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A review of the status of the Western polecat *Mustela putorius*: a neglected and declining species?

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Abstract: The Western polecat *Mustela putorius* has a widespread European distribution and is currently listed as Least Concern by the *IUCN Red List of Threatened Species*. Reports are increasing of polecat population declines in several countries, although a paucity of data means population trends are poorly understood. This paper reviews and summarises information on the polecat's status and range-wide population trends. Information and opinion were gathered for 34 countries, from individuals and organisations studying polecats and from reviewing the literature and national Red Lists. Where trends were identified, the polecat population is known or suspected to be declining in 20 countries, reported to be stable in five countries, stable or increasing in one country, and increasing in two countries. For many countries, data are so limited in quantity or spatial scale, or at risk of bias, that trends could not be identified or confidence in trend assessments is low. The main drivers of polecat decline are poorly understood, but might include habitat degradation; changes in prey availability; competition with invasive carnivores; poisoning; conflict with human interests; harvesting and killing of polecats; and hybridisation. Robust survey methods and systematic monitoring programmes are urgently needed to gather up-to-date data on polecat population trends across the species' range.

Keywords: *Mustela putorius*; population status; population trend; status review; Western polecat.

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Introduction

Monitoring the distribution and abundance of species is fundamental to the conservation, research and management of wildlife populations (Wilson and Delahay 2001). The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species assessments provide information that is essential to guide species conservation efforts and management of natural resources at multiple scales, inform national development policies and legislation, and produce recommendations for conservation action (Rodrigues et al. 2006).

The Western or European polecat *Mustela putorius* (hereafter referred to as the polecat) is a medium-sized carnivore of the family Mustelidae and is the ancestor of the domestic ferret *Mustela furo* (Sato et al. 2003, Costa et al. 2013). It is widespread in the western Palaearctic, ranging from the Atlantic coast of Iberia in the west to the Ural Mountains in the Russian Federation in the east, but is naturally absent from Ireland, northern Scandinavia, part of the Balkans and the eastern Adriatic coast (Mitchell-Jones et al. 1999). Additionally, populations of wild-living polecat- or ferret-like animals of unresolved taxonomic identity, but which are believed to be native, occur in Morocco and Algeria (Gippoliti 2011, Ahmim 2013).

The polecat's preferred habitat type varies across its range but includes riparian vegetation and water courses (Zabala et al. 2005, Rondinini et al. 2006, Mestre et al. 2007), grasslands, pastures, human settlements (Baghli et al. 2005), woodland edge, agricultural land (Birks and Kitchener 1999) and montane pine forests (Virgós 2003). The polecat's diet has been described as generalist, comprising mainly rodents, amphibians, lagomorphs, birds and carrion (Lodé 1997). However, this varies across the polecat's range and is more specialised in some areas; for example, it is dominated by European rabbit *Oryctolagus cuniculus* in Mediterranean regions (Santos et al. 2009) and Britain (Birks and Kitchener 1999); by amphibians, specifically anurans, in Switzerland (Weber 1989), France (Lodé 1997) and Denmark (Hammershøj et al. 2004); and by small rodents, notably the common vole *Microtus arvalis*

and field mouse *Apodemus* sp., in western Poland (Malecha and Antczak 2013) and Hungary (Lanszki and Heltai 2007).

The polecat is listed on Appendix III of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) (Council of Europe 2016) and Annex V of the EU Council's Directive on the conservation of natural habitats and of wild fauna and flora (EU Habitats Directive) (European Environment Agency undated). In many countries, the polecat is legally hunted for fur (for example, Russia and Scandinavia), or trapped as a perceived pest species (for example, Croatia and France), and it receives some level of legal protection in other countries (for example, Britain and Luxembourg) (Skumatov et al. 2016).

The polecat occurs at a low population density, is typically nocturnal and leaves few distinctive field signs, which makes the species difficult to monitor systematically (Birks 1997). The main methods used to study and monitor polecats are live trapping (e.g. Birks 1997, Baghli et al. 2005), radio-telemetry (Birks and Kitchener 1999, Baghli et al. 2005, Rondinini et al. 2006), analysis of game bag and pelt harvesting data, and collection of road casualties and other, mostly incidental, records such as live sightings (Birks and Kitchener 1999, Birks 2008, Barrientos and Bolonio 2009, Barrientos and Miranda 2012, Croose 2016).

A paucity of data means that population trends for the polecat across its range are poorly understood. However, in recent years there have been reports of population declines in several countries (Skumatov et al. 2016). In light of this, in 2014–2016 the category for the polecat, Least Concern, was reviewed. As part of this assessment, researchers from several countries in the polecat's range reported, notwithstanding the known increases in some countries (representing recoveries from severe historical declines), that the polecat population was declining, or suspected to be declining, and others had insufficient data to inform population trends. Nevertheless, the overall global population trend for the polecat was deemed unlikely to reach the rate of decline that would make a Near Threatened categorisation appropriate (an overall loss of 20%, or more, of the global population over the preceding 13 years (three generations), an anticipated such loss over the next 13 years, or such a rate of loss over a 13-year period part before and part after 2016). Thus, the global categorisation remained as Least Concern (Skumatov et al. 2016). The structure of the Red List criteria means that the polecat could be declining at a “globally averaged” rate of 19% per 13 years and still correctly be categorised as Least Concern even though such a decline rate would be interpreted by most people as of

considerable concern. During the Red List assessment, the polecat was deemed the most difficult of all small carnivore species to categorise, the confidence in the categorisation is low and the widespread uncertainty of the polecat's status in many countries indicated that further action was warranted.

This paper reviews and presents up-to-date information on the current status and population trends for the polecat across its range and discusses the potential drivers and implications of these trends.

