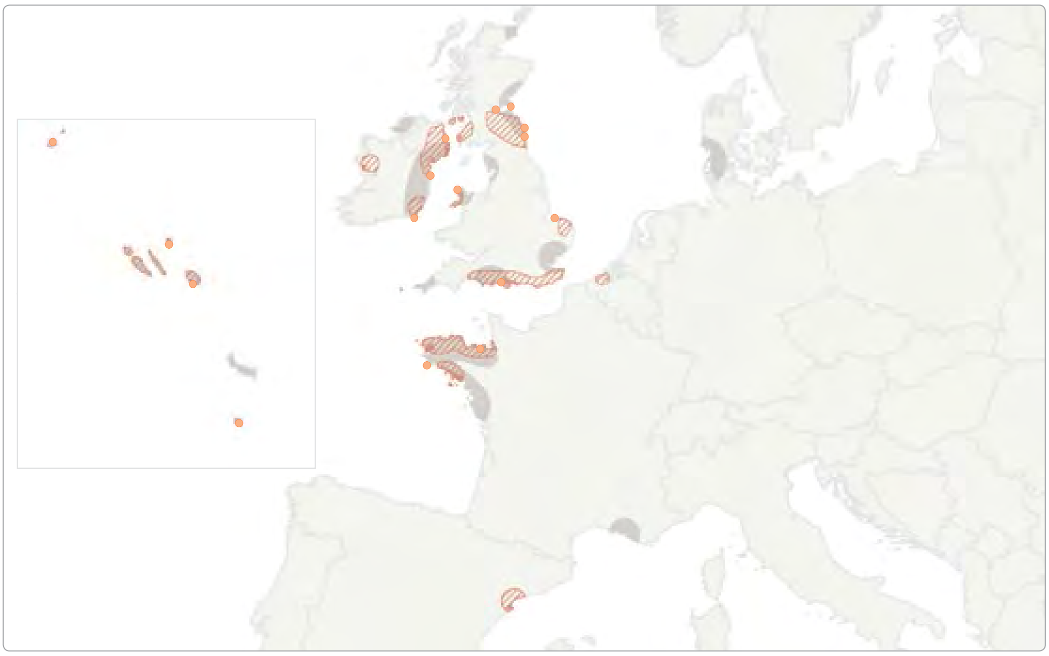

Figure 2. **Current** distribution of Roseate tern colonies in Europe and historical area of breeding distribution in the **1950s** [19] and **1980s** [20].

Threat	Description	Impact
Human intrusions and disturbance	Human disturbance can result in desertion of entire colonies or shifts in subsequent seasons.	High
Problematic native species	Predation by Red foxes (*Vulpes vulpes*), Stoats (*Mustela erminea*), hedgehogs, Black rats (*Rattus rattus*), Peregrine falcons (*Falco peregrinus*) and large gulls (*Larus spp.*).	High
	Competition for nest sites with large gulls.	Low/Medium
Problematic non-native/alien species	Predation by introduced mammals on the Azores (Brown rats, Rattus norvegicus, Polecats, Mustela putorius, Ferrets, M. putorius furo) or elsewhere in Europe American mink (Neovison vison) and Brown rats.	High
Climate change and severe weather	Bad weather can reduce food availability and affect chick survival and growth rate.	Unknown
	Winter storms washed away a major breeding site in Ireland in the mid-1970s, while increased frequency of summer storms threatens another Irish site. Sea level rise may exacerbate the scale of the problem.	Low/Medium
	Food shortage in winter due to declining fish stocks, potentially driven by long-term changes in sea-surface temperature.	Unknown
Hunting and collecting	Trapping on wintering grounds in West Africa.	Unknown, potentially high

Table 2.
Major threats that drove Roseate tern decline and may still constrain the population [2].

recent observations, suggesting that the species is either very rare or locally extinct [3, 10, 21]. Small numbers have bred in the Camargue in southern France, as well as northwest Germany, Belgium and possibly Denmark, though often in mixed-species pairs [2, 4, 17, 20].

In the Azores, Roseate terns have bred on all nine islands of the archipelago, and have used 49 sites, of which breeding has been consistent at only five (two colonies on Flores, and single colonies on Graciosa, Terceira and Santa Maria; Figure 2) [3]. Roseate terns were exterminated in Ireland and nearly disappeared from Britain in the 19th century, but the species recovered and recolonised Ireland in 1913 [4, 20]. The main colony in Ireland is Rockabill, on the east coast, followed by Lady's Island Lake in the southeast [10]. In Britain, the main breeding sites are in Anglesey (Wales) and on Coquet Island in northeast England [10].

Table 3.
Conservation actions in place for Roseate tern [2].

Action	Description	Impact
Monitoring and planning	Species Action Plan in place.	Medium/high
	Most major breeding colonies are regularly monitored.	High
Site/area protection	There are 53 IBAs identified for Roseate tern in Europe, of which 45% are fully designated as SPAs or other protected areas, including most breeding colonies and the main foraging sea area around Rockabill, and 8% are not protected.	Medium/high
Site/area management	Wardening of breeding colonies, particularly in the UK, Ireland and France.	High
	Habitat management to create suitable terraces and vegetation.	High
Species recovery	Nest box provision in Ireland, the UK and France.	High
Invasive/ problematic species control	Control of American mink in France and rats in the UK and Ireland.	High
Education and awareness	Awareness raising campaign in Ghana and Senegal to reduce trapping in winter.	Unknown
Legislation	Fully protected by the Law and included in a number of international treaties (see 'Legal protection and conservation status').	High

Major threats

Persecution for the millinery trade drove Roseate terns close to extinction in Europe in the 19th century [4]. The species always had a very restricted range compared to other tern species, as it requires islands with low predation close to high densities of prey [17]. Currently, the Roseate tern population in Europe is limited by factors that affect the number and quality of suitable colony sites [3]. This is because Roseate terns have relatively low adult survival rates [22] and high productivity is essential for population stability [23].

The main reasons for the Roseate tern decline in Europe during the 1960s and 1970s relate to the conditions at the breeding colonies, mainly the loss of the colony at Tern Island in Ireland due to storms, as well as a shortage of food in the wintering grounds in Africa and persecution [1, 2, 4, 10, 24]. In Europe during this period, increasing Herring gull (*Larus argentatus*) and other gull populations resulted in increased competition and also predation, while human disturbance also increased through the development of recreational activities, which facilitates predation [2, 10, 23, 24].

Currently, predation by mink and Peregrine falcons is one of the main reasons for destabilisation of colonies [1, 23, 25], while erosion of breeding sites is a potential threat for the long-term viability of colonies [2, 10]. Trapping in the wintering grounds is an ongoing threat, indicated by a resurgence of trapping activity recorded recently in Ghana [3].

Drivers of recovery

Following dramatic declines in the 19th century, Roseate terns recovered thanks to protective legislation that banned hunting of the species [4]. After the more recent declines of the 1960s and 1970s, the species recovered thanks to targeted conservation actions, including control of predators, protection of breeding sites and provision of nest boxes to improve colony productivity and size. Management on Rockabill has contributed to enhanced productivity of the colony compared to other sites, an the site benefits from much higher food availability and inaccessibility to predators thanks to its large distance offshore [3, 17, 24, 26]. Education and awareness raising campaigns were also carried out, particularly in West Africa [10].

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5. Overview of wildlife comeback

In this section we synthesise the information gathered in the species accounts to ask what this information can tell us about the resurgence of selected species in Europe, in terms of the magnitude of change in abundance and distribution and the predominant reasons underlying the comeback of these species. This will help us to apply lessons learned to other species across Europe in order to stem the tide of biodiversity loss, meet conservation targets and ultimately allow the re-establishment of a wilder Europe for all to enjoy.

Changes in population size

The species presented in this study were selected on the basis of a notion that they had all undergone a recovery after a period of serious decline. As a result, it is not surprising that all the bird and mammal species [with the exception of the Iberian lynx (*Lynx pardinus*), for which the data showed declines in abundance although recently the species has been showing signs of steep recovery from its all-time low] showed increases in abundance from the mid-20th century to the present. However, there was high variability among species (Figures 1 and 2). This is due in part to the variation in rate of increase across the study period, but also to the regional variation within species trends.

Mammals

For mammals, the greatest abundance increases over the period from 1960 to 2005 were observed in herbivores, specifically in the European bison (*Bison bonasus*) and the Eurasian beaver (*Castor fiber*), and the vast majority of recent trends greatly exceed the Palearctic vertebrate average [1] (Figure 1). Brown bear (*Ursus arctos*), Harbour seal (*Phoca vitulina*) and Northern chamois (*Rupicapra rupicapra*) show the smallest increase, which is still greater than the Palearctic vertebrate average [1]. In terms of average annual growth rates, the Eurasian beaver (*Castor fiber*) again shows the highest rates, followed by the European bison (*Bison bonasus*), although with much variability between years, and the Grey seal (*Halichoerus grypus*) (Figure 3). While most of the species with complete time series showed overall increases since 1961, recovery of the Northern chamois and Harbour seal was evident from 1965 and 1977 respectively. It is important to note that time series are not complete for all of our species (see Figure 3), and that the number of populations for which data were available also varied over time.

Regional patterns in abundance change show a complex picture when grouped across species (Figure 5). Eastern Europe, which has been the source for many of the comeback species [e.g. the Grey wolf (*Canis lupus*) and the Eurasian lynx (*Lynx lynx*)], exhibited the lowest increases in abundance, while southern and western regions in particular experienced on average the highest increases in population abundance across mammal species. This is likely to reflect growth in abundance at the range margins of several species.

Variation in abundance change was largest in western Europe which is most likely a reflection of varying success of range expansion and population establishment in areas where wildlife had previously been decimated.

It is important to remember that since 2005 there have been further increases for some species and populations, although much of this data was not yet available for our analysis (but see recent development sections in the species accounts).

Birds

For birds, the majority of species or populations increased by between two and seven times, but others ranged from less than 10% for Red kite (*Milvus milvus*), to more than 70 times for the Svalbard population of Barnacle goose (*Branta leucopsis*) and more than 40 times for the Russian/Baltic population of that species, more than 40 times for the Iceland/Greenland population of Pink-footed goose (*Anser brachyrhynchus*) and more than 30 times for White-headed duck (*Oxyura leucocephala*) (Figure 2).

Much of this variability was due to differences among bird species in the realised yearly growth rates, as well as the year at which recovery began. On average, species recovered by 5% per year from

Grey seal at Donna Nook in England, an RAF bombing range where decades without persecutionhave left the seals now being very relaxed in the presence of humans.

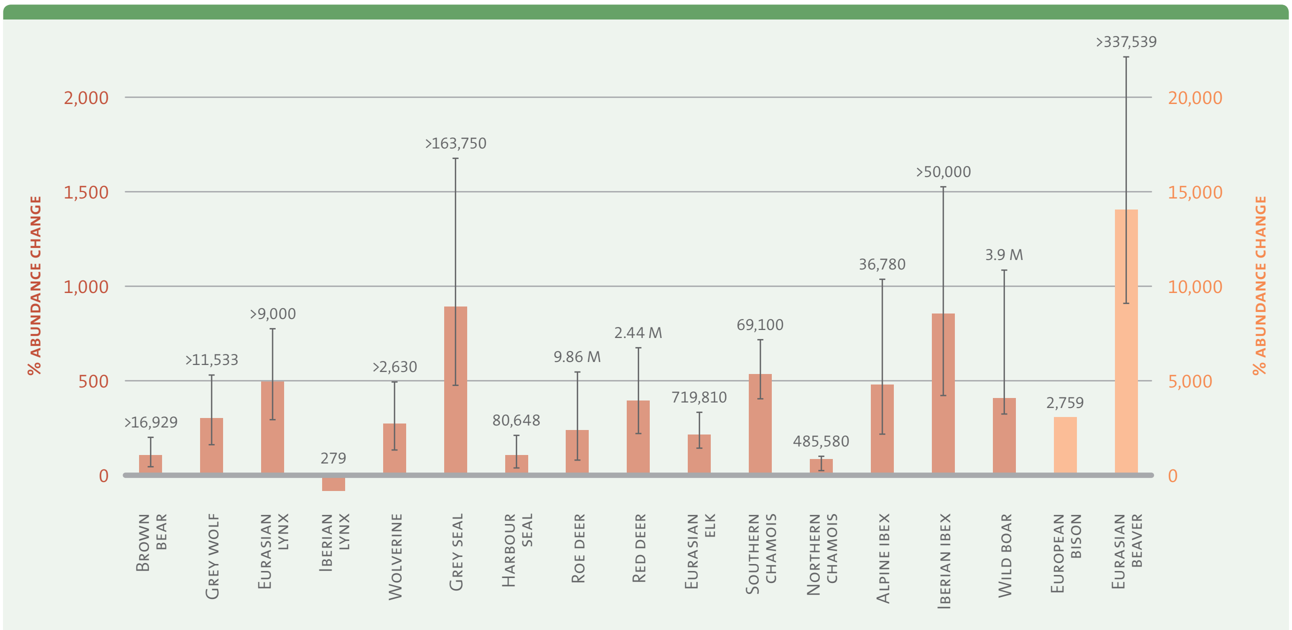

Figure 1. Average change in population abundance between 1960 and 2005 for 17 mammal species covered in this study (insufficient data for the Golden jackal), with carnivores on the left and ungulates and beaver on the right. Left hand axis relates to species with **red bars**, right hand axis to those with **orange bars** (Eurasian beaver and European bison). The Iberian lynx has shown signs of comeback since 2005. Whiskers are 95% confidence limits; numbers denote the current European population size.

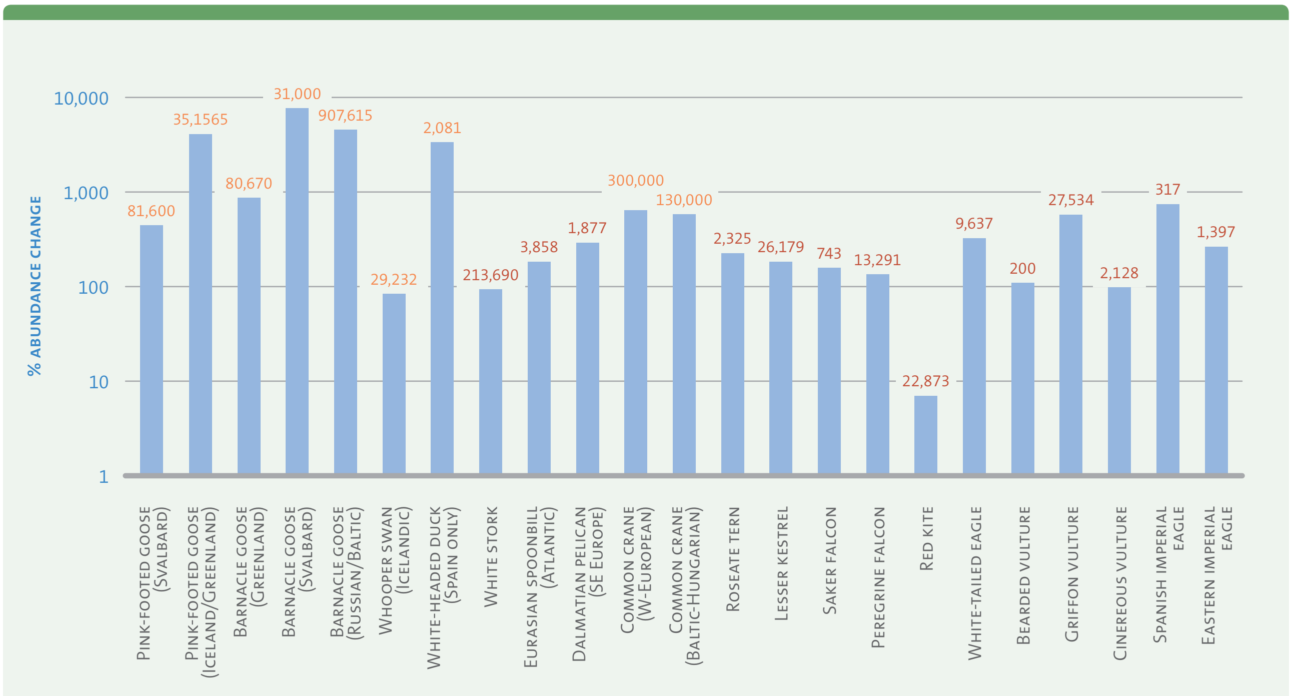

Figure 2. Change in population size (%) of bird species in Europe from the minimum population estimate during the time period for which data were available for each species, showing the current population size in Europe as number of breeding **pairs** or **individuals**.