Materials and methods

Information on the polecat's status and population trends was gathered by two means. Firstly, a literature search was undertaken using Google search, Google Scholar and online library databases to source published and grey literature. The keywords used in the search were polecat, Western polecat, European polecat and *Mustela putorius*. Relevant literature was scanned for any information on the polecat's status and population trends. Secondly, organisations, researchers and biologists who may hold information on polecats, in countries where the species is known to occur, were identified and contacted. Individuals and organisations were contacted if they were known to be studying polecats, had authored papers or reports on polecats, had contributed to the *IUCN Red List* assessment or Red List assessments in their own countries, or engaged in activities that generated many polecat records. Correspondents were contacted via email or ResearchGate. Correspondents were asked to classify the polecat population in their country into one of the following categories: increasing, stable, declining, unknown/data deficient. They were also asked to highlight any relevant literature in which population trends are listed and identify other individuals or organisations that might hold information on polecats. Finally, national Red Lists were reviewed to ascertain the category to which the polecat was assigned. In several countries within the polecat's range, neither published information on polecats nor individuals or organisations working on polecats were traced and nor had the species been assessed in the country's national Red List. Information was gathered from 2014 to 2017.

Results

Information on the status of the polecat population was gathered from 34 countries across the species' range.

Table 1: A summary of Western polecat *Mustela putorius* population trends and national Red List category in countries across its range (it does not include countries for which no information was available.)

Country	Polecat population trend	Red List category for country ^b	References
Albania	Decline? ^a	Endangered	Prigioni (1996); National Red List (2013)
Austria	Decline	N/A	A. Kranz pers. comm. (2016)
Belarus	Decline	N/A	Sidorovich et al. (2008); Sidorovich (2011a,b,c); V. Sidorovich pers. comm. (2016)
Belgium	Possible decline? ^a	Least concern for Wallonie region; vulnerable for Flanders region	Libois (1996); Portail de la Wallonie (undated); Instituut voor Natuur- en Bosonderzoek (2014)
Britain	Increase	N/A	Croose (2016)
Bulgaria	Possible decline? ^a	N/A	Peshev (1996); Spiridonov and Spassov (1997), cited in Kryštufek (2000)
Croatia	Decline	N/A	Konjević (2005)
Czech Republic	Decline	Data deficient	Plesník et al. (2003); Ryšavá-Nováková and Koubek (2009)
Denmark	Decline	Least concern	Pertoldi et al. (2006); National Environmental Research Institute, Denmark (2014)
Estonia	Stable or increase	Least concern	Red Data Book of Estonia (2008); T. Maran pers. comm. (2015)
Finland	Decline?	Vulnerable	Liukko et al. (2016); H. Henttonen, pers. comm. (2017)
France	Probable decline	Least concern	Berzins and Ruette (2014); Bensettiti and Puissauve (2015); Calenge et al. (2015, 2016); Inventaire National du Patrimoine Naturel (2017)
Germany	Decline	Near threatened	A. Schreiber pers. comm. (2015); A. Weber pers. comm. (2015); H. Ansoerge pers. comm. (2015); H. Krüger pers. comm. (2015)
Greece	Unknown	N/A	Kominos and Galanaki (in press.); P. Georgiakakis pers. comm. (2017)
Hungary	Stable? ^a	N/A	Miklós (2002); Lanszki and Heltai (2007)
Italy	Unknown, possible decline	Least concern	Pedrini et al. (1995); Istituto Superiore per la Protezione e la Ricerca Ambientale (2014); Rondinini et al. (2013); M. Pavanello pers. comm. (2016)
Latvia	Stable	N/A	J. Ozolins pers. comm. (2017)
Lithuania	Decline? ^a	N/A	Mickevicius and Baranauskas (1992, cited in Birks and Kitchener 1999)
Luxembourg	Decline ^a	N/A	Baghli and Verhagen (2003)
Netherlands	Stable	Data deficient	Zoogdierverseniging VZZ (2007); Hofmeester and Dekker (2016)
North Africa (Algeria and Morocco)	Data deficient	N/A	Gippoliti (2011); Ahmim (2013)
Norway	Unknown	Vulnerable	Syvertsen et al. (1996); The Norwegian Biodiversity Information Centre (NBIC) (2016)
Poland	Unknown, possible decline	N/A	Pertoldi et al. (2006)
Portugal	Data deficient, probable decline	Data deficient	Rodrigues et al. (2006); Costa et al. (2014)
Romania	Decline	N/A	A.D. Sándor pers. comm. (2015)
Russia [categorised by Federal Districts (FD)]	Weak decline	N/A	All FDs: Russian Research Institute of Game Management and Fur Farming, unpublished data
Northwestern FD	Stable or weak increase		
Central FD	Weak decline		
Privolzhsky FD	Stable		
Ural FD	Increase?		
Southern FD	Decline or stable?		
Slovakia	Stable?	N/A	Malecha et al. (2009)

Table 1 (continued)

Country	Polecat population trend	Red List category for country ^b	References
Slovenia	Unknown	N/A	D. Vrček pers. comm. (2017)
Spain	Unknown, probable decline	Near threatened	Virgós (2001, Virgós 2007); Melero et al. (2012); E.J. Virgós; I. Zuberogoitia; and J. Herrero pers. comm.
Sweden	Stable	Least concern	Species Information Center (2017); H. Thurffjell pers. comm. (2017)
Switzerland	Increase	Vulnerable	P. Dollinger pers. comm. (2016)
Turkey	Unknown	N/A	Kryštufek and Vohralik (2009)
Ukraine	Unknown, possible decline	N/A	Ruzhilenko (2009); A. Volokh pers. comm. (2016)

^aNo up-to-date information collected for these countries, so the trend presented is based on the most recent information available.

^bN/A denotes that either the polecat was not assessed in the national Red List or no information was traced.

The information gathered from each country is presented below alphabetically. No information could be found for 7 countries. A summary of population trends is presented in Table 1 and Figure 1.

In *Albania*, the polecat was categorised as Endangered in the National Red List in 2013 (National Red List 2013). Previously published information suggested that the species was becoming rare (Prigioni 1996).

In *Austria*, data from hunting-bags of polecats suggest a population decline (A. Kranz pers. comm. 2016). The hunting bag of both Western and Steppe polecats *Mustela eversmannii* combined (the majority being Western polecats) increased from 6000 in 1955 to almost 14,000 in 1968, then decreased to 6000 in 2003 (Reimoser et al. 2006). Official hunting bag statistics for 1983–2014 show periodical cycling but a clear general downward trend, resulting in a decline by approximately half of the polecat hunting bag during the 31-year period (A. Kranz pers. comm. 2016). However, it is not known how variation in hunting effort affects the trend in hunting bags.

In *Belarus*, the polecat has undergone a long-term decline in some regions since the early 1970s (Sidorovich et al. 2008). By 2008–2010, the polecat population had become fragmented in Belarus with a fairly low population density and no reliable information about the species in many parts of the country (Sidorovich 2011a). It is currently regarded as rare (V. Sidorovich pers. comm. 2016).

In *Belgium*, previously published data suggested that the population was stable to decreasing (Libois 1996). The polecat has been assessed for the Red List in two regions of Belgium. In Wallonie region, the polecat is listed as Least Concern with a stable population (Portail de la Wallonie undated) whereas in Flanders, the polecat is listed as Vulnerable (Instituut voor Natuur- en Bosonderzoek 2014).

In *Britain*, the polecat population is increasing and expanding its range following a severe widespread

historical decline and range contraction driven by persecution (Birks and Kitchener 1999, Birks 2008, Croose 2016). Having become confined to a small area of Wales by the early 20th century, the polecat population has been recovering since the 1930s, due to a reduction in persecution pressure and reintroductions to parts of its historical range. The population is now more widespread than at any time in the last hundred years, although it is still absent from considerable parts of its former range, including most of Scotland (Croose 2016). The most recent polecat population abundance estimate was 46,000 animals in 2006 (Birks 2008).

In *Bulgaria*, information on the polecat is contradictory, with suggestions that the polecat was common with a stable distribution (Peshev 1996) and that the population was declining (Spiridonov and Spassov 1997, cited in Kryštufek 2000).

In *Croatia*, the polecat population is reportedly declining in many parts of the country and it has been suggested that a recovery plan for the species is needed (Konjević 2005).

In the *Czech Republic*, the polecat is believed to have declined (Ryšavá-Nováková and Koubek 2009), and the species was categorised as Data Deficient in the Red List for the Czech Republic in 2003 (Plesník et al. 2003). Polecats are not currently hunted but according to hunting data, 1655 individuals were caught in 2000 and more than 20,000 individuals have been caught since the beginning of the 1970s (Ryšavá-Nováková and Koubek 2009).

In *Denmark*, the number of polecats killed by hunting during the last 60 years has been declining, according to the Danish game-bag record (Møller et al. 2004, cited in Pertoldi et al. 2006). Additionally, genetic bottleneck tests have indicated that polecat populations in southern Denmark have declined recently, whereas populations in northern Denmark have expanded recently (Pertoldi et al.

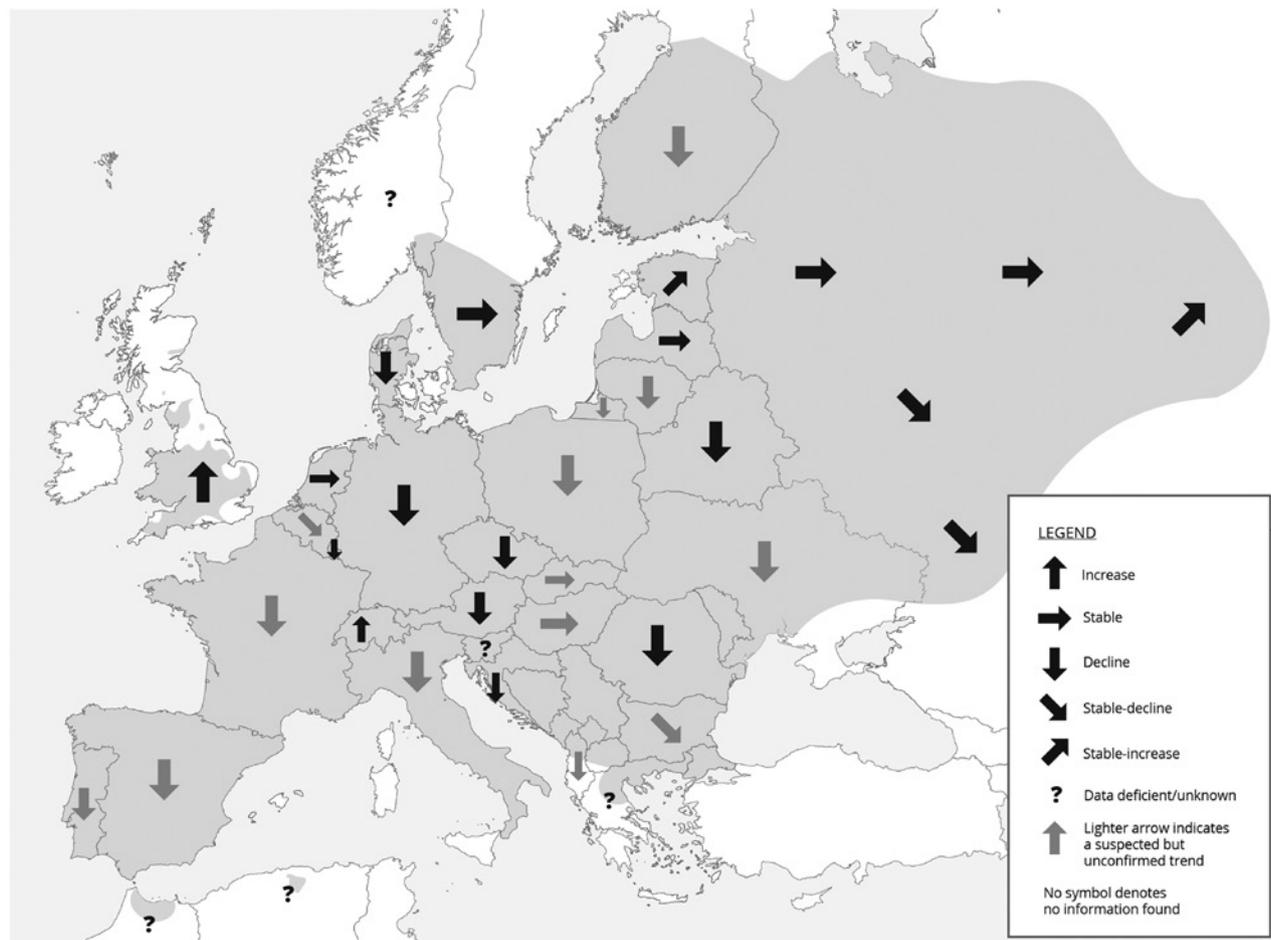


Figure 1: The Western polecat's *Mustela putorius* distribution (dark grey shading) and population trends in countries across its range.