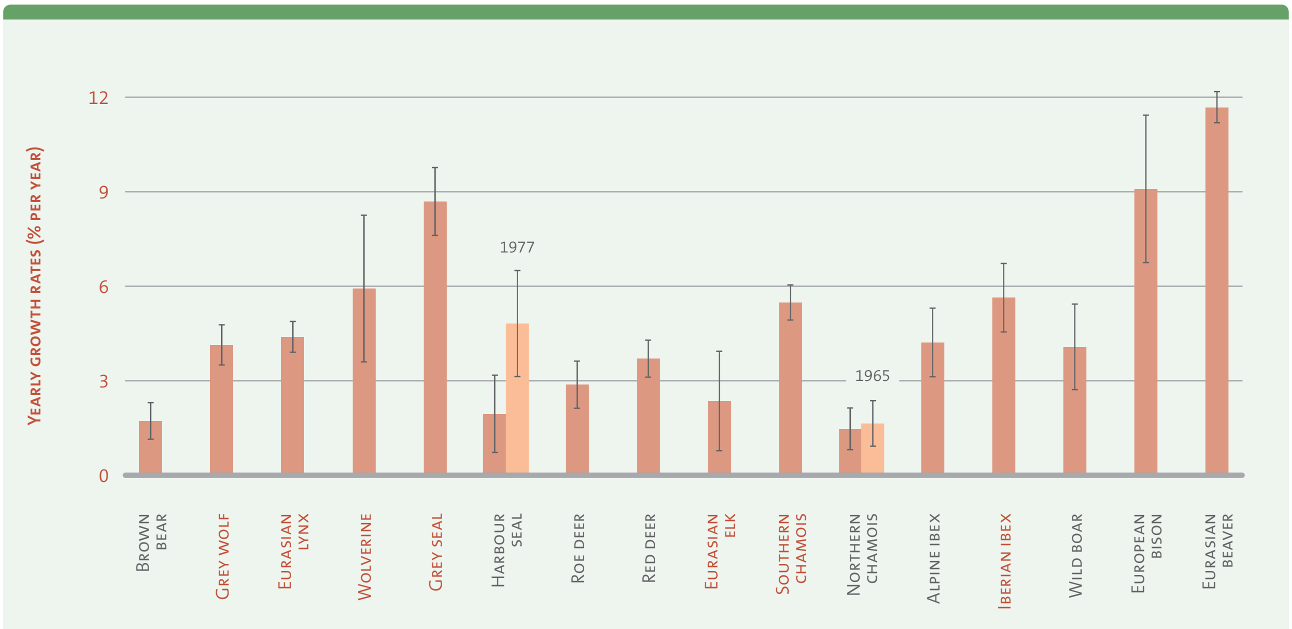

Figure 3. Average annual growth rates for mammal species in the study which show resurgence in Europe. Annual growth rates were for the period of 1961 to 2005 in most cases. **Red text** denotes species with time series data starting later than 1961 (see individual species accounts). **Orange bars** indicate annual growth rates from the beginning of population recovery (year indicated above bars). Error bars show standard error of the mean. The Iberian lynx (no increase apparent in the data) and Golden jackal (lack of data) were not included in the analysis.

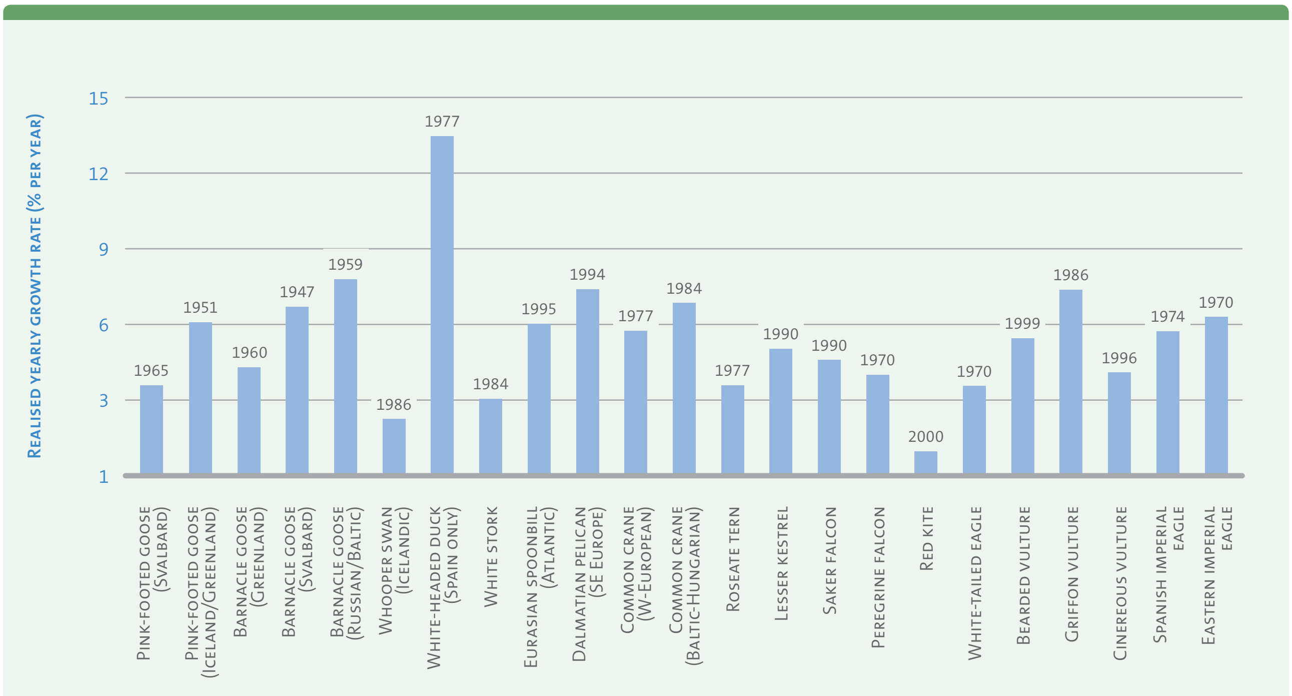

Figure 4. Realised growth rate (% increase per year) of bird species in Europe from the beginning of population recovery (year indicated above bars).

Species	Family	1950s		1980s				Present					50km grid		
		Year	Area (km²)	Year	Area (km²)	Range change (%)	Trend	Area (km²)	Range change (%) from 1950s	Trend from 1950s	Range change (%) from 1980s	Trend from 1980s	Range change (%) from 1950s	Range change (%) from 1980s	Trend from 1980s
Anser brachyrhynchus	Anatidae	1950s	52,853	1980s	100,480	90.11	+	81,700	54.58	+	-18.69	–	137.98	25.18	+
Branta leucopsis	Anatidae			1980s	74,360			153,361			106.24	+		308.44	+
Cygnus cygnus	Anatidae	1950s	218,871	1980s	948,483	333.35	+	956,566	337.05	+	0.85	+	457.13	28.56	+
Oxyura leucocephala	Anatidae			1977	69,468			114,243			64.45	+		109.47	+
Ciconia ciconia	Ciconiidae	1949	3,419,388	1980s	2,970,754	-13.12	–	3,002,274	-12.20	–	1.06	+	0.00	15.10	+
Falco naumanni	Accipitridae	1950s	1,996,843	1980s	962,421	-51.80	–	549,089	-72.50	–	-42.95	–	-63.44	-24.14	–
Falco cherrug	Accipitridae			1980s	329,142			393,284			19.49	+		68.79	+
Falco peregrinus	Accipitridae	1950s	5,368,092	1980s	2,319,207	-56.80	–	3,018,237	-43.77	–	30.14	+	-33.61	53.67	+
Milvus milvus	Accipitridae	1950s	3,217,313	1980s	1,782,714	-44.59	–	1,436,825	-55.34	–	-19.40	–	-40.69	7.04	+
Haliaeetus albicilla	Accipitridae	1950s	1,436,518	1980s	1,346,599	-6.26	–	2,097,030	45.98	+	55.73	+	81.79	93.93	+
Gypaetus barbatus	Accipitridae	1950s	489,342	1980s	99,765	-79.61	–	214,749	-56.11	–	115.25	+	-34.26	222.46	+
Gyps fulvus	Accipitridae	1950s	1,102,886	1980s	516,483	-53.17	–	378,054	-65.72	–	-26.80	–	-36.31	35.99	+
Aegypius monachus	Accipitridae	1950s	798,355	1980s	154,999	-80.59	–	124,357	-84.42	–	-19.77	–	-66.46	72.76	+
Aquila adalberti	Accipitridae			1974	110,960			89,408			-19.42	–		63.93	+
Aquila heliaca	Accipitridae	1950s	727,382	1980s	287,564	-60.47	–	220,119	-69.74	–	-23.45	–	-52.88	19.18	+
Grus grus	Gruidae	1950s	1,745,498	1980s	1,963,302	12.48	+	2,020,788	15.77	+	2.93	+	31.01	16.48	+

Table 1b.
Historical (1950s and 1980s) and present (c. 2012) areas of breeding distribution of each bird species, except colonial nesting species, including range changes and trend between each time period. Range change was also calculated on the basis of a 50km x 50km grid for comparability with 1980s Atlas data. The quality of species distribution data in Russia is poor, due to low coverage, and therefore Russia was not included in this analysis.

the year at which the population size of each species was at its lowest point (Figure 4). Raptors tended to show a lower yearly growth rate than waterbirds (4.7% and 5.9% per year on average, respectively) and variability tended to be higher among waterbirds than among raptors. White-headed duck showed the largest rate of increase (13% per year) and Red kite showed the lowest (<1% per year). Overall recovery of the population of Red kite in Europe is very recent, having only become apparent since around 2000, making it difficult to estimate growth rate, while different parts of the species' range show opposing trends. Red kites in northwest Europe have increased by 9% per year since 1970, but suffered ongoing declines of <1% per year in its strongholds in Spain, France and Germany.

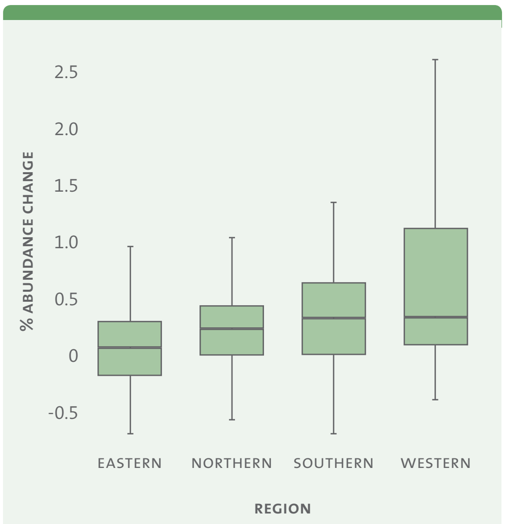

Figure 5.
Change in population abundance by region in Europe for the 18 mammal species considered in this study. Bars are median abundance change values, whiskers depict range of values excluding outliers.

Changes in distribution

It is to be expected that species increasing in abundance will also increase in range, and this was the overall pattern in birds. Since the 1980s, six species increased in range and three species appear to be stable, with small changes of less than 5% (Table 1a). The apparent decline calculated for the remaining seven species may be to a large degree the result of improved knowledge and accuracy. As the 1980s distributions derive from grid-based atlas mapping, use of a comparable grid to assess range change is more appropriate, particularly for species with patchy or restricted distributions. This method results in a reversal of the trend for all but one species (Table 1a), the Lesser kestrel (*Falco naumanni*). Barnacle goose, White-headed duck and Bearded vulture (*Gypaetus barbatus*) showed the largest increases (Table 1a).

For mammals, the picture was less clear-cut. Since the 1950s/60s, nine species showed range increases, seven species showed range declines, and two remained stable (changes of less than 5%; Table 1b). On the whole, the Eurasian beaver showed the largest increase in range, having expanded its past range by 550%, followed by the Red deer (*Cervus elaphus*) and Iberian ibex (*Capra pyrenaica*) (Table 1b). Overall, we did not find a significant correlation between range change and abundance change (Figure 6). This is likely to be a reflection of the strength of range change metrics for this analysis of wildlife comeback. For mammals, distributions were derived from species ranges

Species	Family	Historical		Past				Present					
		Year	Area (km²)	Year	Area (km²)	Range change (%)	Trend	Year	Area (km²)	Range change (%) to historical	Trend to historical	Range change (%) to past	Trend to past
Bison bonasus	Bovidae	1890	42,074	1971	45,276	7.6	+	2011	14,080	-66.5	–	-68.9	–
Capra ibex	Bovidae	1800	208	1967	36,033	17,223	+	2008	15,602	7,401	+	-56.7	–
Capra pyrenaica	Bovidae	1900	325,672	1967	25,507	-92.2	–	2008	57,538	-82.3	–	125.6	+
Rupicapra pyrenaica	Bovidae			1955	38,891			2008	15,130			-61.1	–
Rupicapra rupicapra	Bovidae			1955	362,556			2008	206,755			-43.0	–
Alces alces	Cervidae	1810	1,602,791	1955	4,051,444	152.8	+	2008	4,454,951	177.9	+	10.0	+
Capreolus capreolus	Cervidae	1900	2,274,768	1967	4,803,807	76.3	+	2008	6,097,612	123.8	+	26.9	+
Cervus elaphus	Cervidae			1955	1,279,674			2008	3,671,669			186.9	+
Sus scrofa	Suidae	1890	4,838,067	1955	4,531,092	-6.3	–	2008	5,339,537	10.4	+	17.8	+
Castor fiber	Castoridae			1955	256,573			2013	1,668,697			550.4	+
Canis aureus	Canidae			1955	417,164			2011	198,042			-52.5	–
Canis lupus	Canidae	1800	5,426,047	1960	2,657,659	-51.0	–	2008	2,685,531	-50.5	–	1.0	+
Lynx lynx	Felidae	1800	6,853,110	1960	3,553,494	-48.2	–	2010	4,392,088	-35.9	–	23.6	+
Lynx pardinus	Felidae	pre-1900	106,233	1960	61,048	-42.5	–	2008	1,265	-98.8	–	-97.9	–
Gulo gulo	Mustelidae	1850	5,210,522	1955	1,977,446	-62.0	–	2012	1,937,527	-62.8	–	-2.0	–
Halichoerus grypus	Phocidae			1955	1,901,193			2008	1,682,976			-11.5	–
Phoca vitulina	Phocidae	1599	1,938,999	1956	1,800,407	-7.1	–	2008	2,071,955	6.9	+	15.1	+
Ursus arctos	Ursidae	1700	9,467,438	1955	3,443,725	-63.6	–	2008	3,892,423	-58.9	–	13.0	+

Table 1b. Historical, past and present distribution areas for 18 mammal species, including range changes. Historical: pre-1900; Past: 1955–71; Present: 2008–2013.

taken from various publications, thus spatial resolution varied between species and time period. There was no grid-based atlas data available as was the case for birds. As a result, it is likely that some of the spatial range change patterns observed arise from issues with the resolution of range data. Specifically, past and historical range data are likely to be less spatially detailed, and it is more likely that species ranging over larger areas are depicted to have a continuous distribution across space, compared to species with smaller ranges for which it is easier to depict discontinuities in range. More recent mapping is also likely to depict more spatial detail: present species maps are often based on habitat suitability modelling, which gives rise to greater spatial detail and introduces discontinuities into species range. It is important that we find techniques to reconcile these spatial resolution issues in order to derive a robust metric of wildlife comeback. At present, abundance change data appears to provide us with a much more robust measure of mammal comeback. However, keeping these caveats in mind, we believe that some broad-scale patterns can be derived from our analyses, particularly with regard to some of the more widespread species whose range size pattern is likely to be less affected by spatial resolution.

Despite these caveats, consideration of spatial distribution data can provide us with broad-scale clues as to why there is such marked variation in abundance. A comparison of past (1950s/60s for mammals, 1980s for birds) and present distributions

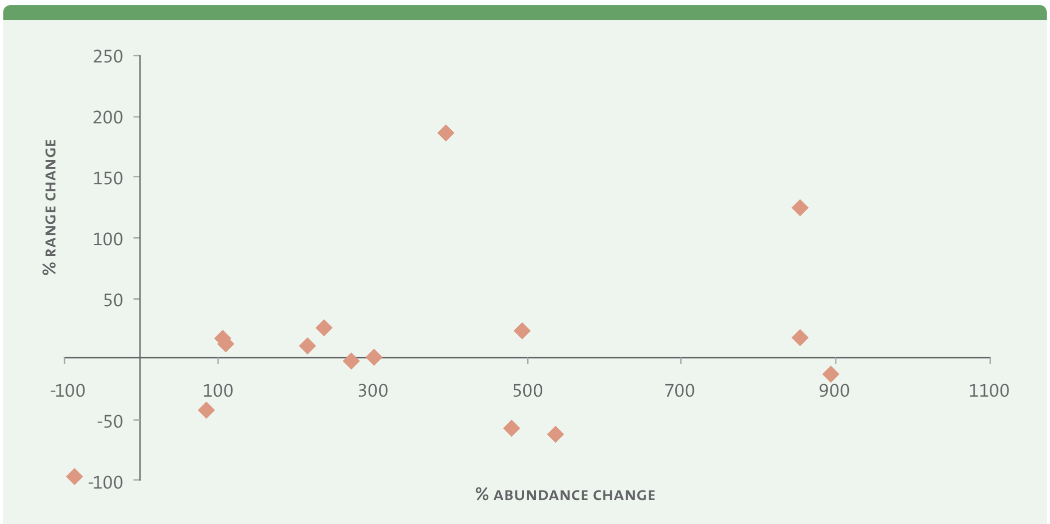

Figure 6. Percentage range change of mammal species versus % abundance change between past and present day, excluding extreme outliers European bison and Eurasian beaver.