2006). The polecat was categorised as Least Concern in the Danish Red Data Book in 1997 (National Environmental Research Institute, Denmark 2014).

In *Estonia*, the polecat population is thought to be stable or increasing, based on hunters' opinions (T. Maran pers. comm. 2015). The polecat was categorised as Least Concern in the Estonian Red List in 2008 (Red Data Book of Estonia 2008).

In *Finland*, the polecat was categorised as Vulnerable in the Red List of Finnish mammals in 2015 (Liukko et al. 2016). The polecat has become scarce in western and central Finland, with viable populations remaining in eastern and south-eastern Finland (H. Henttonen pers. comm. 2017).

In *France*, the status of the polecat is uncertain, particularly in the south-east and south-west of the country, although a decline is suspected (Berzins and Ruelle 2014). The polecat's total distribution in France declined from 465,680 km² in 2007 to 334,300 km² in 2013 (Bensettiti and Puissauve 2015) but differences in methodology between the two periods exclude

quantitative comparisons. Regional variations in the polecat population's trends are strongly suspected. The polecat's conservation status was most recently assessed in 2012 (covering the period 2007–2012) and was classed as unfavourable-inadequate in two biogeographical regions: Alpine and Mediterranean (Bensettiti and Puissauve 2015). Conversely, the polecat's conservation status was classed as favourable in two other regions in 2012: Atlantic and Continental (Bensettiti and Puissauve 2015). Using data collected by the French national hunting and wildlife agency (ONCFS; Office National de la Chasse et de la Faune Sauvage) under the "small carnivorous species logbooks" programme, a modelling approach estimated relative population density for the polecat across the French agricultural regions (Calenge et al. 2015). Results suggested strong spatial variations in population densities, with lower relative densities in the Alpine and Mediterranean regions (Calenge et al. 2015). A modelling approach intended to address trends in datasets predicted a probable decrease in polecat population densities in 36% of the French agricultural regions and

a probable increase in 24% of them between 2004–2008 and 2009–2012 (Calenge et al. 2016).

In *Germany*, a decline in the polecat population has been suggested to have occurred during the late 20th and early 21st centuries, based on a decrease in hunting bags (A. Schreiber pers. comm. 2015). The polecat still occurs in all states in Germany at a low population density but has decreased in numbers in some areas (H. Krüger pers. comm. 2016). However, this perceived decline could be merely an artefact of a decrease in trapping and hunting efforts, as hunting bags of the stone marten *Martes foina* have also decreased and this species' bag is deemed to be a good indicator of trapping activity (H. Krüger pers. comm. 2016). In Saxony-Anhalt, there was a steep decline in distribution during the late 20th century, whereby the polecat's range in this state (with a total land area of 20,452 km²) dropped by 10,120 km² between 1962–1989 and 2005–2014 (H. Ansorge pers. comm. 2015, A. Weber pers. comm. 2015). Additionally, the reported number of polecats killed on roads and railways approximately halved between 2006–2007 and 2012, without the implementation of any polecat-specific protection measures on roads or railways (A. Weber pers. comm. 2015). Although there is a lack of comparable data for elsewhere in Germany, similar declines are strongly suspected in at least three other federal states of Germany: Mecklenburg-Western Pomerania, Brandenburg and Thuringia (A. Weber pers. comm. 2015). The polecat was included in the 'pre-warning list' (analogous to Near Threatened) for Germany in 1998 where it remained for the 2009 edition of the German Red List (Haupt et al. 2009). This classification is a compromise between the different Red Lists of the 16 German states; some states classify the polecat in higher threat categories than Near Threatened, whilst others classify it as Least Concern (A. Schreiber pers. comm. 2017).

In *Greece*, the polecat was listed as Not Evaluated in The Red Data Book of Threatened Animals of Greece in 2009 due to a paucity of data on its distribution and population trends (Legakis and Maragou 2009, cited by Kominos and Galanaki in press). However, the species is considered to be rare (P. Georgiakakis pers. comm. 2017). Recent records have extended the polecat's previously known range into western and northwestern Greece (Kominos and Galanaki in press.).

There was no information available on polecat population trends in *Hungary*, but it is considered to be common and widespread throughout the country and is legally hunted in season (Miklós 2002, Lanszki and Heltai 2007).

In *Italy*, the status of the polecat is currently unknown (M. Pavanello pers. comm. 2016) but was categorised as

Least Concern in the Italian Red List assessment in 2013 (Rondinini et al. 2013). The polecat is considered to be of minimum management interest and consequently there has been little research on the species (Istituto Superiore per la Protezione e la Ricerca Ambientale 2014) and data are scarce and unevenly distributed (M. Pavanello pers. comm. 2016). However, there are some suggestions that the polecat population is slowly declining (M. Pavanello pers. comm. 2016). The polecat seems to have disappeared from the whole province of Trento, with the last known record of the species reported in 1960 (Pedrini et al. 1995).

In *Latvia*, the polecat population is considered to be widespread and healthy, although the species is possibly being displaced from some areas around human settlements by the stone marten (J. Ozolins pers. comm. 2017).

In *Lithuania*, previously published information indicated that the polecat population has been declining since the 1960s (Mickevicius and Baranauskas 1992, cited in Birks and Kitchener 1999).

There is a lack of up-to-date data on the polecat in *Luxembourg*, but the most recent information indicates that the polecat experienced a large-scale decline in population density since the 1950s and is considered the least common mustelid in the country except for the Eurasian otter *Lutra lutra* (Baghli and Verhagen 2003). The polecat has been listed as a protected species in Luxembourg since 1990 (Anonymous 2009).

In *The Netherlands*, the polecat population declined from 1997 to 2013, followed by a large increase in the number of reported sightings in 2014, believed to be a short-term response to an exceptional increase in the population of common voles (Hofmeester and Dekker 2016). The resulting overall trend in the population during the period 1997–2014 was stable (Hofmeester and Dekker 2016), although the polecat was categorised as Data Deficient in the Dutch Red List in 2006 (Zoogdierverseniging VZZ 2007).

In *Norway*, the polecat population is considered to be small, rare and possibly introduced from fur farms (Syvertsen et al. 1996). No information on population trends could be found, but the polecat was categorised as Vulnerable in the Norwegian Red List in 2015 (The Norwegian Biodiversity Information Centre 2016).

There are no data available on polecat population trends in *Poland*, although genetic bottleneck tests suggest that the polecat population has declined recently (Pertoldi et al. 2006).

In *Portugal*, the status of the polecat is Data Deficient and evidence from several studies suggests a population decline (Costa et al. 2014). The polecat is apparently

widespread in Portugal, but occurs discontinuously and at low densities (Costa et al. 2014). It is not known whether this pattern is the result of a declining population trend or a long-standing situation (Costa et al. 2014). During a 3-year study (2008–2011) in north-west Portugal, where footprint tracking tunnels and scat surveys (alongside genetic identification) were used primarily to detect American mink *Neovison vison*, no evidence of the polecat was collected, indicating that it may have become scarce in the area (Rodrigues et al. 2014). Additionally, in southern Portugal, studies of vertebrate road mortality showed that polecat road casualties are less frequent than those of other carnivore species (Grilo et al. 2009).

In *Romania*, data from hunting bags and population estimates both indicate a slight decline in the polecat population, of approximately 22–25% over a 14-year time period from 2000 to 2013 (A. D. Sándor pers. comm. 2015). The population estimate for the polecat in Romania has declined from just under 28,000 in 2005 to just under 24,000 in 2013 (A. D. Sándor pers. comm. 2015). Although the polecat is widely considered to be the most common mustelid in Romania, during transect surveys for tracks carried out in the centre and west of Romania in 2012–2014, the polecat was only recorded on 54% of transects of predicted suitable habitat, compared with 66% for pine marten *Martes martes*, 76% for wild cat *Felis silvestris* and 91% for Eurasian otter (A.D. Sándor pers. comm. 2015), although this may be a reflection of the polecat's generalist habitat use.

In the *Russian Federation*, the polecat has a large distribution which comprises a significant proportion of the species' entire global range. For Russia, the overall trend derived from snow-tracking data and questionnaires to trappers and hunters has been a weak decline in the number of polecats from 2001 to 2016. Polecat population trends from 2001 to 2016 differ by Federal Districts (FD) of Russia, as follows: in the Northwestern FD, the trend was of stability or a weak increase; in the Central FD, the trend was weak decrease; in the Privolzhsky FD, the trend was stable; in the Ural FD, the trend was stable or increase in distribution; and in the Southern FD, the trend was decrease or stable (Russian Research Institute of Game Management and Fur Farming, unpublished data). Estimates for the total polecat population in Russia in winter 2016, inferred from snow-tracking data, range from 53,000 to 58,500 individuals (Russian Research Institute of Game Management and Fur Farming, unpublished data). However, polecat abundance estimates derived from tracking are unreliable because their tracks are often misidentified as those of other mustelid species, such as American mink.

In *Slovakia*, there is no information on population trends but the polecat is considered widespread and can be hunted during the winter (Malecha et al. 2009).

In *Slovenia*, the polecat population declined from the 1970s to the 1990s according to data from game bags (Kryštufek 2000), but reliable up-to-date data on the species are scarce (D. Vrček pers. comm. 2017).

In *Spain*, available evidence indicates a strong decline of polecats (E.J. Virgós, pers. comm. 2016), however, information is too fragmentary to confirm this (Virgós 2001, J. Herrero pers. comm. 2016, I. Zuberogoitia pers. comm. 2016). The polecat was categorised as Near Threatened in the national Red Data Book in 2006 (Virgós 2007). In Biscay and other areas of northern Spain, trapping and monitoring surveys of American mink have observed a decline in the number of polecats caught in traps, recorded on camera traps and as road casualties, suggesting that the species is becoming scarce (I. Zuberogoitia pers. comm. 2016). The polecat population in Catalonia declined sharply in the 1960s and 1970s, increased from 1991 until 2002 and then declined again, this latter post-2002 decline being attributed to the arrival of American mink (Melero et al. 2012). In the Mediterranean part of Spain, the polecat is thought to be very scarce (E.J. Virgós pers. comm. 2017).

In *Sweden*, the polecat was categorised as Least Concern in the 2015 National Red List (Species Information Center 2017). However, data are derived from trapping records and there are very few mustelid trappers, thus, the accuracy of the data is uncertain (H. Thurffjell pers. comm. 2017). It is thought that the number of polecats is somewhat lower than in the 1990s, but the population is stable and the polecat's range has been recorded as covering a larger area of Sweden than previously thought (H. Thurffjell pers. comm. 2017). The Swedish Hunters Association estimates that 2,835 polecats were killed in 2014–2015 (Svenska Jägareförbundet 2016).

In *Switzerland*, the polecat population declined until the late 1970s and has since stabilised and increased locally in some areas (P. Dollinger pers. comm. 2016). The last national-level official assessment of the polecat dates from 1994 when the species was classed as Vulnerable (Nievergelt et al. 1994). However, since 2000 many distribution gaps in the Swiss Midlands and Jura have been filled and in the Grisons the species has expanded its range in the Vorderrhein Valley almost to the Oberalp Pass, and in the Hinterrhein Valley to the Via Mala area (Infofauna 2016). Additionally, there has been a large, sustained increase in reported road mortalities of polecats (from two in 2009 to 153 in 2014) (P. Dollinger pers. comm. 2016). Such increase in road mortalities has been

observed in few other species, so it is more likely to reflect an increasing polecat population rather than a change in reporting behaviour, although there are currently no other data to confirm this (P. Dollinger pers. comm. 2016).