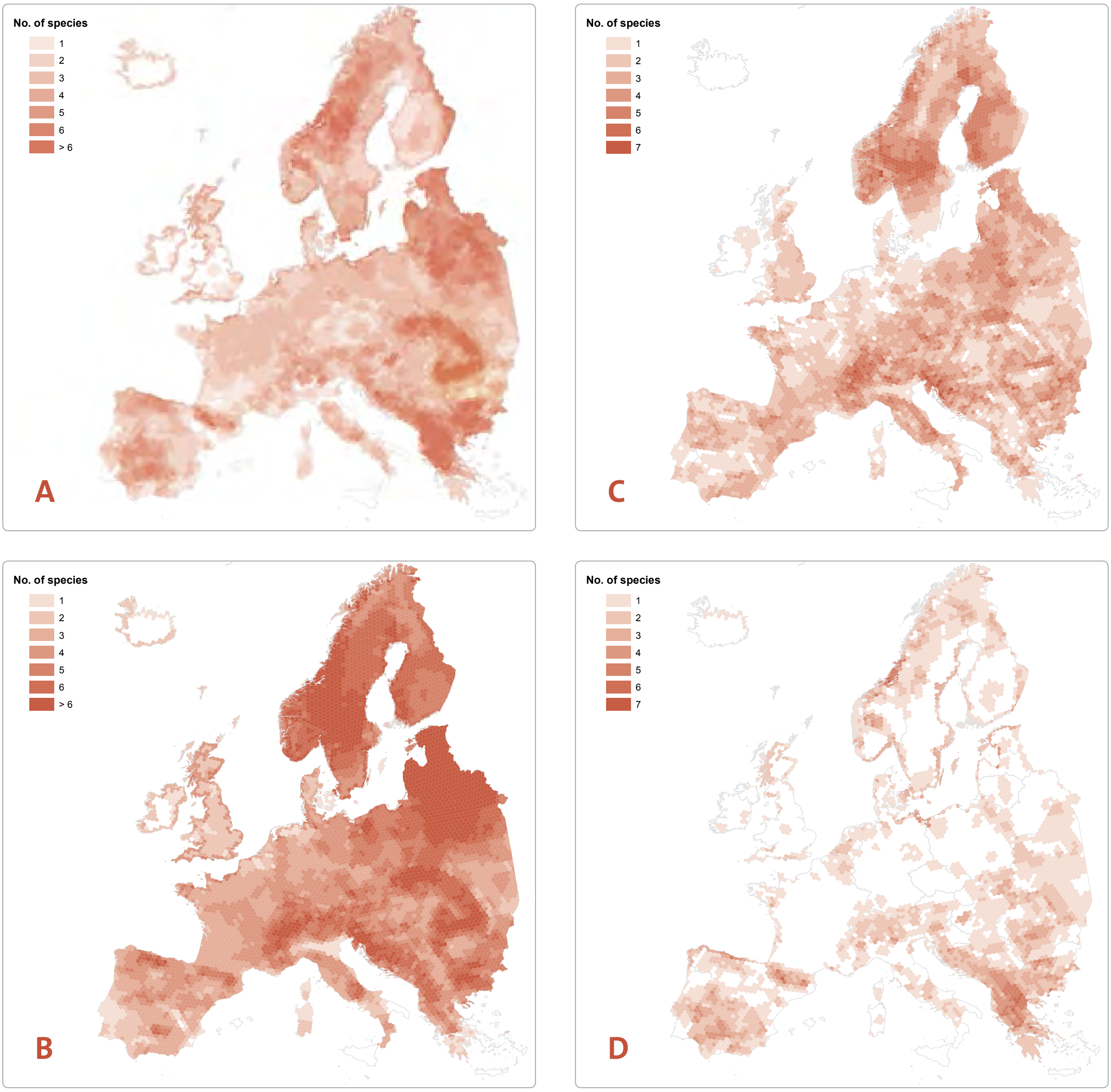

Figure 7. Mammalian species richness patterns for the period (A) 1950s-1960s, and (B) present day. Note that this dataset comprises only the 18 mammal species which were the focal species of the study (see species accounts). Spatial occurrence of distribution gains and losses, between 1950s/60s and present day, expressed as number of species gaining (C) or losing (D) distribution area.

shows changes in the overall pattern of the spatial distribution of our selected species over these time periods and can help to pinpoint spatial patterns of range expansion and contraction (Figures 7, 8 and 9).

This analysis revealed that the overall pattern of distribution of selected mammal species broadened within the timeframe, with the number of species present increasing recently in central, eastern and northern Europe in particular. The broad picture of distribution change between past and present distributions shows that distribution expansions in our study species occurred widely across Europe (Figure 7C), while distribution contractions were mainly reported from southeastern Europe and the Pyrenean region (Figure 7D). Much of the pattern of loss observed in southeastern Europe was concurrent with the pattern of distribution losses in large carnivores (Figure 8B). Distribution gains amongst carnivores were most pronounced in Fennoscandia (particularly Finland and Sweden, where four of the six terrestrial carnivore species in the study occur) and Croatia/Slovenia (Figure 8A). Overall, Europe has seen a north and westward expansion of carnivore distributions from southern and eastern populations, many of which are providing us with the recent range expansions highlighted in the species accounts. Distribution gains for hoofed mammals were more spread out across the continent (Figure 8C), a trend driven by distribution increases in all four species of deer. On the other hand, distribution losses were mainly confined to small pockets across the Alps and central Italy, which were driven by overall distri-

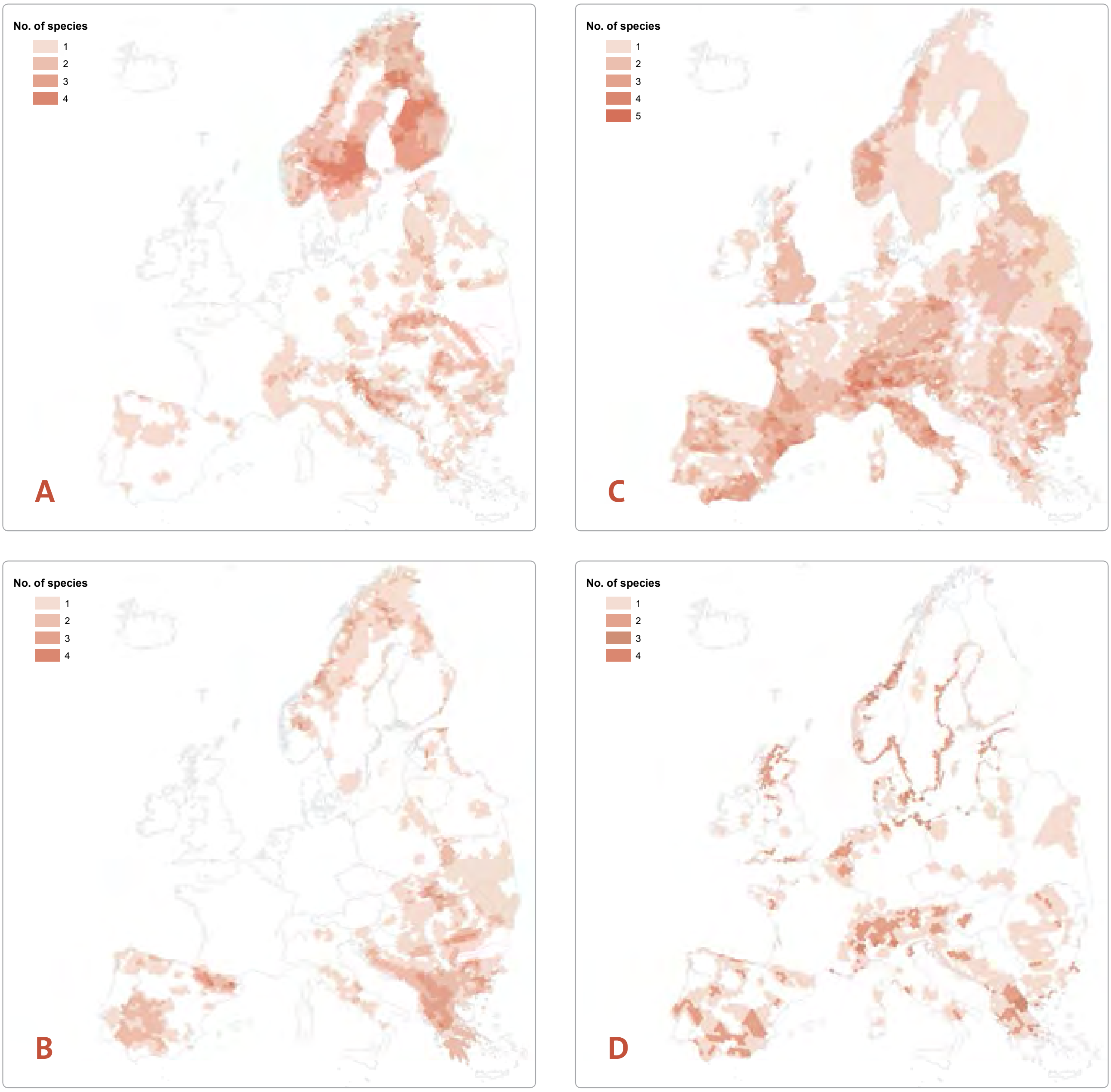

Figure 8. Spatial occurrence of distribution gains and losses for mammals, between 1950s/60s and present day, expressed as number of species gaining [carnivores (A), ungulates (C)] or losing distribution area [carnivores (B), ungulates (D)].

bution losses in bovids. However, since this refers to relatively localised areas, it may again be a reflection of difference in spatial resolution of the underlying range information.

For birds, a comparison of the current spatial distribution of species with that in the 1980s (Figure 9) suggests an increase in the number of species present in northern and north-central Europe and a decline in southeastern Europe, as is the case with the mammals. Similar patterns can be seen for the number of species gaining and losing in their distribution since the 1980s, with more species expanding their range in central and northwestern Europe, and more species contracting in southeastern Europe, but also in Iberia (Figure 9).

For mammals, we investigated the pattern of range change further. Distribution changes from the past to the present were on the whole positive for ungulates (+15.28%, n=9; five species gaining in distribution and four species contracting) and negative for carnivores (-13.9% and -19%, respectively including (n=8) and excluding pinnipeds (n=6); four species gaining in distribution and four contracting), although order did not have a significant effect on range change (Figure 10A). Positive range change was most pronounced among medium to large species (50–100 kg average weight), though again this was not statistically significant and showed much variation (Figure 10B). There was a larger amount of positive range change for species which expanded from larger past ranges, compared to those species expanding from smaller ranges, though again this was not significant (Figure 10C).


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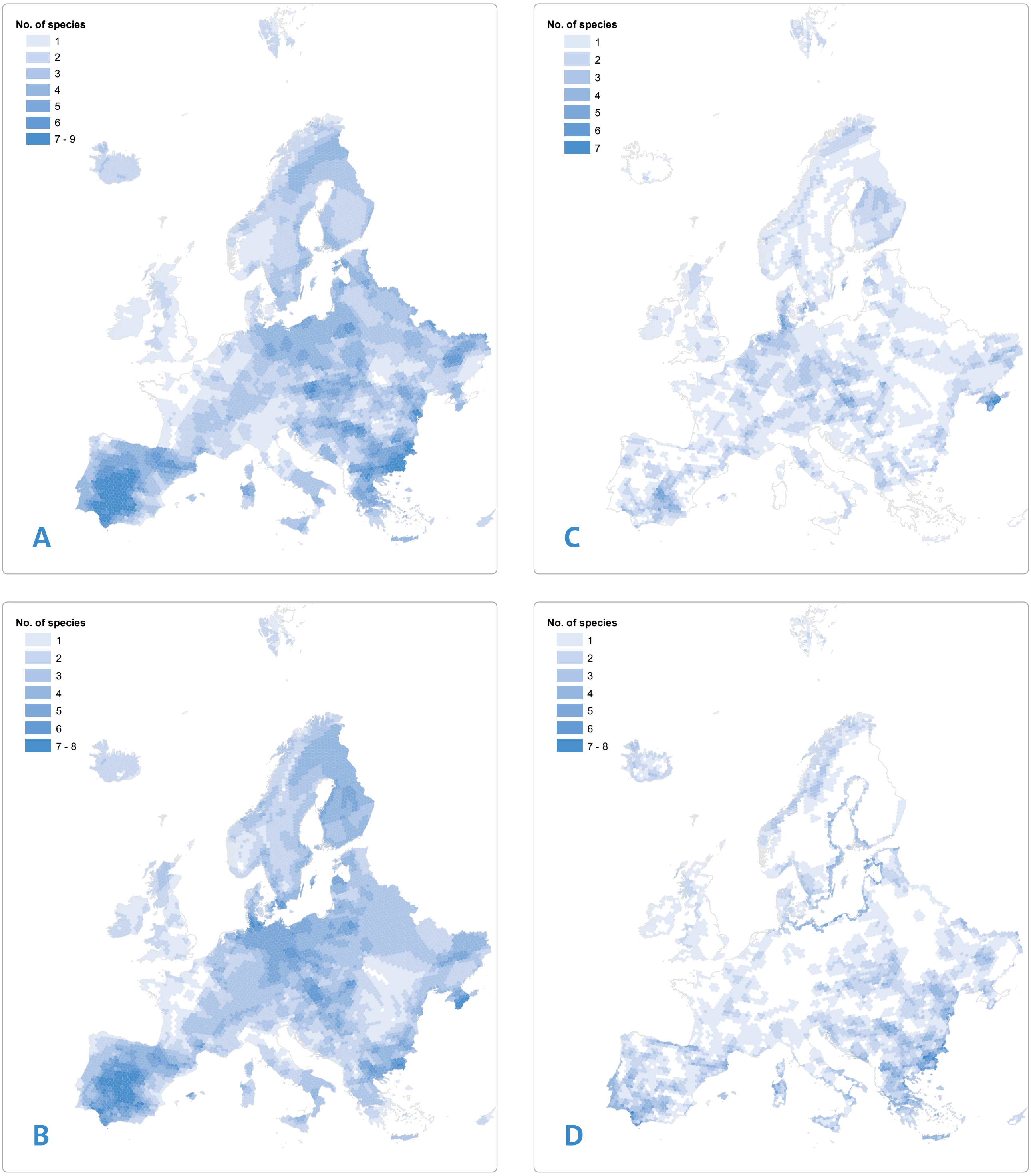


Figure 9. The spatial distribution across Europe of the number of bird species considered in this study in the 1980s (A) and at present (B), and the spatial distribution of expansion and contraction of bird species' ranges across Europe since the 1980s, expressed as number of species gaining (C) or losing (D) distribution area. The quality of species distribution data in Russia is poor, due to low coverage, and therefore Russia was not included in this analysis.

A so-called "soft release" of a young bison into a temporary enclosure in the Bieszczady National Park in Poland, one of Europe's rewilding areas. The European bison is rarer than the Black rhino in Africa, but still each year many dozens of individuals are shot, just because there are not enough areas that are prepared to receive them.

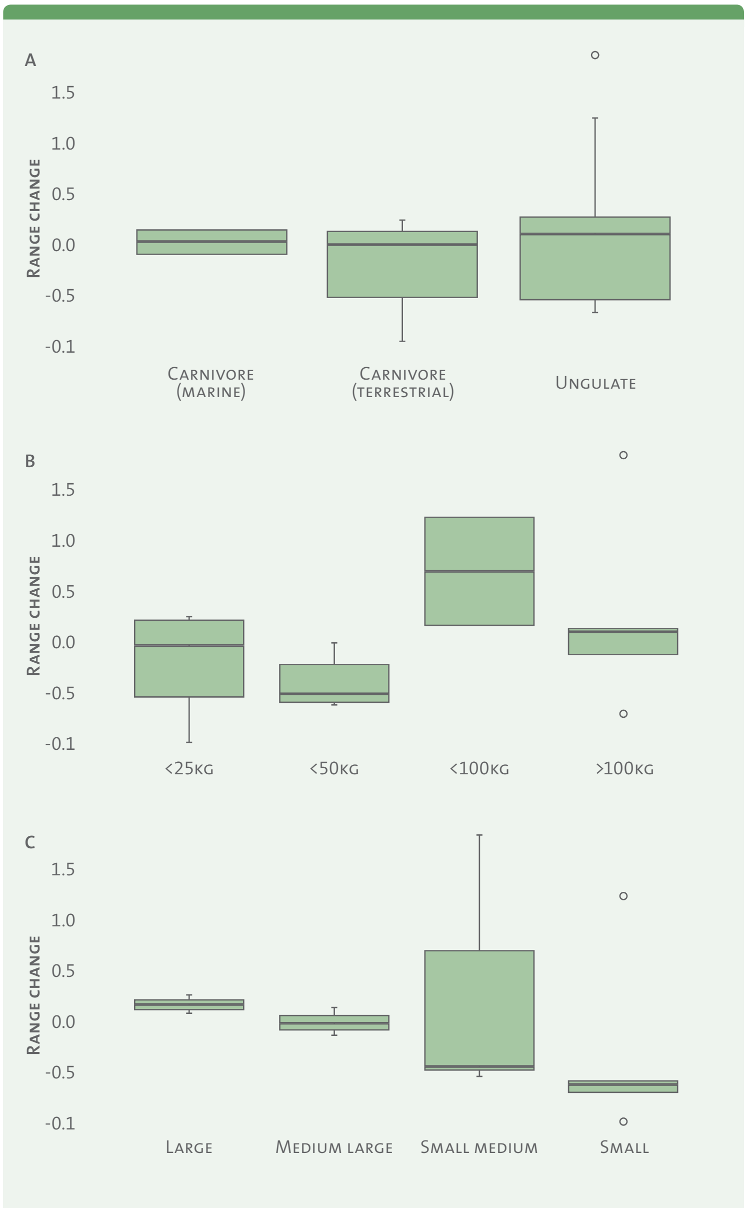


Figure 10.
Median range change in mammals between past and present day by (a) order, (b) body size and (c) past range size. Bars represent range of values, and points outlying values.

Understanding changes in a historical context: causes of decline and historical baselines

While current patterns of comeback in selected species of European wildlife seem encouraging, it is important that we see these changes in a historical perspective. What caused species to become decimated across Europe in the first place and what are the historical baselines? Here, we address these two issues through a more in-depth view at causes of historical declines in birds and assessment of historical baselines for mammals.

It should be noted that, to date, attribution of causal factors for population increase and range expansion has often not been the focus of wildlife management and conservation biology studies, with much focus on reasons for population declines instead. Causal factors and their relative importance are difficult to tease apart, probably because active interventions such as hunting control and legal protection are more obvious and hence thought to have a larger impact. Conversely less apparent or slower acting changes such as habitat alteration or land abandonment may be less evident, and therefore recognition of their impact will be slower. Nevertheless, we can make some cautious conclusions.

Causes of historical declines in bird species

One of the most revealing analyses from which to learn about patterns in wildlife comeback is to analyse concordance among the reasons for change among species. The most frequent causes of historical declines for the focal bird species were persecution and habitat loss or degradation, which were cited as key drivers for 15 and 10 species, respectively (Figure 11). Illegal hunting still poses a problem for many species today (Figure 12), despite the fact that all are legally protected from hunting, with the exception of Pink-footed goose and Barnacle goose, for which population management plans are in place. The extensive loss of wetland habitats in Europe has had considerable negative impacts on many species of waterbirds, including White-headed duck, Dalmatian pelican (*Pelecanus crispus*), Eurasian spoonbill (*Platalea leucorodia*) and Common crane (*Grus grus*), while land-use change and the spread of human development and associated disturbance, especially to nesting sites, continue to pose threats to many species (Figure 12).