In *Turkey*, the polecat occurs in Thrace in the north-west of the country, but population trends for the species are unknown (Kryštufek and Vohralik 2009).

In *Ukraine*, the Red Data Book of Ukraine lists the status of the polecat as Not Assessed, with insufficient data (Ruzhilenko 2009). Other information suggests that the polecat is declining rapidly, supposedly due to modifications in wetlands and mature forests (A. Volokh pers. comm. 2016).

No information could be found on polecat population trends or abundance in part of its range in south-eastern Europe, in Macedonia, Montenegro, Moldova, Serbia, and Bosnia and Herzegovina and in Andorra and Liechtenstein.

In *North Africa*, the status of the populations of wild-living polecat-like animals in north-central Algeria and northern Morocco is poorly known and the species may be very rare (Gippoliti 2011, Ahmim 2013). The Algerian population has been said to number around 30 animals, some of which have been taken into captivity, and there have been some reports of these animals being sold in markets in western Algeria (Ahmim 2013).

Of the countries for which information on polecat population status or trends was available, the majority trend is of a population decline or suspected decline, noted in 20 countries. This decline extends through most of the Mediterranean region and is suspected in much of the Continental and Alpine regions. Population increases are only reported for certain in two countries (Britain and Switzerland) and this is predominantly due to these populations still recovering from a steep historical decline and range contraction. The polecat population was reported to be stable in five countries (Hungary, Latvia, the Netherlands, Slovakia and Sweden) and stable or increasing in one country (Estonia).

Discussion

The polecat is known, or suspected, to be declining in multiple countries across its range. Nevertheless, the global population is still considered to be large and relatively stable in the eastern half to three-quarters of its range, including in Russia which comprises a large proportion of the polecat's entire global range.

In countries where polecat populations are declining, the main drivers of this decline are, generally, not well-understood, and may vary across the species' range. This decline has been attributed, at least provisionally, to several factors; degradation and modification of habitat; changes in prey availability; competition with invasive carnivores; secondary poisoning and environmental pollutants; conflict with human interests; harvesting and accidental killing of polecats; and hybridisation.

Habitat alteration

Habitat fragmentation, degradation and modification have been commonly cited as one of the principal causes of polecat population decline (Blanco and Gonzalez 1992, cited in Pertoldi et al. 2006, Cabral et al. 2005, cited in Costa et al. 2014). In particular, the drainage and destruction of wetlands is thought to have contributed to a decline in polecat populations in Germany, France, and a past decline in Switzerland (A. Schreiber pers. comm. 2015, P. Dollinger pers. comm. 2015) and modifications of wetlands and mature forests have been suggested to be contributing to declining polecat populations in Ukraine (A. Volokh pers. comm. 2016). In Switzerland, the stabilisation and recovery of the declining polecat population was attributed to habitat improvement through creation of new ponds for amphibians and revitalisation of small rivers (P. Dollinger pers. comm. 2015). Hedgerows are frequently used by polecats (Birks and Kitchener 1999) and consequently, the removal or modification of hedgerows may have a negative impact on polecats by reducing habitat connectivity. In France, hedgerow ground area declined by 5% per year from 1982 to 1990 (Pointereau 2002), although this has not been linked to a decline in polecat abundance or distribution.

Prey availability

Habitat fragmentation, degradation and modification may have adverse impacts on polecat prey species and thus may affect the population status of polecats. Polecat population declines in both Switzerland and Austria have been attributed partly to the decline of amphibians (Weber 1987, A Kranz pers. comm. 2016). Amphibians can constitute a significant proportion of the polecat's diet, comprising 87% in a study in Denmark (Hammershøj et al. 2004) and frogs comprised 98% of polecat diet in Białowieża Forest, Poland, during mild winters (Jedrzejewska and Jedrzejewski 1998). The importance of European rabbits

to polecat diet has been well-documented in the Mediterranean (Santos et al. 2009) and Britain (Birks and Kitchener 1999). The European rabbit population is declining in some parts of its range and in Spain has declined by 80% since 1975 (Delibes et al. 2000, cited in Smith and Boyer 2008), which is considered to be one of the main threats to the polecat population in that country (Virgós 2002, cited in Mestre et al. 2007). A decline in other mammalian prey species, such as the European hamster *Cricetus cricetus*, which can be an important prey species for polecats (Lanszki and Heltai 2007), is possibly contributing to the decline in polecats in parts of its range, for example, in Saxony-Anhalt, Germany (A. Weber pers. comm. 2015). It has been suggested that decreasing prey populations may be contributing to a suspected decline in polecat numbers in Portugal (Cabral et al. 2005, cited in Costa et al. 2014).

Competition with invasive carnivores

The polecat is increasingly under threat from competition with invasive non-native carnivores. In Catalonia, Spain, the abundance of polecats, estimated by captures and sightings, was significantly lower after American mink arrived in the area and decreased significantly with the increase in annual relative abundance of mink (Melero et al. 2012). Indeed, the polecat was the carnivore most significantly affected by American mink, a pattern that is likely to be due to the partial overlap between the polecat and mink's spatial and trophic niches (Melero et al. 2012). Furthermore, the range expansion of the mink population in Spain was more rapid in areas where there were no polecats (Ruiz-Olmo et al. 1997). In Belarus, the polecat's long-term decline has been attributed to the naturalisation and expansion of the American mink, which competes with polecats for prey, such as water vole *Arvicola amphibius* and root vole *Microtus oeconomus* (Sidorovich et al. 2008, Sidorovich 2011a). Furthermore, male American mink have aggressive interactions with both sexes of polecat, which may have a detrimental impact on polecat reproduction (Sidorovich et al. 2008, Sidorovich 2011a). There is also concern that range expansion of American mink in north-west Portugal may affect the abundance or distribution of the polecat there (Rodrigues et al. 2014). The expansion of American mink in south-west France is of concern for the polecat and the European mink *Mustela lutreola* (Léger and Ruetten 2005). In Russia, there has been an observation of an American mink killing a female polecat (D. Skumatov, personal observation). A meta-analysis of datasets from 21 countries found that polecat adult sex-ratio is skewed toward males in populations

coexisting with American mink (Barrientos 2015). This could become an issue of conservation concern if the number of reproductive female polecats declines (Barrientos 2015). However, in Britain, polecats coexist with American mink and in a study in southern England, mink changed their activity patterns to become predominantly diurnal in the presence of polecats and Eurasian otters, which may be an avoidance mechanism facilitating the coexistence of mink, otters and polecats (Harrington et al. 2009), although the study was unable to attribute this avoidance mechanism specifically to otters or polecats or a combination of both species. Further research into competition between and coexistence of American mink and polecat would be worthwhile.

The expansion of the non-native raccoon dog *Nyctereutes procyonoides* has impacted polecats in Belarus, as the two species compete for carrion in late winter and early spring (Sidorovich et al. 2008). In areas of Belarus, such as the Lovat terrain, which are completely occupied by the raccoon dog, polecats have almost disappeared from forest-bog mosaic and have become less common in valleys (Sidorovich 2011a). Raccoon dogs have been recorded attacking litters of small and medium-sized mustelids in breeding dens and whilst there is no evidence of raccoon dogs killing polecat kits, it has been suggested that this behaviour is plausible (Sidorovich 2011a). In addition to competition between polecats and non-native carnivores, the decline of polecats in Belarus and some local exclusion of polecats in Latvia has been attributed to the population and range expansion of the stone marten, a native carnivore, around human settlements (V. Sidorovich pers. comm. 2016, J. Ozolins pers. comm. 2015). The transmission of diseases to polecats from sympatric carnivores could be an emerging issue for polecat populations; in Russia and Belarus, multiple cases of rabies in wild polecats have been confirmed and there have also been cases of polecats with Aleutian mink disease (Skumatov 2004). In Belarus, it has been hypothesised that an epidemic of an unknown disease caused a crash in the American mink population in 2003 (Sidorovich 2011a). Following the epidemic, it was noted that some local polecat populations declined, suggesting this presumed disease was a threat also to polecats (Sidorovich 2011b).

Secondary poisoning and environmental pollutants

Secondary poisoning and environmental pollutants are known to affect polecats in parts of the species' range. Polecats are exposed to second-generation anticoagulant

rodenticides (SGARs) through the consumption of poisoned rodents. In Britain, 31% of polecats analysed contained SGAR residues (Shore et al. 2003). Polecats are particularly vulnerable to exposure to rodenticides because those living in farmland prey heavily on rats around agricultural premises in autumn and winter when rodenticide use is at a peak (Shore et al. 2003). However, Shore et al. (2003) had no concerns that the current usage of SGARs would limit further polecat range expansion in Britain. In south-western France, Bromadiolone residue was found in 15% of analysed polecats and two polecats had lesions and liver residues indicating that Bromadiolone was directly responsible for their death (Fournier-Chambrillon et al. 2004). Incidental poisoning is considered to be one of the main contributors to the decline in the polecat population in Croatia (Konjević 2005). In Switzerland, a major decline of the otter population prior to the 1980s was partly attributed to high levels of PCBs (polychlorinated biphenyls) in frogs (Weber 1990), which can also constitute a major prey source for polecats. However, a study in south-west Germany found that PCB levels in polecats and their prey (frogs and toads) are comparatively low and concluded that polecats could feed exclusively on amphibians without consuming a harmful amount of PCBs, thus PCBs could not then be a factor affecting polecat populations at that time (Engelhart et al. 2001). In Spain, the suspected decline of polecats is thought to be associated with the use of pesticides (E.J. Virgós pers. comm. 2015).

Harvesting and killing of polecats and conflict with human interests

The polecat is still legally harvested in parts of its range in Eastern Europe, Scandinavia and Russia and the impact on the population has not been examined. Overall, the number of polecats caught and taken from the wild is low (Skumatov et al. 2016) and is significantly smaller than numbers of trapped pine martens and American mink. In Russia, intentional harvesting of polecats is not intensive because the price of polecat pelts is very low (approximately 350 Russian Roubles or 3–4 US Dollars in 2015–2016); five–ten times less than for pine marten and stone marten pelts and two–three times less than for American mink pelts.

The polecat suffers from a poor cultural image and a negative reputation and is still perceived as a pest species or ‘vermin’ in some countries (Packer and Birks 1999, Konjević 2005). A questionnaire survey of gamekeepers in Britain, where the polecat population is increasing, found that most (68%) regarded the polecat as a minor

pest (Packer and Birks 1999). Conflict with human interests, both real and perceived, often arises from polecat predation of poultry and game birds (Packer and Birks 1999, Konjević 2005). In Russia, polecats are occasionally killed when they are perceived as a threat to domestic livestock, such as chickens, ducks and rabbits. In Austria, it is legal to hunt polecats, as a perceived pest of wild game, throughout the year (A. Kranz pers. comm. 2016).

In many countries where polecats were hunted historically for fur and sport and persecuted as a pest, the species now has legal protection which prohibits hunting and intentional killing. In Britain, the polecat population underwent a severe historical decline due to persecution for the protection of game birds and harvesting for fur (Langley and Yalden 1977). A reduction in persecution allowed the population to recover from the mid 20th century and the polecat has been afforded limited legal protection since 1982, which prohibits certain methods of killing it (Birks and Kitchener 1999). In France, the polecat was classified as a ‘pest’ in half of the French departments in 1997, 1999 and 2007 (Ruelle et al. 1999, Albaret and Ruelle 2012) and only incidental hunting is allowed (Aubry et al. 2016). Trapping of polecats in France was prohibited from August 2012 to July 2015 (Albaret et al. 2014); then subsequently from July 2015 to July 2018, trapping of polecats is not permitted except in two areas of France. In Switzerland, only one individual polecat was killed, under a special licence, in each of the years 2009, 2013 and 2014 (P. Dollinger pers. comm. 2016). The overall impact on the species of any intentional killing of polecats in these countries must be fairly minimal.