Changes in land-use have also resulted in decreases in food availability, which was another key driver of declines (Figure 11). The intensification and abandonment of low-intensity agriculture, for example, led to a decline in prey availability for Lesser kestrel and Saker falcon (*Falco cherrug*), while the vulture species [(Bearded vulture, Griffon vulture (*Gyps fulvus*), and Cinereous vulture (*Aegypius monachus*)] all suffered from declines in carrion availability that resulted from the reduction or abandonment of livestock farming in marginal mountainous areas.

Poisoning, as a result of the toxicity of organochlorine agricultural chemicals or of consumption of poisoned bait intended for vermin, was another major historical driver of decline for nearly all birds of prey considered in this study (Figure 11), and accidental poisoning poses an ongoing threat to many species across Europe [2]. In fact, unintentional effects of persecution were considered critical threats for the largest number of species in this study (Figure 12), in all cases for birds of prey.

Historical baselines of mammal distributions

Unfortunately, abundance data are rarely available prior to the 1950s, and historical distributions (pre-1900s) could not be obtained for all of the mammal species in this study. As a result, a comprehensive analysis of range changes from a historical baseline could not be undertaken across the species set. Dividing the dataset into carnivores and herbivores makes for interesting case studies in Europe, since carnivores have often been persecuted by humans in the past, while hoofed mammals, particularly deer, have been widely hunted.

By the 1950s and 60s, distributions of carnivores had declined dramatically across Europe from historical levels. In our analysis, all five species of terrestrial carnivore with dated historical distribution data had undergone range declines by an average of around 50% (Table 1A). Range declines among terrestrial carnivores were largest for the Brown bear (*Ursus arctos* -63%), the Wolverine (-62%) and the Grey wolf (*Canis lupus* -51%). Amongst the six ungulate species with dated historical range distribution, the Alpine ibex (*Capra ibex*) showed particularly pronounced increases, from just over 200 km^2 to over 30,000 km^2. Because of uncertainty about the accuracy of the historical distribution, calculation of average range change for ungulates from historical to past times excluded the Alpine ibex, and was calculated as an average range increase of 28%, varying from a 92% decrease in the range of the Iberian ibex to an increase of 152% in the Eurasian elk.

This analysis clearly highlights the importance of establishing a historic baseline against which to gauge conservation success. Clearly, in the case of carnivores, a mid-20th century baseline greatly reflects an already impoverished fauna. It is against this background that critical evaluation of recent distribution increases must be measured, as these frequently merely reflect taxa bouncing back slowly from large-scale historical lows.

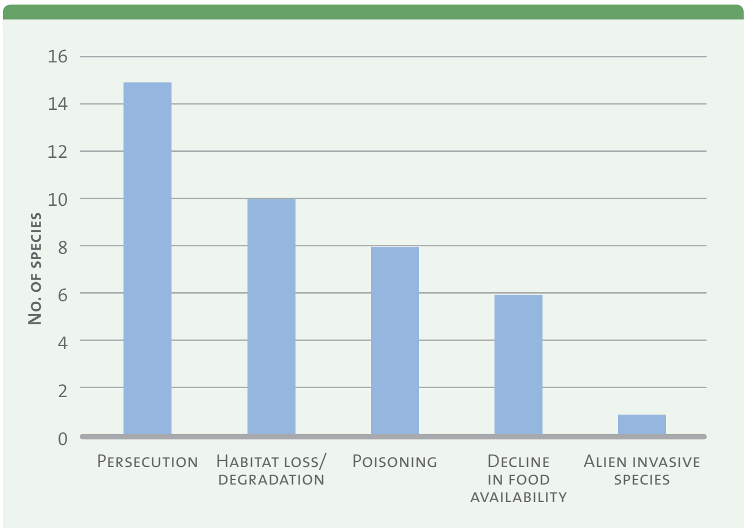
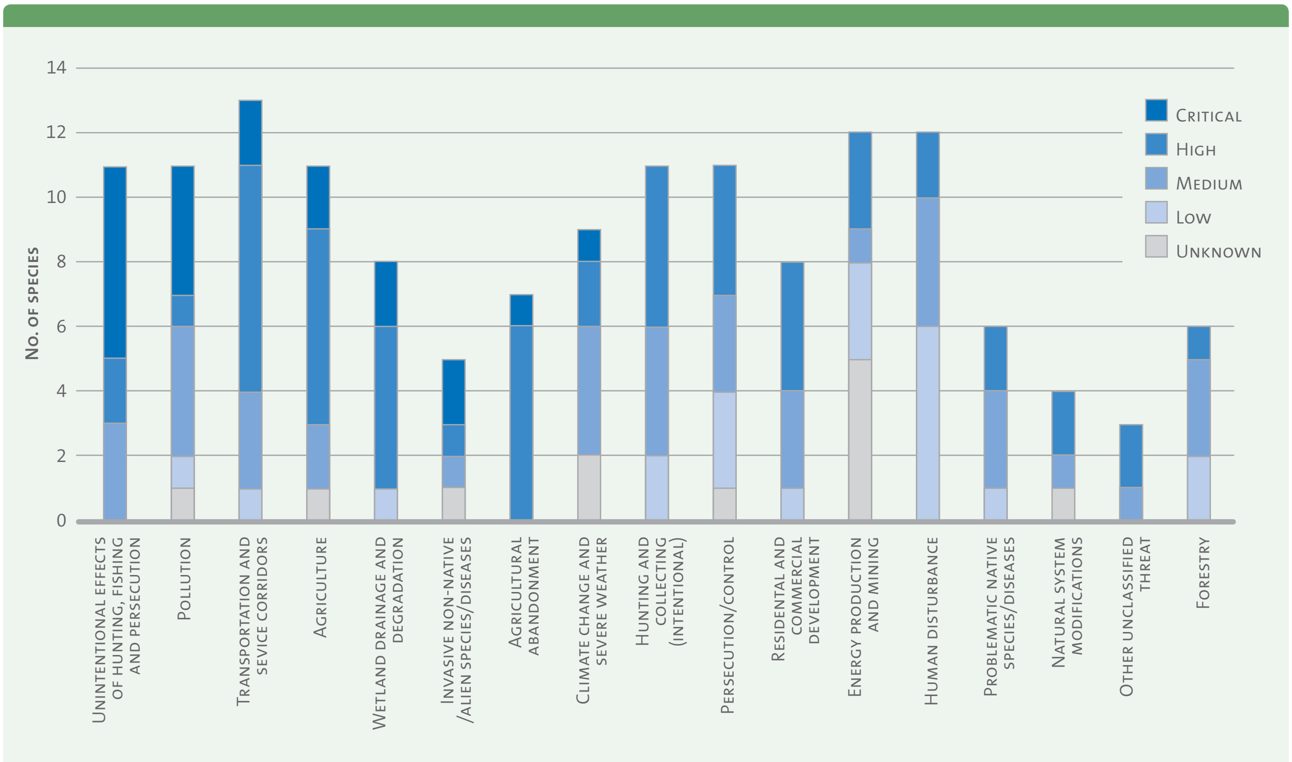


Figure 11. Main drivers of historical decline across bird species.

Figure 12. Summary of threats that drove declines and may still constrain populations of bird species, and their impact.



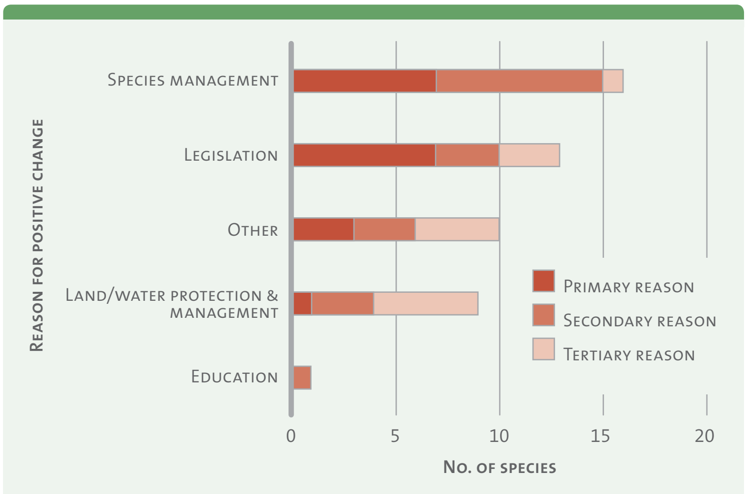


Figure 13. Reasons for resurgence for the 18 mammal species in this study. Horizontal bar shows the proportion of species/populations for which each reason was identified.

Reasons for species recovery

Overall, drivers of recovery reflect to a degree the main threats that caused historical declines. As such, legal protection (e.g. from overexploitation and persecution, as well as site protection) and targeted conservation action, were the overarching reasons for species comeback. Here we provide a more detailed overview of reasons for recovery for mammals and birds separately.

Drivers of mammal species recovery

The data reveal that mammal species comeback tends to rely on a variety of factors. However, for 16 of the 18 mammal species in the study, species management (e.g. reintroductions, compensation schemes, changes in hunting regimes) was cited as one of the top three reasons for recovery, followed by legal protection (13 out of 18 species; Figure 13). Furthermore, both emerged as the most frequently cited primary reason for an increase in abundance over the study period, probably because legal protection of species is likely to lead to better species management in order to comply with legislation.

Actively boosting existing or setting up new populations, via translocations and reintroductions, was the foremost type of species management linked to increased abundances, cited for 10 of the 18 mammal species as amongst the top three reasons for comeback. Management to reduce non-natural mortality, such as via changes to hunting regimes and management to decrease levels of persecution, was amongst the top three reasons for comeback for five species, including Harbour and Grey seals. Changes in hunting practice may frequently be due to legal protection as well, but we kept these categories

Box 1: How many should there be? Historic baselines for wildlife populations

For many thousands of years, humans have been present in Europe and have made use of its living resources for food, clothing, medicines and fuel. The status of European wildlife is therefore part of a dynamic and changing system, and current trends in European wildlife need to be interpreted against a sound understanding of the magnitude and drivers of past changes.

There is a great need to appreciate historic sizes of wildlife populations in order to gauge how wildlife populations in Europe are changing today. This baseline level, against which current and future wildlife populations can be measured, provides us with the means to make accurate assessments of our successes, or failures, in wildlife conservation.

The field of historical ecology, used in order to reconstruct past changes, is developing rapidly. Only recently have scientists started to unravel the long-term impacts of humans on wildlife. For long-term trends in biodiversity, there often remains little option but to set baselines to the point at which systematic data collection was started, since long-term data sets are frequently lacking [1]. This is highly undesirable, as systems have often undergone dramatic change by the time monitoring programmes start. Typically, for ecological data like estimates of population abundance, good records began around the 1960s-1970s. There are limited examples of longer-term abundance datasets that precede this time period [1, 2], though sometimes inferences can be made using ancillary information (e.g. [3]).

For occurrence or sighting data, there is a greater depth of historical records from which inference on the changing state of nature can be drawn. Resources such as museum specimens, archaeological records and literature monographs can all provide an enhanced historical record, though any inherent bias must be carefully accounted for to gain an accurate picture of the historical distribution of species [4].

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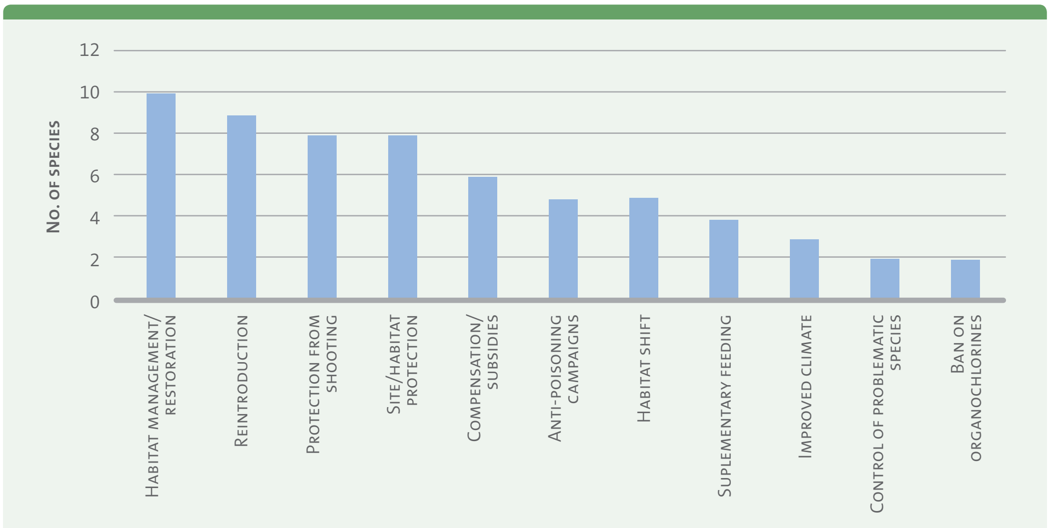


Figure 14. Main drivers of recovery across bird species.

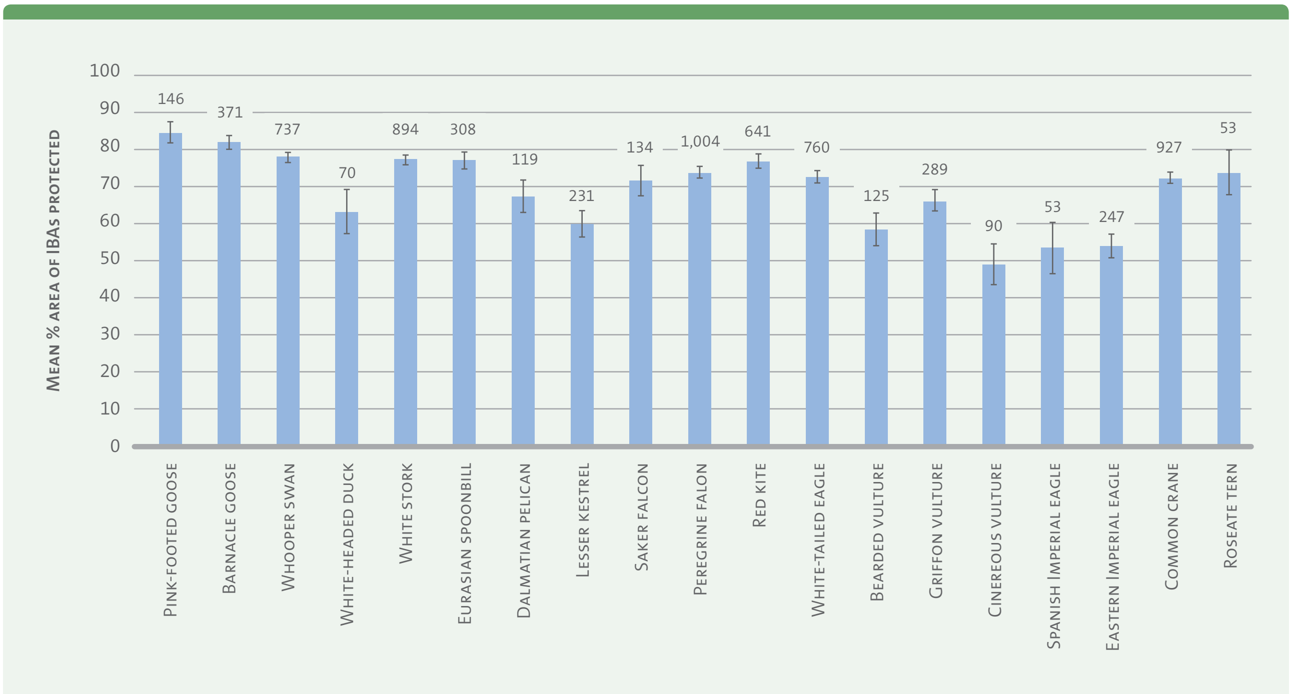
separate because changing in hunting practices tend to relate more to the establishment of sustainable harvesting, as opposed to an outright ban on exploitation.

Drivers of bird species recovery

Two of the most frequent drivers of recovery of bird species were protection from shooting and habitat management and restoration (Figure 14), including wetland restoration, protection of nest sites, and mitigation of mortality caused by collision with and electrocution by power lines. Targeted conservation actions, including species reintroductions and species recovery management, including supplementary feeding and artificial nest boxes, have contributed to the comeback of 15 of the species considered in this study.

In most cases, implementation of these conservation activities are promoted by Species Action Plans (SAPs) produced and endorsed by the European Union (EU) under the Birds Directive, and also by the Bern Convention, the Convention on Migratory Species (CMS) and the African-Eurasian Waterbird Agreement (AEWA) (see 'Introduction'). Whether in the form of SAPs or other conservation programmes, all 19 species benefitted from monitoring and planning activities, although coverage across species' ranges varies. Protected areas are also in place for all the species, covering on average nearly 70% of the area of key sites for each (identified as Important Bird Areas, IBAs) [3], but the coverage of designation, as well as enforcement, varies both between species (Figure 15) and across countries.

Figure 15. The mean coverage of area of Important Bird Areas (IBAs) by protected areas. Whiskers are the standard error of the mean and the number of IBAs identified for each species in Europe is shown above the bars.



Dalmatian pelicans at the Kerkini Lake in Greece. Fishermen here have substantial incomes from showing the pelicans to visitors.

Opportunities to address species declines have also been taken in legislation and policy not primarily concerned with nature conservation. For example, many of the economic incentives (subsidies and compensation measures) in place (Figure 14) consist of agri-environment measures under the EU Common Agricultural Policy and are concerned with appropriate management of farmland habitats. Although the effectiveness of such measures varies widely across the EU and between species [4], appropriate targeting of management prescriptions, such as for Lesser kestrel and Saker falcon, has proved effective. Similarly, concerted effort by scientists, conservationists and land managers recently resulted in new regulations in EU sanitary legislation, which allow abandonment of livestock carcasses in the field or at vulture feeding stations [5, 6], thus ensuring that regulation of disposal of carcasses in response to Bovine Spongiform Encephalopathy (BSE) will not further reduce food availability for scavengers.

In some cases, notably for the geese, Common crane and Whooper swan (*Cygnus cygnus*), recovery was an unintended result of land-use change, as the species shifted their habitat use towards more productive intensively managed pastures, meadows and other croplands. Similarly, the increases of White storks in southwest Europe (and partly also northwestern populations) were partly the result of new foraging opportunities on landfill and reduced mortality owing to the cessation of migration, as well as the increase in food availability with the introduction and expansion of a non-native crayfish species.

Protection from persecution, protection of key sites and habitats, and active conservation efforts, promoted in particular by the EU Birds Directive and SAPs, and often implemented through projects such as those funded by EU LIFE [7], are among the most important drivers of comeback for the species considered in this study. In fact, the implementation of the EU Birds Directive and more specifically the designation of protected areas (including Special Protection Areas, SPAs, as part of the Natura 2000 network in the EU), has been shown to benefit the conservation status of all species listed in Annex I of the Birds Directive (see 'Introduction') [8].

Conclusions

There is large variation in the increases shown by selected species of mammals and birds in population abundance, with some marked regional variation. Range change is likely to provide a less robust metric than abundance change, since there are underlying issues of spatial resolution of range maps over time.

The key drivers of comeback for both the mammal and bird species considered in this study were legal protection, especially from persecution, and targeted species-specific conservation effort, including reintroductions and other recovery management. For bird species, habitat management and site protection were also very frequently cited as factors that contribute to species recovery.

It is important to consider that the set of species included in this study consists of a selection of species that have recovered following considerable historical declines and most have not yet recovered to pre-decline levels. This is true also for many other species in Europe which are currently showing population and range increases. However, this comeback has to be set against other species which are still declining throughout Europe, indicating the limitations of current conservation strategies.

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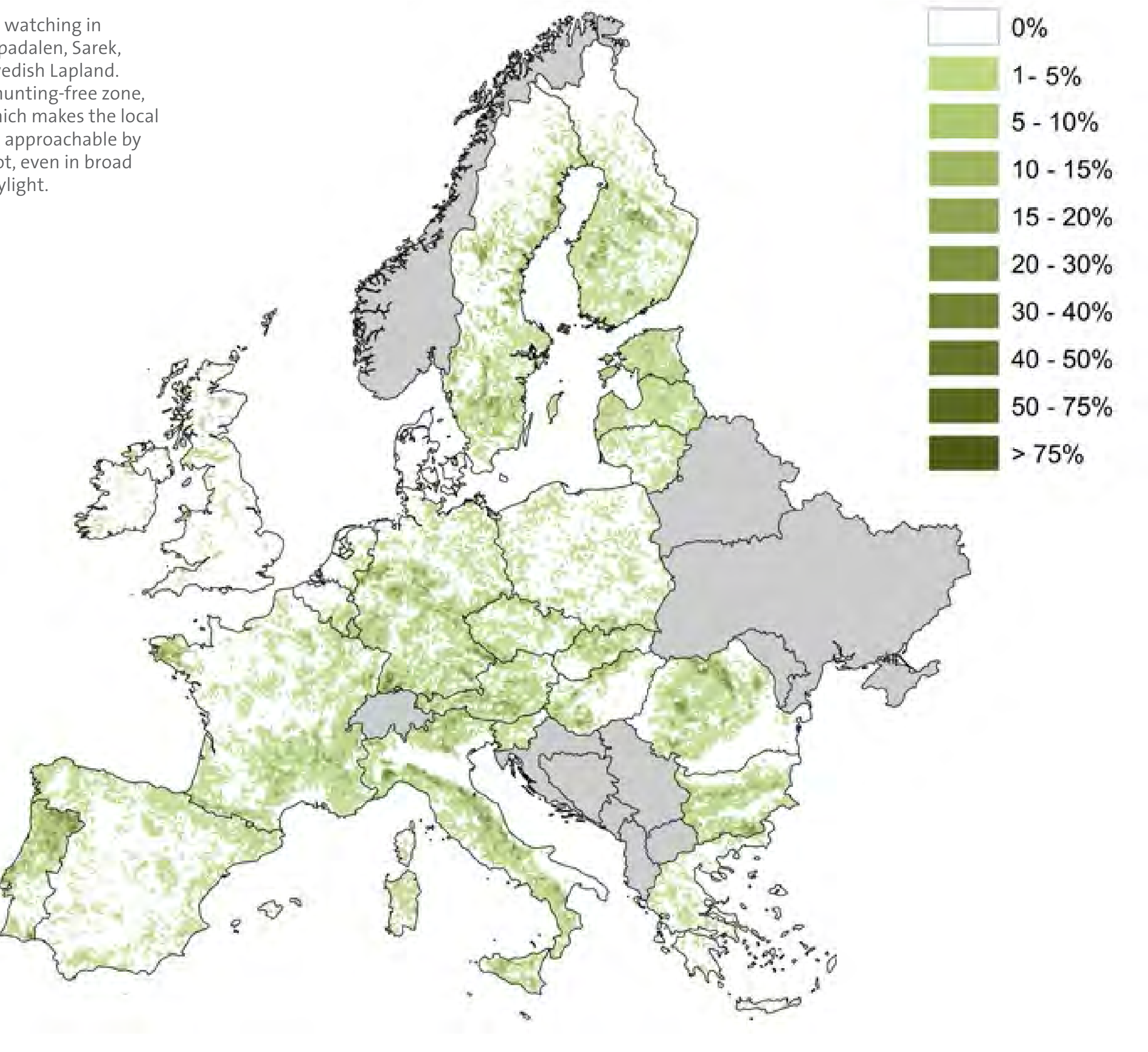
6. Reconnecting with nature

Opportunities of wildlife comeback in Europe

Against the backdrop of continuing biodiversity loss across the globe, and the ongoing population declines witnessed in a large number of European species, the recovery of a select number of mammal and bird species across Europe shows that conservation successes are possible where a number of factors combine to create opportunities for wildlife. These opportunities have arisen from a number of different reasons – primarily a reduction in threats to certain species, enforcement used against illegal killing, legal restrictions on hunting and conservation management practices such as species reintroductions where populations have declined. To a lesser extent some changes in land use, such as the current trend of agricultural land abandonment across Europe, have also contributed. This land can have value because of the wildlife it contains or for the provision of a suitable environment to allow wildlife to return to these abandoned areas of land benefitting both biodiversity and people (Figure 1 [1]).

Figure 1. Projected localisation of hotspots of abandonment and wildlife comeback in Europe. These hotspots are classified as 'agriculture' in 2000 and are projected to show wildlife comeback or become afforested by 2030 [1].

Elk watching in Rapadalen, Sarek, Swedish Lapland. A hunting-free zone, which makes the local elk approachable by foot, even in broad daylight.



The comeback of large and charismatic wildlife in Europe is set to increase people's interactions with wildlife in the remaining wildernesses of Europe and bring wildlife into increasingly close proximity to human-dominated landscapes. Human perceptions of wildlife are also shifting amongst the population. Despite an overall estrangement from the natural world, increased urbanisation and higher standards of living have caused a shift towards more favourable views of the intrinsic value of wildlife. For example, large mammals were seen as attractive species by respondents to a questionnaire survey conducted across sites in eight European countries [2].

Because of the widespread and substantial historical declines in European wildlife populations and ranges, the species comeback we are currently witnessing is resulting in levels of wildlife which may seem unprecedented. Wildlife comeback in the real world therefore creates new opportunities to interact and benefit from nature, but may also lead to challenges of reconciling human and wildlife interests on this densely populated continent. After all, it is a lack of reconciliation between human and wildlife interest that caused the dramatic declines of these recovery species in the past and continues to affect the overall status of both global and European biodiversity.

Here, we give an overview of the exciting opportunities wildlife comeback brings to people, and the main areas in which we need to reconcile wildlife comeback with human needs. Ultimately there is a lot to gain, as Europeans will get increasing opportunities to enjoy nature, and see and reconnect with wildlife again, in the near future.

Benefits and opportunities of wildlife comeback

In order for wildlife comeback to be successful, it needs to be widely acceptable to a number of stakeholders whose support will be gained by seeing the opportunities of such a process. This includes land managers, local communities, government and industry, who could all potentially have a vested interest in species comeback schemes. Recognising the opportunities in the form of ecological, economic and cultural benefits is one step towards that process.

Ecological and landscape benefits

The functioning of ecosystems and the services they provide relies on the processes and interactions between species assemblages. Consequently, changes in species composition can have knock-on effects on the ecosystems. There is growing evidence that the removal of predators from an ecosystem can have profound effects on species composition at all trophic levels [3] which suggests that the reintroduction of such species could reverse these changes and provide benefits to other taxa and the ecosystem as a whole. The reintroduction of Grey wolves (*Canis lupus*) into Yellowstone National Park after a 70-year absence has been found to elicit a trophic cascade effect by increasing predation pressure on the Elk (Wapiti) (*Cervus elaphus*) population. The reduction in Elk allowed for greater browse and fruit availability for the then threatened Grizzly bear (*Ursus arctos*) population for which an increased percentage consumption of fruit was observed after the wolf reintroduction. The decrease in herbivory by Elk could also be beneficial for other mammals, birds and pollinators[4].

Similarly, in Europe, control of the Red fox (*Vulpes vulpes*) and subsequent reduction in pressure on the Mountain hare (*Lepus timidus*) was observed when Eurasian lynx (*Lynx lynx*) populations recovered due to protection from hunting [5]. This theory has been examined in other areas of Europe where conflict is occurring in some forest systems due to increasing top-down effects of large numbers of herbivores on the vegetation [6]. The reintroduction of carnivores is put forward as one of the key solutions. Although hunting could be used for herbivore population control, research suggests that the presence of carnivores has additional indirect effects on ungulates through changes to the behaviour (avoiding high risk areas for predation), habitat selection and spatial distribution of prey which human management cannot replicate [6]. This is one of the ecological arguments for reintroducing Grey wolf and Eurasian lynx to Scotland, where Red deer (*Cervus elaphus*) have reached record levels [7] and are causing habitat damage [8]. Based on research from wolf reintroductions in North America, it is suggested that few wolves would be needed to see noticeable benefits to the ecosystem [9].

The reintroduction of species at other trophic levels can also provide ecological benefits such as creating suitable habitat for other species. Research on the effects of reintroduction of Eurasian beaver (*Castor fiber*) in Poland observed improvements in wetland condition – a culmination of a higher groundwater level, reduced erosion of stream banks, increased sediment flows and greater diversity of species suited to slow-moving waters [10]. The new wetland habitat and improvements to existing ones benefitted a large number of plant and animal species. However there was an increase in damage to human property as a result

Lodge owner Inga Sarri from Nikkaluokta, in Swedish Lapland. One of many countryside entrepreneurs who are developing nature tourism products. Wildlife plays a key role for many of them.

of this reintroduction, which is something that needs to be mitigated in order to maintain support from the local community [10].

The restoration of natural processes as a result of wildlife comeback such as herbivory, carnivory and scavenging can shape a landscape without people actively managing it. A self-supporting ecosystem can reduce land management costs. In terrestrial ecosystems of Europe, large herbivores such as the European bison (*Bison bonasus*), Aurochs (*Bos primigenius*) and Wild horse (*Equus ferus*) have historically performed key roles in maintaining structural diversity; subsequently, as populations became extirpated, agricultural practices and ecosystem management regimes became the primary replacement in the absence of these species. Whilst extant herbivores might not be able to exert a comparable influence on the environment as these larger species have done in the past, they still contribute to the functioning of ecosystems through processes such as grazing, browsing, defecation and trampling. This has relevance for abandoned agricultural land where succession would progress if unmanaged: by allowing the recolonisation of grazers, afforestation can be prevented and high species diversity of open habitats can be maintained [11] without the provision of grazing livestock. Furthermore, restoring ungulate populations has been suggested as a necessary intervention to maintain large predatory mammal species in sufficient numbers [12].

One important consideration is whether any areas can be left entirely alone or whether active management or some sort of human influence is always needed. In some cases, the lack of large herbivores in Europe means that a large perturbation such as fire is still necessary to open up habitat, thereby allowing the conditions for a self-sustaining system by ungulates. In addition, the fact that humans have shaped the landscape over such a long time in Europe can make it hard to determine the characteristics of natural conditions. For example, afforestation and the reintroduction of Red deer are management practices carried out on the Isle of Rum in Scotland. This focus on maintaining a single species in a forest community is not thought to be replicating historical natural conditions and has actually created an artefact that is not self-sustaining and that requires continuous human management intervention. This serves as a caution that focussing so narrowly can lose sight of the importance of restoring ecosystem processes as a whole which is of greater benefit to conservation in Europe [13].

A safari group in the Velebit mountains, Croatia, looking for Balkan chamois near the Paklenica National Park.

Economic benefits

Wildlife Watching

The importance of tourism for conservation has been illustrated in a study looking at globally threatened birds and how encouraging bird watching visits can generate money for protected areas, particularly for highly threatened species, and in developing countries [14]. This study suggested that protected area managers could also enhance their budgets by specifically promoting bird watching tourism, thereby providing much needed funding for threatened birds. In a similar way, the initial investment of bringing back other species in Europe could have a longer term conservation benefit not only for the species but for the ecosystem as a whole. Wildlife comeback can promote local and national tourism especially if there are some flagship species that can act as a draw to visitors. Worldwide, wildlife watching has been proven to be a very profitable activity, from which some of the revenues can be fed back into species and habitat management as discussed below.

Wildlife comeback has the potential to provide significant economic benefit at many scales, from benefitting local communities to contributing to a country's GDP. One of the ways this can be achieved is via an increase in incomes from wildlife watching opportunities and associated tourism, whether for bird watching or for the opportunity to see and photograph many rare or charismatic species. Income can be generated both directly from tours and accommodation costs and indirectly through purchasing products and services locally. Wildlife tourism can also provide employment opportunities as an alternative livelihood in rural areas where prospects are limited and unemployment is high.

Worldwide, the types of wildlife-related experiences and number of companies offering such activities have increased considerably in recent years [15]. For example, statistics related to whale watching reveal that the number of countries involved in whale watching (from 87 to 119), the number of tourists (from 9 to 13 million) and total expenditure (from $1 to 2.1 billion) have increased substantially between 1998 and 2008 [16]. Tourism growth has been particularly pronounced in many developing countries, with many areas that are hotspots for biodiversity experiencing over 100% increase in visitor numbers between 1990 and 2000 [17]. In regions such as East Africa, wildlife watching is responsible for the majority of income from tourism [15] and it is reasonable to infer that the draw of wildlife has been behind much of the increase in tourism in similar areas of high biodiversity. For example in South Africa where safari opportunities are a major attraction, tourism accounts for 7.7% of GDP [18] and in Namibia, the communal conservancy scheme implemented by the government has generated an increasing contribution to the national economy between 1990 and 2011 [19].

Other than direct payments in the form of entrance fees to national parks, costs for a tour guide and accommodation, indirect payments can also be important in supporting the local and national economy through the purchase of products and services from other sectors both by tourists and by residents whom the tourist income has benefitted [15]. Provided that certain measures are in place, the influx of visitors to view wildlife can provide economic relief to the often poor rural communities [15]. The TAMAR project in Brazil is one such enterprise which has achieved success in attracting tourists to visit marine turtle nesting sites, resulting in both socio-economic and conservation benefits [20]. The project incorporates the training and employment of local people, extending the benefits from visitors to the wider community, and implementing marine turtle research for conservation [15]. However meeting the demand of the tourist industry can often mean relying on foreign investment and in some cases, part of the economic benefit is appropriated to other countries [15].

In more developed regions, there has long been an interest in wildlife related activities and this sector is fairly well established. Preliminary findings in the USA suggest that hunting, fishing and wildlife watching for recreation accounted for 1% of national GDP in 2011 and such activities are considered pivotal for local and national economic growth [21]. Wildlife watching was the most popular activity, more popular than sport fishing and hunting combined. At the EU level, a 2011 study for the Commission estimated the economic value of the benefits provided by tourism, recreation and employment supported by Natura 2000, a network of nearly 26,000 protected sites in the EU. The study suggested that expenditure related to tourism and recreation supported by Natura 2000 sites was between €50 and €85 billion in 2006, supporting between 4.5 and 8 million full-time-equivalent jobs [22].

At the national level, there is a considerable economic opportunity for wildlife related activities with an existing and interested market. In the UK for example, over half of the adult population of England visit the natural environment at least once a week [23]. In Scotland, no less than 56% of all travel is nature oriented [24] and it is having clear economic benefits. Work commissioned by Scottish Natural Heritage estimated that total annual visitor spending attributable to nature-based tourism (including outdoor activities other than wildlife watching) is £1.4 billion with 39,000 associated full-time-equivalent jobs [25]. The opportunity for real economic benefits from wildlife resurgence, and the nature tourism that can be generated from that, seems to be realistic in several areas of Europe.

The presence of a key charismatic species can act as a great incentive for people to take part in wildlife watching and sometimes to pay a lot of money for the privilege. For instance, a permit to see the Mountain gorillas (*Gorilla beringei*) of the Virunga mountain range of Rwanda, Democratic Republic of Congo and Uganda costs each international tourist between $400 and $750 [26], which has the benefit of generating local and national revenue. In addition, the presence of regular visitors and monitoring is one of the reasons contributing towards the survival and potential recovery of this threatened population [27]. There are issues surrounding revenue-sharing amongst all stakeholders but whilst there are still challenges to be overcome [28], this example shows that there are individual species that provide enough of a draw to attract high numbers of visitors.