Even in countries where it is no longer legal to hunt or kill polecats, polecats are vulnerable to mortality through predator control aimed at other species. In Britain, polecats are caught and sometimes injured or killed in traps set for species such as American mink, stoat *Mustela erminea*, least weasel *Mustela nivalis*, or common rat *Rattus norvegicus* (Croose 2016). In the Atlantic biogeographical region of France, polecats may be misidentified as American mink and killed during mink trapping programmes, but the impact of this has not been quantified (S. Ruelle, personal observation). Road traffic collisions are also a major form of recorded mortality of polecats (e.g. Kristiansen et al. 2007, Croose 2016), and the presence of rabbits, a major prey and carrion source, on or adjacent to roads may increase the risk of mortality from vehicle collisions (Barrientos and Bolonio 2009, Barrientos and Miranda 2012). An increase in road network density and traffic flow in parts of Europe could potentially have population-level effects on polecats.

Hybridisation

Western polecats hybridise with other species of Mustelinae such as Steppe polecat, European mink, Siberian weasel *Mustela sibirica*, and domestic or feral ferret (Ternovsky and Ternovskaya 1994, Cabria et al. 2011, Skumatov 2011, Costa et al. 2013). Western polecats hybridise with Steppe polecats in a zone of sympatry in parts of Eastern Europe and Russia and wild-caught hybrids are held in museum collections in parts of Russia and Ukraine (Ternovsky and Ternovskaya 1994). The sympatry is a recent phenomenon resulting from range expansion of Steppe polecats in Europe over the last 100–150 years (Heptner 1967). This suggests that such hybridisation might potentially be a threat to the Western polecat. Hybridisation between polecats and the endangered European mink has been recorded in France (Lodé et al. 2005), Belarus (Sidorovich 2011c), Finland (Granqvist 1981), Estonia, Spain and Russia (Cabria et al. 2011). However, hybridisation and genetic introgression between the two species are uncommon events (Cabria et al. 2011) and thus seem unlikely to affect the polecat population, which is very much larger than that of the European mink. In Britain, polecats hybridise with domestic and feral ferrets to produce polecat-ferret hybrids and the proportion of admixture in wild polecats is relatively high (31%) (Costa et al. 2013). Whilst the polecat phenotype seems to have selective advantage over the ferret phenotype in the wild, the impact of widespread introgression of ferret DNA into the polecat population and possible impacts on the fitness of introgressed individuals are unknown (Costa et al. 2013). In Saxony-Anhalt, Germany, introgression with domestic ferrets has been found in 6% of polecat individuals analysed genetically and in 10% of individuals assessed morphologically (A. Weber pers. comm. 2016).

Overall, the causes of population declines across parts of the polecat's range have not been examined systematically and thus are poorly understood. It seems probable that it may be a combination of factors and the exact contributors may vary across the polecat's range. Unknown for many potential contributory factors is whether they have a population-level effect on the species as a whole or merely affect polecats on an individual or local level through, for example, premature death. Distinguishing these effects could help to infer whether these contributors will lead to a decline in polecat populations.

Limitations of the review

This review was somewhat limited in its scope, precision and potentially accuracy by the paucity of reliable data

on polecat population trends for much of its range. A key issue appears to be that in most countries, the polecat is not a species of conservation priority, management interest or economic importance (for example, in Italy, Spain and Croatia, and indeed most countries where, unlike in Britain and Switzerland, the species has never been reduced to small remnant populations). It is therefore one of the least-studied carnivores in Europe. Much of the information used in this review relied on the opinions of researchers or unsystematic and unquantified information, with little or no scientific data to corroborate it. Whilst expert knowledge is widely used in the science and practise of conservation, often due to a relative lack of data, such judgements may be biased, poorly calibrated, or self-serving and therefore result in poor inference and decision making (Martin et al. 2012). Additionally, some of the data used to inform polecat population trends were derived from hunting bags or records (for example, in Russia, Germany, Austria, Romania and Sweden). As such, these data may be more of an indication of changes in trapping and hunting efforts than of changes in polecat population trends, as was found to be the case for stoat and least weasel bags in England (McDonald and Harris 1999); therefore, caution is needed when inferring trends from such information. Caution is also needed when interpreting population trend assessments based on information collected over short time periods. The abundance of some predator species fluctuates in accordance with small mammal abundance [for example, stoat and least weasel (Korpimäki et al. 1991) and hen harrier *Circus cyaneus* (Redpath et al. 2002)]. Consequently, polecat abundance may fluctuate accordingly in countries or regions where polecat diet comprises a high proportion of small mammal species. Thus, short-term trends in polecat populations may actually be an artefact of fluctuations in polecat prey species. Finally, it is problematic that there is a lack of robust monitoring methods for polecat populations, making it difficult to establish monitoring and recording schemes for the species.

Conservation implications and recommendations

Given the apparent widespread decline or suspected decline in many of the polecat's range countries, there is an urgent need to establish robust monitoring techniques and systematic monitoring programmes to gather accurate up-to-date data on polecat trends. An example of monitoring schemes used to gather data on polecats is the national polecat surveys of Britain, which have

used a citizen science-based approach to collect polecat records from naturalists, researchers and members of the public, to monitor the re-colonisation of the species in the country (Birks and Kitchener 1999, Birks 2008, Croose 2016). Furthermore, questionnaire surveys of naturalists, forestry agents and hunters have been used to elicit information on polecat distribution and preferred habitat types in the Valencia region of Spain (Virgós 2003). We recommend the prioritisation of research on polecats in countries where populations are known or suspected to be declining, with a focus on the collection of data to discern accurate population trends and research to determine the causes of declines. Furthermore, gathering up-to-date information on population trends in countries where polecats are not believed to be declining would be worthwhile, in order to confirm suspected trends equally. Improved national status assessments would better inform future IUCN Red List assessments on a global level.

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