Similarly, the recovery of charismatic species in Europe could prove to be an economic opportunity as well as an ecological one. As the Abruzzo region of Italy started being marketed as bear and wolf country, due to recent resurgence in populations, the number of tourists to the area increased even though the likelihood of actually seeing any individuals of those species is still low [29]. The Brown bear (*Ursus arctos*) is also the flagship species for the Somiedo Natural Park in northern Spain and has attracted increasing numbers of tourists to the local area almost exclusively due to the use of the bear as a means for promoting tourism [30]. An assessment of wildlife watching in Finland suggests that the number of visitors increased by 90% between 2005 and 2008 with the majority of tourists drawn by the presence of predators such as Brown bear and Wolverine [31]. In economic terms, preliminary results estimated a turnover from this sector of €4–5 million in 2012 with wildlife watching and photography as the main reason for an estimated 73% of tourists who visited Finland [32]. In Cevennes National Park in France, the reintroduced Griffon (*Gyps fulvus*) and Cinereous vultures (*Aegypius monachus*) have provided new bird watching opportunities for tourists, attracting 80,000 visitors per year. It was also estimated that

The view from a bear watching hide in Suomussalmi, Finland. An experience of a lifetime.

after the establishment of feeding points in farms for the reintroduced vultures of Cevennes, their scavenging service rendered an annual saving of €440,000 on the disposal of dead livestock [33].

While in some cases, a single large charismatic species can prompt significant expenditure for the opportunity to view it, there are plenty of more affordable opportunities for wildlife watching. In the UK, the Royal Society for the Protection of Birds (RSPB) produced a report that looked at visitor spend and local economic impacts relating to several high profile bird species such as the White-tailed eagle (*Haliaeetus albicilla*), Osprey (*Pandion haliaetus*) and Red kite (*Milvus milvus*) [34]. Following reintroduction or recolonization, these three species have benefitted local economies through visitor numbers and associated revenue. The Osprey for example is thought to be the top bird species in the UK for tourism and brings in an estimated £3.5 million income a year to the watching sites and surrounding areas [34]. High profile species aside, bird watching as an activity itself can provide an important source of income. The RSPB's reserve network (206 reserves covering 142,044 hectares across the UK) supported nearly 2,000 jobs in 2009, with a contribution of over £65 million to local economies [35].

One challenge when considering the opportunities of wildlife watching is that while profitable, certain activities could prove detrimental to the very species the tourists have paid to see. The activity could prove counterproductive if human disturbance affects the species behaviour. There is concern that with a rise in whale watching tourism, the animals themselves could be negatively affected by disturbance [36] highlighting the need for regulation of such activity [37]. Other impacts could be deleterious to wildlife health. Despite the clear economic opportunity from tourism (a Figure of $20 million per annum has been estimated as revenue generated directly and indirectly through gorilla-related tourism [38]), there have been concerns over health risks to gorillas and recommendations on keeping a certain distance away to minimise the risks [39]. In order for wildlife watching to be sustainable, the wellbeing of the wildlife must be valued alongside the benefits to tourism.

Revenue generation from wildlife tourism is complicated to calculate precisely as it can come from both direct and indirect sources, so estimations based on direct expenditure is likely to be a minimum estimate of actual monetary value [15]. Nevertheless the initial findings from the few examples presented here strongly support the opportunity of economic benefits that wildlife comeback could create. In order to ensure local communities are engaged with these schemes, there is a need to link the benefits from wildlife watching to rural development. For example, the attraction of wildlife can be used to market traditional products in the area, especially those areas where there can be substantial conflict between wildlife and the interests of locals (e.g. agriculture). Direct marketing to wildlife tourists and using charismatic species to brand products can become a way of reducing conflict particularly when the species or the visitors it draws lack local support.

Hunting and fishing

Compared to other interest groups, hunters will have a lot – maybe even the most – to gain from increased wildlife numbers in Europe. There will simply be more wildlife in Europe to hunt – more species and higher densities of them. If done sustainably, hunting could become part of a new local economy around areas that are seeing a wildlife comeback.

The Community Conservancies of Namibia is one particularly interesting example of how hunting combined with wildlife tourism can be very beneficial for wildlife comeback. The devolution of rights to wildlife and wildlife benefits from the state to communities and other landowners in the 1970s has led to a significant increase and range expansion of wildlife, a positive shift in local attitudes to wildlife, a drop in poaching, increased large landscape connectivity, local income and employment [40]. In the build-up phase of wildlife numbers, hunting revenues played a crucial role before tourism benefits could be realised. Such experiences could be tried and applied in Europe as well.

Angling and hunting already provide key income in Europe: 25 million anglers spend about € 25 billion every year [41] whilst the annual expenditure of 7 million hunters amounts to € 16 billion [42]. Hunting tourism has been put forward as a way of diversifying the local economy in rural areas of northern Sweden [43]. Attitudes towards hunting were mixed, but those that responded positively advocated the importance of hunting to maintain economic, social and cultural values [43]. However, hunting tourism is not necessarily conducive to visitors who want to watch wildlife. Widespread hunting often generates avoidance behaviour in

Wildlife watching hide being built in the Eastern Rhodope mountains in Bulgaria. The main attractions here will be Black vulture, jackal and wolf.

species [44] [45] and if animals become unnaturally shy there could be less opportunity for developing wildlife watching tourism. This calls for proactive management policies such as zoning to designate separate areas for hunting and core areas of strict protection for wildlife observation.

Certification

A final economic opportunity that can arise from wildlife comeback is the potential for certification of products, which in turn will improve their marketing. Many different types of product labelling and certification schemes claim to provide benefits for certain species or ecosystems and it is becoming a popular avenue to attract market-based funding for wildlife conservation [46]. In Europe, it has been offered as one of the approaches to managing the population of Brown bear in Croatia, by marketing local products as 'bear friendly' which could have the combined benefit of generating more income to areas where bears are present and also reduce possible conflict by giving local people an incentive to support the presence of the bears [47]. In Spain, a company is marketing 'bird friendly' organic food products from the Ebro delta with the dual mission of contributing to the conservation of unique European species and ecosystems and promoting the socio-economic development of rural areas [48].

Given the benefits that are manifest both within Europe and around the world, the potential economic opportunities that wildlife comeback can provide are quite compelling. Although some of the economic evaluations are often preliminary and attributing income from specific sites or activities can be difficult, general indications are that with a good management plan in place, communities from local to national could benefit financially from wildlife comeback. The value of nature tourism to people is not just monetary, but can be beneficial in terms of health and well-being, and can have positive cultural impacts.

Cultural and societal benefits

Wildlife plays a large part in human culture, from folklore to hunting activities, and this cultural benefit is recognised as one of the ecosystem services derived from biodiversity [49]. The relationship between human culture and ecosystems as a whole is dynamic, both strongly influencing the other. As humans have always shaped the environment in which they live, so environmental change can affect cultural identity and social stability [49].

The importance of natural heritage for people has been recognised both nationally in some countries e.g. the National Trust in the UK [50] and internationally e.g. the World Heritage Convention [51]. In Europe, the European Landscape Convention was established in 2000 to identify and protect landscapes that are important to people and incorporates the aspirations of the public into the management, planning and protection of the landscape [52]. Given the recognition at a policy level of how important nature is to people, there is potential for political backing of wildlife resurgence, particularly in regions where wildlife is closely embedded in human culture. In this way wildlife comeback could offer the opportunity to contribute to the conservation of both the natural and cultural heritage of Europe.

Evidence for the human fascination with wildlife has been demonstrated since the time of prehistoric cave paintings. In modern times, much of the connection with nature has changed but has not been altogether lost. The Grey wolf is one such species that is firmly embedded in human culture from the ancestral link to the domestic dog to literary depictions across Europe, North America and Asia [53], both historical and contemporary [54]. With the resurgence of certain species such as the wolf in Europe, there is the opportunity to maintain and re-establish these cultural links to the past and to attract visitors to reconnect with these cultural emblems.

Other societal benefits from having access to nature, aside from direct revenue generation (see above), is the contribution nature makes to physical and mental health and the enhancement of educational opportunities [48]. Nearly 30 case studies from across the EU demonstrate the many opportunities that thriving wildlife can bring even on a very local scale, emphasising the importance of integrating nature conservation into EU policies [48].

Reaping the benefits of wildlife comeback: reconnecting human and wildlife needs on a densely population continent

In order to fully reap the benefits of wildlife comeback, we need to learn lessons from the causes of past declines and reasons for recovery, both for the continued well-being of comeback species and to create positive conservation outcomes for other species. As we have seen in this report, legal protection and conservation management of species in conjunction with effective policy frameworks, education, communication and participatory approaches to species management are mechanisms to help us reconnect with wildlife and create conservation success stories against the backdrop of biodiversity loss [55].

Developing the policy framework for wildlife comeback

Wildlife comeback in Europe, although limited to only a few species at present, is directly relevant to national, EU and other multilateral targets for nature conservation. Under the Strategic Goal C, signatories to the Convention on Biological Diversity Aichi Targets are required *to improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity* [56]. Any wildlife comeback directly contributes towards this target. Similarly, there are other international biodiversity agreements relevant to a European context [e.g. the Convention on Migratory Species (CMS)] to which signatories have to adhere (see below). At the EU level, schemes to restore wildlife populations apply to two of the six targets of the EU biodiversity strategy for 2020 [57]. The first relevant target is to fully implement the Birds and Habitats Directive by improving the conservation status of species and habitats listed, which the recovery of depleted populations contributes towards. Under the Birds Directive, for example, action plans are in place for around 50 species which have been identified as priorities for funding, such as the Egyptian vulture (*Neophron percnopterus*) [58]. Likewise, the second relevant target aims to restore at least 15% of degraded ecosystems, and could be supported by restoring abandoned lands.

Since 1961, there has been a 28% decline in the human population in rural Europe, a trend that is particularly pronounced in Eastern Europe (41% decline in rural population since 1961; [59]). Socio-economic and demographic factors are principal drivers of rural depopulation [1], although agricultural intensification under the European Union's Common Agricultural Policy (CAP) has contributed to a trend of abandoning less productive and economically less viable areas in favour of intensive farming of highly productive areas; this trend is set to continue with the ascension of eastern and central European countries to the Union [60]. Land abandonment of this kind has been linked to population recovery in some species (e.g. Roe deer, Eurasian elk, Iberian ibex, Wild boar in this report), but has also been implicated in the observed 53% decline in farmland birds across Europe since 1980 [61] (Figure 2), a reduction attributed to agricultural intensification and loss of open and heterogeneous habitat [62, 63]. At a regional level, bird species in the northwestern Mediterranean Basin responded differently to land abandonment

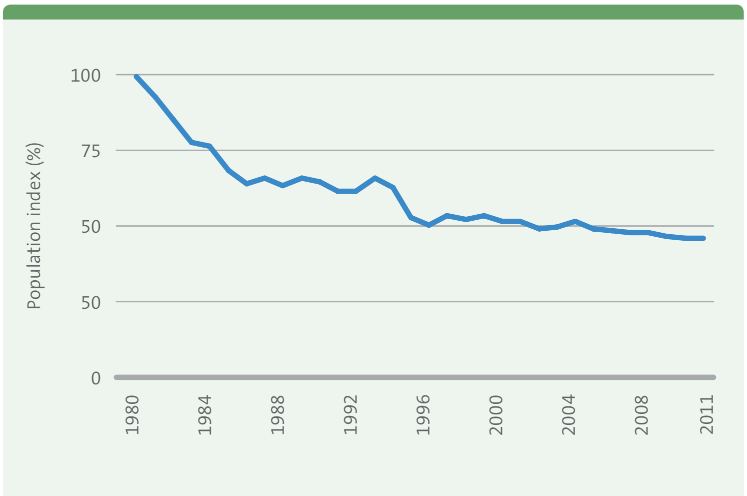


Figure 2. The Farmland Bird Index, developed by the Pan-European Common Bird Monitoring Scheme (PECBMS) (EBCC/RSPB/BirdLife/Statistics Netherlands), shows a continuing decline in common farmland birds in Europe.

depending on habitat preference: communities were found to be altered, with positive results for woodland species overall and declines observed for farmland species [64]. Similarly, the long-term conservation goals for the Apennine yellow bellied toad (*Bombina variegata pachypus*) could be compromised in the face of land abandonment in northern Italy, due to the importance of agricultural activities in providing suitable habitat for the species [65].

The comeback of the European otter (*Lutra lutra*) in the Czech Republic provides an example of how land use change can provide conservation benefits: the species benefited from the restoration of freshwater habitats after a reduction in intensive agricultural area [66]. Land abandonment therefore has the potential to provide opportunity for wildlife comeback but it is not always a universal positive outcome for all species. Specific responses to habitat change will depend on the nature and extent of that change and on the ability of individual species to adapt to different conditions, so it has been suggested that for the purposes of policy regarding agricultural land abandonment, a tailored approach should be taken to apply zoning or at least to ensure that the context of each area is taken into consideration within plans for regional reforms [67].

Worldwide, traditional agricultural landscapes have high cultural value, and this is reflected in the 29 traditional agricultural landscapes currently listed as UNESCO World Heritage Sites [1, 68]. Because of their cultural and biodiversity importance (e.g. for farmland species [69], conservation of traditional and low-intensity farming systems, known as High Nature Value (HNV) farmland, has been actively promoted [70]. Roughly 15–25 % of the European countryside qualifies as HNV farmland [71], while 63 of the 231 habitat types in the EU Habitats Directive depend on agricultural practices [72]. Much of

One of the challenges around increased populations of large animals is the danger of more traffic accidents. There are ways to handle this through fencing and wildlife overpasses/bridges.

the current conservation focus is therefore on protecting low-intensity farming systems for the benefit of common farmland species, while land abandonment could instead promote the return of other wildlife, such as the species illustrated in this report, which were abundant prior to agricultural intensification.

The comeback of large predators and the persistence of HNV farmland are difficult to reconcile. For example, the return of the Grey wolf in France has been relatively difficult compared to Italy: in France, wolf recovery takes place amidst extensive agricultural activity with large flocks of sheep grazing in summer pastures [73], while in other areas, such as the Apennines of Italy, land abandonment and a decrease in rural population has created space for returning wolves [74, 75]. On the one hand, there is a need for policies which encourage the return of wildlife species which were once numerous across Europe in forests and natural open and semi-open landscapes. On the other hand, many current policies seek to maintain low intensity agricultural landscapes which benefit those species which have come to dominate our agricultural landscapes since. However, one dimension that has not yet been investigated in Europe is to what extent non-managed, open areas can match the HNV farmland in terms of biodiversity value. For example, grasslands used to be vital landscape elements across Europe [76], so that species now considered as farmland species may have originally developed in older open and semi-open landscapes of Europe. Substitution of livestock by wild herbivores on recently abandoned farmland may thus provide opportunities for these species.

Providing space for returning wildlife

Europe's large and charismatic species often require significant amounts of space. Effective conservation of many species of wildlife therefore requires implementation of recovery strategies over large areas and cooperation between several countries and administrative regions across which populations roam. For example, mean home range size of male Brown bears can exceed 1,000 km^2, while male Wolverines (*Gulo gulo*) may range over areas in excess of 600 km^2 [77]. Purple herons (*Ardea purpurea*) often feed at distances of up to 15–20 km from their colony [78, 79], giving rise to home ranges of more than 700 km^2. Wolf packs also range over large distances (>600 km^2 [77]) and often cross borders [80].

Given that protected areas contribute to species recovery (e.g. Grey seal, Northern and Southern chamois, Iberian lynx accounts in this report), it is important that the protected area network provides significant amounts of space and connectivity to aid wildlife comeback. The existing network of Natura 2000 sites and protected areas provides important refuge and core habitat for a number of species in some regions (e.g. Grey wolf in the Alps [81]), yet the current management may be inadequate on its own for other species (e.g. steppe birds in Spain [82]). It also needs to take into account the needs of seasonal migrants, e.g. ungulates which move from higher to lower altitude in winter because of better food availability and climate [83–85]. There is a clear need to assess the effectiveness of the current protected area network under scenarios of future wildlife comeback and land abandonment in order to address gaps in the network and connectivity issues which would limit range expansion of returning wildlife, including the design of permeable landscapes for improved 'green infrastructure'. Re-connecting habitats also requires measures such as the construction of underpasses and bridges (or 'ecoducts') across roads and railways to ensure safe passage of wildlife while minimising traffic collisions (e.g. via fencing [86]).

Spatial considerations become even more of an issue for species that cross country borders, requiring the establishment of trans-boundary management plans. Europe is home to many migratory species, providing the breeding, wintering and/or passage parts of their range, and much effort is being devoted to disentangle the drivers of population change in these species [87–89]. This has often expanded the spatial scale at which to consider effective recovery strategies to include areas outside Europe. International agreements on the protection of migratory species have been drawn up under the auspices of the Convention on Migratory Species (CMS), for example the African-Eurasian Waterbird Agreement [90] in response to patterns of sustained and often severe declines in many Palaearctic–African migrants [91]. European species such as the Black-tailed godwit (*Limosa limosa*) have been listed as a species for conservation action as part of this agreement [92]. Within Europe, the middle-European population of the Great bustard (*Otis tarda*) has been the focus of a multi-country memorandum of understanding to protect the species [93]. Many cetaceans migrate across European waters [e.g. the Wadden Sea populations of Common (*Phoca vitulina*) and

Part of the crew from the private nature reserve Faia Brava in Portugal. Here, land abandonment is being transformed from a huge problem into an opportunity.

Box 1. Return and urbanization of wildlife: a disease risk?

Wildlife, livestock, inadequate biosecurity and poor animal husbandry have been increasingly implicated as a major contributor to disease in wildlife, livestock and humans worldwide [1–3]. The implications of this are currently seen in the case of Badgers, cattle and bovine tuberculosis in the UK: culling of Badgers is currently underway in two trial areas to reduce TB in cattle [4], despite protests and an ongoing controversy about the scientific evidence for the effectiveness of a cull on reducing TB incidence, the humaneness of the approach and its legality given European wildlife legislation [5–7]. Similarly, there is growing concern about the introduction of highly pathogenic disease from livestock into wildlife populations, such as the transmission of highly virulent strains of avian influenza from farmed to wild birds, and issues of disease in wild meat consumption [8].

Return of wildlife to vast tracts of land which are managed for livestock production is likely to increase the scope for direct and indirect disease transmission between wildlife and livestock, since many diseases are able to infect multiple species [9]. Wildlife also plays a role in providing a reservoir for disease vectors. For example, both Lyme's disease and tick-borne encephalitis have relatively high prevalence in Central Europe [10, 11]. Areas with high deer density are generally also considered high-risk areas for these tick-borne diseases [12], although climatic effects are also implicated in the northward expansion of diseases such as tick-borne encephalitis [11]. In Sweden, for example, the spread of the disease due to climatic factors is likely to have been compounded by the marked increase in Roe deer numbers since the 1980s [13]. Also, in Denmark, density of Roe deer and incidence of neurological manifestations of Lyme's disease are correlated in both space and time [14].

Some species have the capacity to use altered habitats and food sources created by humans and adapt their behaviour to new environments and pressures [15]. As a result, urban wildlife populations have been on the increase, such as Gulls, Foxes, Badgers, Wild boar, Deer, etc. and conflicts have started to emerge [16–19]. Urban wildlife populations are likely to increase further, and apart from structural damage to human property, this has also raised the issue of zoonotic disease spread in urban environments (e.g. leptospirosis in urban Wild boar [20]; alveolar echinococcosis in urban foxes [21, 22]) so that effective disease surveillance and education on disease prevention is necessary to avoid spread of zoonoses.

However, it has also been suggested that declines in biodiversity will cause an increase in disease transmission and number of emerging disease events. West Nile Virus primarily replicates in birds, but is transmitted via mosquitos to mammals including humans, with recent zoonotic outbreaks of the disease in parts of the eastern USA. Recent research found that incidence of West Nile Virus in humans was lower where bird diversity was higher [23]. Therefore, despite the possibility that biodiversity may serve as a source for disease, current evidence overall suggests that preserving intact, naturally functioning ecosystems and associated biodiversity should generally reduce the prevalence of infectious diseases [24].

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Grey seals (*Halichoerus grypus*)] and many bat species migrate large distances across Europe, and international agreements have been signed to ensure their protection [94–97].

Trans-national efforts have been initiated to establish a viable metapopulation network via reintroductions for some depleted populations [e.g. Bearded vulture (*Gypaetus barbatus*) [98]]. Where species are wide-ranging, reintroductions in one country and subsequent dispersal of individuals can lead to human-wildlife conflict in another. In these cases, successful wildlife comeback relies on the concerted effort of range states to protect existing populations whilst allowing expansions into new territories. There is also a need for a trans-national strategy to deal with damage caused by wildlife in order for countries to equally share the benefits and costs of wildlife comeback. A prominent example and worldwide media event, bear JJ1, popularly called "Bruno" – reintroduced into the Italian Alps and subsequently dispersing to Austria and Germany, thus becoming the first Brown bear recorded in Germany since 1835 – was shot in Bavaria, Germany, in May 2006 following reports of livestock predation [99]. The incident led to discussions on how to manage bears at the trans-boundary level [100]. In efforts to develop trans-boundary wildlife conservation and management plan, it is important to remember legal obligations imposed by international and European nature conservation legislation, such as laid out in the Bern Convention and EU Birds and Habitats Directives [101].

Dealing with wildlife damage

As recovering species are set to come into closer contact with humans, their settlements, livestock and crops, it is inevitable that wildlife will cause some damage (see also Box 1). In the past this has led to high levels of persecution of the implicated wildlife, causing historical population declines and at present slowing the restoration of some species of wildlife, particularly large carnivores, across Europe [102, 103]. It is important that we learn from past and present experiences to select the most appropriate measures to ensure that wildlife and humans can co-exist across Europe.

Predation of livestock by large carnivores is most often a symptom of depleted populations of natural prey. For example, in some parts of its range where wild prey abundance is low and livestock is abundant, wolves primarily or almost exclusively feed on livestock [e.g. Northern Portugal [104], Greece (Table 1)]. However, in areas of high wild prey abundance and low livestock numbers, livestock may make up only a small percentage of prey biomass of wolves (e.g. around 1% in central and western Poland; [105] and 3% in the western Carpathians of southern Poland [106]; Table 1). Encouraging increases in prey species in conjunction with those of large predators is therefore paramount to establish natural predator-prey systems across Europe. In central Europe, Eurasian lynx are implicated in conflict with humans less often than larger carnivores [107], probably because they generally prey on smaller species, such as lagomorphs, rather than intensively farmed livestock (Table 1). On the other hand, high levels of predation on Reindeer make the lynx the most costly of all predators in Scandinavia (Table 1). Other prominent examples of predation on livestock or game are Hen harriers (*Circus cyaneus*) preying on Red grouse (*Lagopus lagopus scotica*) in Scotland, and Red kites on rabbits (*Oryctolagus cuniculus*) in Spain, creating conflict between conservationists and hunters [108, 109]. Otters, Grey herons (*Ardea cinerea*) and Great cormorants (*Phalacrocorax carbo*) have affected stocks on unprotected fish farms [110–112], and depredation of apiaries is a prominent source of conflict with bears [113] (Table 1).

Herbivory by large ungulates shapes the composition of plant communities and *vice versa* [117, 118]. Large ungulates are therefore an integral part of natural European landscapes. However, where they occur at high densities, damage to agricultural crops by ungulates or waterfowl by far exceeds damage from livestock predation. For example, the level of agricultural damage caused by wildlife [(mainly Wild boar (*Sus scrofa*)] in Arezzo province, Italy, was seven times higher than the mean annual value of wolf compensation payments [119]. Large herbivores can cause damage to crops via grazing and browsing, but also via trampling and alteration of environmental factors such as nutrients and light [120–122]. Grazing and browsing can also damage commercial forestry and regeneration of trees of conservation importance [123, 124], however, the relationships between herbivore densities, tree species composition and damage are often complex [125–127]. Even higher are compensation costs incurred for crop damage by geese, e.g. in the Netherlands, where on average €7 million is spent as crop damage money annually, with an additional €8–10 million spent as compensation money for farmers compared to less than €1 million per year for crop damage and compensation for mammal species (2008–2012 [128]).

Preventing conflicts between humans and wildlife altogether presents the most difficult challenge, effectively requiring a reduction in the spatial overlap between wildlife and human interests (e.g. via zoning of protected areas for different activity levels, including core protection zones [129], as in UNESCO biosphere reserves [130]). Establishment of core protection zones presents a

Table 1. Livestock damage by mammalian carnivores in Europe. For Brown bear, Eurasian lynx and Grey wolf, only the three most important populations were considered; *no more recent information available; ** estimated; reindeer and deer numbers are for semi-domestic and farmed stock only.

Brown bear *Ursus arctos* [114, 115]

Population/ country	Damage to	Period	Cases (per period)	Cost (per period)	Compensation scheme
Carpathian (excl. Ukraine):					
Poland	Beehives, livestock	2007–2010	<1,200 cases (mainly hives)	€119,565	Yes
Romania	Orchards, livestock	1987–1992*	No information	€54 million	Yes
Serbia	Beehives, orchards, livestock	–	No information	No information	Yes
Slovakia	Beehives, livestock	Annual	160 sheep/goats, 200 hives, 15 cattle	€20,000	Unknown
Scandinavian:					
Finland	Beehives, livestock, game	Annual	681 reindeer, 100 sheep, 250 hives, <10 other livestock	€922,700 total, mainly for reindeer	Yes
Norway	Livestock, reindeer	Annual max	7,000 sheep, 75 reindeer	€2 million (sheep), €35,000 (reindeer)	Yes
Sweden	Beehives, livestock, reindeer	Annual	100 sheep, 500 hives, 25 other livestock	€30,000	Yes + incentive payments of €190k to reindeer owners
Dinaric-Pindos:					
Albania	Agriculture, orchard, beehives, livestock	-	Unknown	Unknown	No
Austria	Beehives, livestock, game	Annual max	100 sheep/goats, 2 cattle, 30 beehives	No information	Yes, voluntary (hives, livestock)
Bosnia & Herzegovina	Beehives, orchard, livestock	Annual	42 sheep, 23 hives, 20, cattle/horse/pig, 5 orchards	No information	Yes
Croatia	Beehives, orchard, livestock (rarely)	Annual	32 cases	€6,000	Yes
Greece	Beehives, livestock	Annual	200 sheep/goats, 220 cattle/horses, 535 hives	€141,000	Yes
Italy (Alps)	Beehives, livestock	Annual	No information	€48,000 total, more than half for hives	Yes
Macedonia	Beehives, livestock	2007	167 large livestock, 53 sheep/goats, 152 hives	No information	Unknown
Slovenia	Agriculture, beehives, livestock	Annual	521 cases	€156,000	Yes

Eurasian lynx *Lynx lynx* [114, 115]

Population/ country	Damage to	Period	Cases (per period)	Cost (per period)	Compensation scheme
Carpathian (excl. Ukraine):					
Czech Republic	Livestock	–	No information	No information	Yes
Poland	Livestock (rarely)	Annual	1–2 cases	Negligible	Yes
Romania	No information	–	No information	No information	Yes
Serbia	Livestock (rarely)	Annual	Negligible	Negligible	N/A
Slovakia	Livestock	2010	14 sheep/goats, 1 cattle	<€2,000 registered, but not compensated	Losses registered, but compensation requires prevention
Scandinavian:					
Finland	Livestock, reindeer, game	2011	554 reindeer, 25 other livestock	€843,000	Yes
Norway	Livestock, reindeer	Annual	10,000 sheep, 8,000 reindeer	€6,300,000	Yes

Population/ country	Damage to	Period	Cases (per period)	Cost (per period)	Compensation scheme
Sweden	Livestock, reindeer, game	Annual	40,000 reindeer**, 150 sheep	€25,000 sheep	Yes + €3.5 million incentive payments for reindeer herders
Baltic:					
Estonia	Game, livestock (rarely)	2011	20 cases	€2,000	Yes
Latvia	Game, livestock (rarely)	Annual	1–3 sheep & rabbits	No costs to date	N/A
Lithuania	No depredation registered	N/A	No depredation registered	No costs to date	N/A

Iberian lynx *Lynx pardinus* [116]

Spain (possibly Portugal)	Livestock	2006–2012	716 kills in 40 attacks (78% of attacks on poultry)	€3,985 poultry €4,380 lambs	Yes, replacement & fencing improvement

Grey wolf *Canis lupus* [114, 115]

Carpathian (excl. Ukraine):					
Czech Republic	Livestock	Annual	10 sheep/goats, 1 cattle	€1,800	Yes
Poland	Livestock, game	Annual max	1,200 animals, mainly sheep/goats	€94,900	Yes
Romania	Livestock	–	No information	No information	Yes
Serbia	Livestock, game	–	No information	No information	No
Slovakia	Livestock	2010	500 livestock	€16,000	Yes
Dinaric-Pindos:					
Albania	Livestock, dogs	–	Unknown	Unknown	No
Austria	Livestock, game	2009–2011	102 sheep (+90 missing), 3 calves	No information	Yes, voluntary
Bosnia & Herzegovina	Livestock	2011	400 cases	No information	Unknown
Croatia	Livestock, dogs, game	2010	1,777 livestock	€194,000	Yes (livestock only)
Greece	Livestock	2006–2009 average	32,000 sheep/goats, 2,000 cattle, 2,000 horses/donkeys	€1,500,000	Yes
Italy (Alps)	Livestock	2011	383 cases, mostly sheep/goats	€92,656	Yes
Macedonia	No information	–	No information	No information	No
Slovenia	Livestock	2007–2011 average	453 cases	€269,000	
Iberia:					
Portugal	Livestock	2010	2,497 cases	€763,858	Yes
Spain	Livestock	Annual	Unknown	€2,000,000**	Yes

Wolverine *Gulo gulo* [114, 115]

Finland	Reindeer	Annual	2,500 cases	Unknown	
Norway	Livestock, reindeer	Annual max	Unknown	€5,000,000	
Sweden	Reindeer	Annual max	Unknown	€2,500,000	

key tool for wildlife population increase. Conflicts may be caused by the movement of wildlife into adjoining human-inhabited areas (e.g. Brown bear in Slovenia and Wolverine in Norway [129]), but these can be offset by opportunities for wildlife viewing and hunting (see above). On a local scale, exclusion or deterrence of wildlife can be highly effective. For example, electric fencing has been used to exclude bears from apiaries and small crop plantations [114, 131, 132], keep wolves and lynx out of sheep grazing fields [114] and mitigate crop damage [133, 134].

In areas where wildlife never really disappeared, traditional agricultural systems have persisted which provide techniques for limiting livestock or crop damage. For example, in the Carpathians and parts of Italy, a long period of coexistence between humans and large carnivores has allowed both parties to coevolve by means of reciprocal ecological and behavioural adjustments [135]. For example, guarding of livestock by dogs decreases the incidence of livestock depredation [136, 137], and employing local knowledge to avoid high-risk areas and confining livestock at night can also be highly effective [137]. Advocating and employing traditional techniques in areas where wildlife has recently returned may provide an effective tool for minimising wildlife damage.

Compensation schemes [138] are frequently used to offset livestock losses caused by predators, such as wolf, bear, lynx, and raptors [139, 140] (Table 1), and crop damage caused by large herbivores, cranes, ducks and geese [141, 142]. Where the relevant wildlife species is not of conservation concern, occurs at higher densities or over a much larger area, and crop damage is more extensive, compensation schemes are likely to prove too costly and controlling population densities by culling or regulated hunting becomes the primary route for minimising conflict [143]. However, willingness to pay for compensation schemes is likely to be influenced by a country's wealth and demography (e.g. large sums of money spent on damage compensation schemes in the Netherlands [128]).

The main shortcoming of compensation schemes is that they only address the outcome of human-wildlife conflict, though in some cases it is difficult to prevent or even minimise conflicts in the first place (e.g. geese in grasslands). As a result, they are often costly and unsustainable in the long run, or their cost-effectiveness is affected by the intensity of the livestock regime (e.g. compensation may work in intensively farmed livestock systems, but not in extensively farmed ones [116]). They also often fail at creating positive attitudes towards wildlife [144], yet are preferable to having no system in place at all. Stewardship schemes provide ideal participatory approaches whereby people benefit from having a healthy wildlife population, rather than receiving compensation when damage has happened. It is vital that we learn from experiences worldwide to devise the most appropriate schemes which allow coexistence of wildlife and people, and open up opportunities for local people to benefit from the presence of wildlife.

Humans as part of nature: understanding attitudes and establishing participatory approaches in managing wildlife comeback

People are an integral part in many European landscapes and often come into conflict with wildlife. Sometimes these conflicts can be a manifestation of opposing interests between different stakeholders [145], but commonly they are related to existing attitudes, culture, demography, feelings and levels of knowledge of the populace. Understanding the social and economic issues involved in human-wildlife conflicts, as well as the cultural and historical background, is therefore of utmost importance to develop a sound understanding of the processes that form people's attitudes towards wildlife [146, 147].

Worldwide, landscapes not only have a biological carrying capacity to support returning wildlife, but also a social carrying capacity affected by emotions, attitudes and knowledge of people, such as the abundance of wildlife which is tolerated by the local inhabitants [47]. Understanding attitudes, beliefs and behaviours towards wildlife is vital in increasing cooperation and helping parties to reach an optimal agreement or compromise in a participatory approach and ultimately may make the difference between a successful or unsuccessful conservation programme [148]. The level of exposure and distance to returning wildlife has a direct bearing on attitudes within the human population [149]. For example, attitudes of urban citizens towards wolf comeback are generally positive as opposed to more negative attitudes held by rural inhabitants [74, 150]. In Sweden, negative attitudes are stronger in areas with wolf populations than elsewhere [149, 151]. Impact of wildlife on personal income is also important in shaping perceptions: in Central Asia, local communities primarily relying on cash crops were more tolerant towards Snow leopards (*Uncia uncia*) than those relying on livestock [152]. In Poland, carp losses to otters were perceived as higher by private owners than by managers of state-owned fisheries [153]. However, in many cases negative attitudes are held

Wild boar family in central Berlin, Germany. Berlin city has about 4,000 wild boar living within the city limits.

by specific special interest groups in direct conflict with wildlife, e.g. hunters and farmers, and are not a reflection of attitudes of rural populations as a whole. For example, hunters of wolf prey showed more negative attitude towards predators such as wolves than the non-hunting public [151].

Since wildlife comeback is a relatively recent phenomenon in Europe, it is important to learn from experiences around the world on how to create participatory approaches. In the cases of large predators, empowerment of the local community to deal with wildlife conflict directly is vital. For example, prior to wolf reintroduction in northwestern USA, empowerment of local landowners and livestock producers was achieved by legalising active management of problem wolves, including harassment and shooting on sight of wolves attacking livestock on private land [154]. Finding consensus and acceptance of methods to limit human-wildlife conflict is vital in order to avoid wildlife losses through illegal control via poaching and poisoning which has been highlighted as a particular problem to mammalian carnivores [103] and raptors, such as vultures, eagles and the Red kite [155, 156]. However, in most cases, the costs of non-lethal control methods are directly borne by the livestock or crop producers [137], making it even more important that these stakeholders are actively involved in the management process and reap the benefits of returning wildlife [137].

Similarly, participatory approaches dealing with species of conservation concern provide interesting lessons to ensure local participation in mitigating potentially negative interactions with wildlife. For example, in Kenya, the Living with Lions project and local communities developed the Lion Guardians program (www.lionguardians.org), in collaboration with the Maasailand Preservation Trust in order to curb the increasing levels of African lion (*Panthera leo*) killings [157]. The project blends the demands of wildlife conservation with those of local culture, drawing on the complex relationship between Maasai and lions. Duties of lion guardians include monitoring of lion movements to warn pastoralists when lions are in the area, recovery of lost livestock, and intervention to stop lion hunting in the communities [158]. Drawing on the cultural importance of many of our European species, such as the Grey wolf, can help to develop approaches which combine inherent wildlife values with cultural values, thus finding common ground between wildlife and human needs.

Some of the over 500,000 visitors at the Wild Wonders of Europe outdoor exhibition in Stockholm during the summer of 2013. In Berlin 2012, it had almost a million visitors.

Other participatory and incentive-based programmes exist for dealing with predation by Snow leopards in India and Mongolia, combining livestock insurance schemes with active guarding of herds, and devising payoffs for not poaching Snow leopards, with implementation being overseen by the local communities (India) or protected area administration and environmental officers (Mongolia) [159]. Similar incentive payment schemes exist in Europe, for example payments to reindeer herders to live alongside large carnivores (Table x.1).

Participatory approaches have also been employed to devise management plans for European wildlife and create benefits for local communities (e.g. Brown bears in Croatia [47]), although it has been noted that wildlife and protected area management decision-making often takes a top-down approach within a European setting (e.g. Germany [160]). Superceding of local or regional wildlife management plans by supranational (e.g. EU) conservation objectives and policies can lead to resentment amongst local communities who feel that they are not represented by the political process [146].

Improving communication and environmental education to increase knowledge and change attitudes

Effective communication of the importance of conservation and our legal obligation to conserve wildlife is paramount to reverse trends of declining biodiversity. European nature protection legislation (EU Birds and Habitat Directives, Bern Convention, etc) provides the legal framework for our efforts to halt and where possible reverse biodiversity and ecosystem service declines, and has resulted in full protection of many species or the establishment of open hunting seasons to maintain populations. To ensure legal protection is enforced, legal status and the enforcement of policy needs to be communicated to local people and stakeholders, thus fostering a culture that encourages wildlife conservation.

Environmental education and communication is vital in creating knowledge about European wildlife, since in the long term, species comeback can only be sustained with the support of stakeholders and the general public. Wildlife comeback in itself has a large communications value. In the face of the ongoing biodiversity crisis, it is vital that conservation successes are effectively communicated in order to show that wildlife recovery can occur if given the chance. Similarly, informing the general public about the often complex ecosystem functions of species can be made easier by using key comeback species as symbols of these complex processes. In this way wildlife comeback can provide a means of positive reinforcement for the future conservation of an area.

Environmental education can lead to more positive attitudes towards wildlife (e.g. wolf and bear conservation in Italy [147]). Establishment of an environmental education programme and close cooperation between conservationists and recreational user groups in the Alps has led to an increase in breeding success of the Golden eagle (*Aquila chrysaetos*) caused by change in human behaviour [161]. However, this link between better knowledge and positive attitudes may not always be the case: hunters, for example, may have the best knowledge of and the most negative attitudes towards species such as the wolf [151].

Some aspects of wildlife comeback are likely to be more difficult to communicate (e.g. issues of native versus non-native species; Box 2). Another example is the communication of wildlife comeback in a historical context. Because major declines experienced by European megafauna often date back to at least the 19th century, current levels of wildlife may seem unprecedented: yet what we see today as wildlife comeback is still confined to small populations relative to historical baselines. "Shifting baselines" arise when anthropogenic factors lead to a change in wildlife population levels over time and collective memory sets these new diminished population levels as the new baseline against which to compare wildlife population change [162]. For the study of long-term population trends, there often remains little option but to set baselines to the point at which systematic data collection was started, since long-term data sets are frequently lacking [163]. As a result, the population increases and range expansions we are currently witnessing for certain species seem without precedence, yet we need to communicate that what we see today is a lower abundance of wildlife compared to historical baselines, and that these lower abundances are due to anthropogenic threats, both past and present, such as presecution, overhunting and habitat loss.

A large proportion of society is more disconnected from the natural world today than ever before, and this disconnection is central to the amounting environmental problems faced by humanity: people with a connection to the natural world also want to protect it [164, 165]. It is important that we understand the scale and consequences of this disconnection against the backdrop of wildlife comeback: do people care about wildlife comeback? What are their feelings about it and why? Do people want wildlife experiences close to home? Pioneering work is currently underway in the UK and the Netherlands to assess the level of children's disconnection with nature [166, 167]. Communication and environmental education strategies need to be adapted to bridge the gap between humans and wildlife, by increasing knowledge and engaging with new audiences, e.g. via new means of communicating such as social media. Finally, the best education will come from direct engagement with nature via establishment of wildlife viewing possibilities and nature excursions (see above).

Conclusion

A keen interest from people, opportunities from land availability, species comeback and support from policy have all combined in bringing about a new era for European wildlife. During a time where biodiversity is in crisis globally, this trend in Europe offers a contrast and a positive outlook for species conservation and human wellbeing. In this chapter we outlined some of the main benefits that could be gained from wildlife comeback. As a direct benefit to people, reconnecting with nature can contribute to the increased wellbeing of individuals. Through opportunities for nature tourism, contributions can be made to local and national economies as well as development in rural areas. Ecological benefits can also be reaped by restoring balance to the natural processes of ecosystems and for the conservation of threatened species.

Putting opportunities into a local context is vital for wildlife comeback to prove sustainable and mitigate any potential conflict with people. Likewise, recognising the needs of species by allowing adequate space and suitable habitat will be essential for ensuring the long-term recovery of wildlife. Understanding the issues that arise from an increasing interaction between wildlife and people and the opportunities that can be realised is critical to ensure a functioning European landscape for both humans and nature.

Box 2. The native versus alien species debate in a wildlife comeback context

This study of species recovery sets the scene for applying the lessons learned to a larger set of species to achieve additional conservation successes. Humans had a long influence on Europe's fauna and flora, and many species currently established in Europe are non-native to our continent. Because of a large number of definitions of what constitutes a non-native species, the first challenge consists of establishing which species of wildlife are to be encouraged and which are seen as detrimental to conservation.

Many species which are non-native to Europe, or native to a restricted part of the continent, have been widely introduced, primarily for activities such as hunting. The Mouflon was introduced to the Alps in the 1960s and has since expanded in range and population size; it has also been introduced to other parts of Europe [1, 2]. The species is often considered native to Corsica, Sardinia and Cyprus despite the fact that it is a semi-domesticated sheep introduced in prehistoric times [2, 3]. This species illustrates very neatly the difficulty of disentangling native from non-native species in Europe. Which species are native? Which are non-native? For which species should recovery from historic persecution be encouraged, or the colonisation of new habitats (e.g. anthropogenic habitats such as parks and cities)? Other species have been introduced much earlier, e.g. the rabbit (a native of the Iberian Peninsula and western France) and the pheasant (native across Asia) most likely in Roman times [4]. Fallow deer has been introduced in some parts of Europe, but is native to other parts and the debate is still ongoing as to where the species is native [5]. Other species were introduced to new areas in Europe for conservation purposes: the Alpine marmot was introduced to the Pyrenees in the 1940s in order to reduce the predation pressure of Golden eagles on the Pyrenean chamois [6]. Since this is the fauna that Europeans are nowadays familiar with, many of these species (including clearly non-native species such as Canada geese and Ring-necked parakeets) are likely to be considered native or unproblematic to the environment by the general public [7, 8]. Accordingly, expansion of non-native species populations may be seen as positive amongst certain demographic groups and any management to control non-native populations may prove unpopular [7, 9]. For example, the House crow, a native species of Asia, became established in the Netherlands where it was originally put on the protected species list – thus, a government-proposed cull was successfully challenged [10].

Uncertainty about the native versus non-native species dichotomy is not just confined to members of the general public [11]. Since a polarised debate is unlikely to lead to a solution of how to approach management of non-native species, more research will have to be carried out, an open scientific debate will have to take place and compromises have to be sought in order to devise a strategy for dealing with increases in abundance or range expansion of (presumed) non-native species in Europe. This is clearly also important in order to establish how to deal with new types of reintroductions, such as assisted colonisation and ecological replacement, for conservation purposes [12], and with natural range expansions as a result of climate change or destruction of natural barriers (e.g. Cattle egret, Jackal [13, 14]).

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An Exmoor pony, one of Europes most original horse breeds, genetically very close to the now extinct European wild horse.

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Appendix 1.

Sources of distributional data for the 18 mammal species and 19 bird species presented in the species accounts. With the exception of IUCN 2011 (mammals) and BirdLife International and NatureServe 2012 (birds) range maps, all maps and other data from the sources were digitised using Geographic Information System software, ArcGIS 9.3 (mammals) and ArcGIS 10 (birds). All distribution maps were amended following feedback from species experts.

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Appendix 2. European countries and regions following the United Nations*

Eastern Europe	Northern Europe	Southern Europe	Western Europe
Belarus	Åland Islands	Albania	Austria
Bulgaria	Channel Islands	Andorra	Belgium
Czech Republic	Denmark	Bosnia & Herzegovina	France
Hungary	Estonia	Croatia	Germany
Poland	Faroe Islands	Cyprus	Liechtenstein
Romania	Finland	Gibraltar	Luxembourg
Russian Federation	Iceland	Greece	Monaco
Slovakia	Ireland	Italy	Netherlands
Ukraine	Latvia	Macedonia	Switzerland
Moldova	Lithuania	Malta	
	Norway	Montenegro	
	Svalbard & Jan Mayen	Portugal	
	Sweden	San Marino	
	United Kingdom	Serbia	
		Slovenia	
		Spain	
		Vatican	

** United Nations Statistics Division 2007. Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings. Available from: http://unstats.un.org/unsd/methods/m49/m49regin.htm and http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe.*

Acknowledgements

This study on wildlife comeback in Europe was initiated by Rewilding Europe and commissioned to Zoological Society of London, BirdLife International and European Bird Census Council, through the financial support of the Swedish Postcode Lottery, Liberty Wildlife Fund and ARK Nature.

We are grateful to WWF International for funding the Living Planet Index project, which provided mammal abundance data for this report, to the European Bird Census Council (EBCC) for providing population indices from the Pan-European Common Bird Monitoring Scheme (PECBMS), and to Wetlands International for providing indices from the International Waterbird Census (IWC).

The species accounts presented in this report relied on the willingness of species experts to review the information we collated to help us present the most accurate picture of wildlife comeback in Europe. We would therefore like to give special thanks to our reviewers: Adrian Aebischer, Javier Alonso, Malin Aronsson, Juan Carlos Blanco, Luigi Boitani, Javier Bustamante, Bernard Cadiou, Juan Carranza, Inês Catry, Giorgos Catsadorakis, Jozef Chavko, Alain Crivelli, Fabienne David, Dimitar Demerdzhiev, Lucia Deutschova, Callan Duck, Olivier Duriez, Miguel Ferrer, Marco Festa-Bianchet, Alv Ottar Folkestad, Aldina Franco, Hans Frey, Robin Gill, Fulvio Genero, Luis Mariano González Garcia, Andy Green, Larry Griffin, Duncan Halley, Miklós Heltai, Márton Horváth, Djuro Huber, Baz Hughes, John Jackson, Thanos Kastritis, Kees Koffijberg, Bjarke Laubek, Franziska Lörcher, Antoni Margalida, Erik Meijaard, Tadeusz Mizera, Stephen Newton, Günter Nowald, Wanda Olech-Piasecka, Otto Overdijk, Jens Persson, Kajetan Perzanowski, Hartwig Prange, Remo Probst, Mátyás Prommer, Norman Ratcliffe, Carlos Rodríguez, Alejandro Rodríguez, Maurizio Sarà, Sue Sayer, Janusz Sielicki, Jon Swenson, Michel Terrasse, Kai-Michael Thomsen, and Henk van der Jeugd. Thanks also to José Tavares and Jovan Andevski of the Vulture Conservation Foundation (VCF) for preparing species accounts for three vulture species, and to Petr Voříšek and Jana Škorpilová at the Pan-European Common Bird Monitoring Scheme (PECBMS) and Statistics Netherlands for producing the population trends for five raptor species.

Many people contributed to this report, without whom this work would not have been possible. We are extremely grateful for the generous help of species experts, organisations and networks that provided data and information: Adrian Aebischer, Javier Alonso, Jovan Andevski, Hólmfríður Arnardóttir, Victor Belik, Keith Bensusan, Arjan Boele, Larisa Bogdea, Yuliya Bondarenko, Luka Božič, Ivan Budinski, Inês Catry, Giorgos Catsadorakis, Claudio Celada, Jozef Chavko, Tomasz Chodkiewicz, Przemysław Chylarecki, Olivia Crowe, Sinéad Cummins, Bernard Deceuninck, Juan Carlos del Moral, Deivis Dementavicius, Dimitar Demerdzhiev, Katarina Denac, Maja Derlink, Sergey Domashevsky, Valery Dombrovski, Jaanus Elts, Richard Evans, Ciprian Fantana, Ruud Foppen, Tony Fox, Aldina Franco, Vladimir Galushin, Andy Green, Richard Gregory, Larry Griffin, Marco Gustin, Ben Hallmann, Gergő Halmos, Richard Hearn, Martin Hellicar, Marc Herremans, Mark Holling, David Horal, Márton Horváth, Dan Hulea, Mihailo Jovicevic, Johanna Karthäuser, Thanos Kastritis, Viesturs Kerus, Elena Kmetova, Dražen Kotrošan, Andras Kovács, Jim Kushlan, Janis Kuze, Robert Kwak, Lars Lachmann, Bjarke Laubek, Teemu Lehtiniemi, Åke Lindstrom, Patric Lorgé, Jesper Madsen, Ubbo Mammen, Saša Marinković, Allan Mee, Tibor Mikuska, Yuriy Milobog, Claire Mirande, Carl Mitchell, Szabolcs Nagy, Reno Nellis, Veronica Neves, Stephen Newton, Günter Nowald, Ismo Nuuja, Torgeir Nygård, Otto Overdijk, Jean-Yves Paquet, Charles Perez, Hartwig Prange, Remo Probst, Mátyás Prommer, Slobodan Puzovic, Gwenaël Quaintenne, Jaime Ramos, Norman Ratcliffe, Liutauras Raudonikis, Eileen Rees, Mira Ruda, Milan Ruzic, Pertti Lauri Saurola, Darko Saveljić, Hans Schmid, Saulis Skuja, Svetoslav Spasov, Nikola Stojnic, Stoycho Stoychev, Maris Strazds, David Stroud, Elchin Sultanov, Péter Szinai, José Tavares, Joaquim Teodósio, Kai-Michael Thomsen, José Torres Esquivias, Rimgaudas Treinys, Wim Van den Bossche, Henk van der Jeugd, Chris van Turnhout, Metodija Velevski, Zdeněk Vermouzek, Vitaly Vetrov, Al Vrezec, Jasper Wehrmann, Gabor Wichmann, Georg Willi, and Simon Wotton, as well as Wetlands International, Research and Monitoring for and with Raptors in Europe (EURAPMON), Monitoring of European Raptors and Owls (MEROS), IUCN/Wetlands International Species Survival Commission (SSC) Specialist Groups on Pelicans, Geese, Cranes, Storks, Ibises and Spoonbills, European Crane Working Group, Albanian Society for the Protection of Birds, BirdLife Belarus (APB), Nase Ptice (Bosnia & Herzegovina), Bulgarian Society for the Protection of Birds (BSPB), BIOM (Croatia), BirdLife Cyprus, BirdLife Finland, Ligue pour la Protection des Oiseaux (LPO), Dachverband Deutscher Avifaunisten (DDA), Naturschutzbund Deutschland (NABU), Hungarian Ornithological and Nature Conservation Society (MME), BirdWatch Ireland, Lega Italiana Protezione Uccelli (LIPU), Lithuanian Ornithological Society (LOD), natur&umwelt (Luxembourg), Macedonian Ecological Society (MES), Laboratory of Ornithology, Institute of Zoology, Academy of Science of Moldova, Center for Protection and Research of Birds (CZIP, Montenegro), Sovon Vogelonderzoek Nederland, Polish Society for the Protection of Birds (OTOP), Romanian Ornithological Society (SOR), Bird Protection and Study Society of Serbia, DOPPS-BirdLife Slovenia, SEO/BirdLife Spain, Ukrainian Society for the Protection of Birds (USPB), Gibraltar Ornithological and Natural History Society (GONHS), Royal Society for the Protection of Birds (RSPB), Rare Breeding Birds Panel (RBBP, UK), and the many other organisations that facilitate the collection and provision of monitoring data for schemes like PECBMS and IWC.

Furthermore, we would like to thank Emma Cutten, Clare Duncan, Jonathan Gunasekera, Peter Hill, Nicole Maddock, Susie Offord, Charlotte Outhwaite, Victoria Price, Louise Raggett, Michael Taylor and Carolyn Thompson for their help with mammal species accounts, map digitisation, data searches and data entry. Richard German digitised and updated the bird species distribution maps, with support from Mark Balman, Joe Taylor, Lynda Donaldson and Chris Doble, and Rob Pople helped collate information on threats and conservation actions. Deli Saavedra, Frans Schepers and Staffan Widstrand at Rewilding Europe and Ariel Brunner and Wim Van den Bossche at BirdLife Europe provided valuable feedback on the report.

We are very grateful to the report designer Kristjan Jung at Rewilding Europe. His design, together with the stunning photographs of European wildlife kindly provided by Wild Wonders of Europe (www.wild-wonders.com) and Rewilding Europe (www.rewildingeurope.com) not only brings this report alive – it emphasises the importance of wildlife comeback and wilderness in Europe.

Wildlife comeback in Europe

The recovery of selected mammal and bird species

The main purpose of this study was to identify the main drivers for recovery of a selected number of wildlife species in Europe, in order to learn lessons for the future.

The results show that a wide-ranging comeback of iconic wildlife species has taken place in many regions across Europe over the past 50 years.

Legal protection of species and sites emerges as one of the main reasons behind this recovery. Active reintroductions and re-stockings have also been important factors.

The conclusion is that nature conservation works, as does investment in our natural heritage. However, in order to halt biodiversity loss and restore other declining and depleted species, more commitment and resources are needed, as well as new kinds of conservation measures.

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We strive to achieve our mission by:

- Conducting world-leading conservation science
- Implementing effective field conservation projects globally
- Providing decision-makers with the best conservation advice
- Building conservation capacity and inspiring people to connect with the natural world

The "Wildlife comeback in Europe" report was commissioned by Rewilding Europe
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