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SPATIAL AND TEMPORAL CHANGES IN DISTRIBUTION AND ABUNDANCE OF THE EUROPEAN POLECAT *MUSTELA PUTORIUS* IN SW POLAND DURING THE YEARS 1980–2020

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Abstract. Using the hunting bags data, spatial and temporal changes in the population densities of the European polecat (*Mustela putorius)* in SW Poland (29 358 km^2, including 8411 km^2 forests) during the years 1981–2020 have been analyzed. Both hunting bags statistics and estimations generated by hunting clubs indicate a sharp increase in the numbers of polecats between 1997 and 2003. However, in the subsequent years, a decline was noticeable in Wrocław, Wałbrzych and Opole hunting regions, while in Legnica and Jelenia Góra hunting regions the population growth levelled off. The population density of the polecat ranged from 0.01 to 0.17 animals per 1000 ha in particular ecoregions in SW Poland. From 1981 to 2010, the number of harvested polecats was slowly but steadily increasing in SW Poland. The increase was very sharp in 2001–2003. However, since 2011, the harvest began to slightly decline. The number of harvested polecats (per one hunting season) in 2001–2020 was lower than that recorded at the end of the 19th century by an order of magnitude. The hunting bag analysis reflects rather poorly the actual population size, as it contains data on the number of shot animals, not those that are alive. However, if hunting bag data are collected by the same methods over several years, they might be used to calculate relative differences of numbers in time and space. In such case, it is however important to keep in mind that bags may reflect population trends as much as shooting efforts. By assuming that the effort was constant over the years 1980–2020 in the present study, the recorded population trend is fairly reliable. The following conservation measures should be considered: raising public awareness, preservation and restoration of suitable habitats, establishment of ecological corridors and reduction of rodenticide use. Mitigation measures should be implemented to reduce road collisions, while trap use in predator control should be abolished. The polecat should be considered for partial legal protection in the whole of Poland.

INTRODUCTION

The European polecat *Mustela putorius* (hereafter referred to as the "polecat") is a meso-carnivore of the family Mustelidae. It occurs throughout Europe, except for Ireland, Norway, and most extreme northern and south-eastern parts of this continent. It inhabits forests, meadows, wetlands and farmlands, often in close proximity to water. The polecat is regarded as a generalist predator feeding mainly on small rodents and birds, but it might specialize locally on a particular prey species such as rabbits, rats, voles, frogs and possibly alien crustacean decapods (Ryšavá-Nováková and Koubek 2009; Malecha and Antczak 2013; Costa et al. 2014; Sainsbury et al. 2020).

Globally, the polecat population is regarded as large and stable, with local declines and increases (Lariviere and Jennings 2009), but a recent review of the polecat status showed that it is in decline in many European countries (Croose et al. 2018). It is also listed as 'least concern' on the IUNC Red List and in Appendix III of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and in Annex V of the EU Council's Directive on the conservation of natural habitats and of wild fauna and flora (EU Habitats Directive). In many countries, the polecat is legally hunted for fur (for example, in Russia and Scandinavia) or trapped as a perceived pest species (for example, in Croatia), while in other countries it receives some level of legal protection (for example, in Britain and Luxembourg) (Birks 2008; Skumatov et al. 2016).

In Poland, the status and distribution of the polecat has not been revised since the early 1980's. In that period, it was regarded as common throughout the country (Pucek and Raczyński 1983). However, during a long period of time (mostly in 1950–1979), it was recorded only in

133 UTM atlas grids. Since each grid covered 100 km^2, the polecat was recorded in merely 5% of grids covering the whole territory of Poland. Since most of these records were made accidentally, with no regular surveys conducted in any part of the country, the coverage was far from completion. Only in the south-western part of the country, the status and abundance of the polecat was investigated in earlier years, using the hunting bags data (Pax 1925, Kopij 1996).

Monitoring the distribution and abundance of the polecat is crucial to its management and conservation. In order to apply management and conservation measures, regional and country-wide surveys are needed to accurately map (in high resolution maps) the occurrence of the polecat and precisely assess its population trends. The purpose of this study was to present maps of polecat distribution in SW Poland, trace long-term population changes, and assess population densities in various macro-regions in SW Poland.

MATERIAL AND METHODS

The study area is situated in SW Poland (Figure 1). It comprises two provinces (voivodships): Opole Province (województwo opolskie) and Lower Silesian Province (województwo dolnośląskie). The total surface area of such defined study area is 29,358 km^2. For further details regarding climate, land use, and hunting districts see Kopij (2022, 2023).

This study is based on the hunting bags and quotas from the years 1981–2020 (archived by the Polish Hunting Association Research Station in Czempiń near Poznań). The estimations (quotas) were based on the same rules as applied to other game mammals in SW Poland (Kopij 2022, 2023; Kopij et al. 2015; Kopij and Panek 2016).

Members of a hunting club and the staff of forest districts located in a given hunting district made an effort to estimate numbers of polecats in their respective hunting district. Their estimation was based on direct field observations conducted throughout the year in this hunting district. Observations were analysed, summed and assumed as estimations.

According to the Polish Hunting Code, polecats can be hunted (mostly by shooting, occasionally by trapping) from 1 September to the end of March, or throughout the year in hunting districts where the capercaillie *Tetrao urogallus* and black grouse *Tetrao tetrix* occur (Dz. U. 2020.1683). Hunters are legally required to report on the number of shot animals.

Harvested numbers (Figures 2, 3) are expressed as the total number of polecats harvested in a hunting district during 20 hunting seasons (i.e. in 2001–2020). In each year, the hunting season begins on the 1st of April and ends on the 31st of March of the successive year. Population density (Table 1) was calculated as the mean estimated number of alive polecats per 1000 ha of the overall surface area.

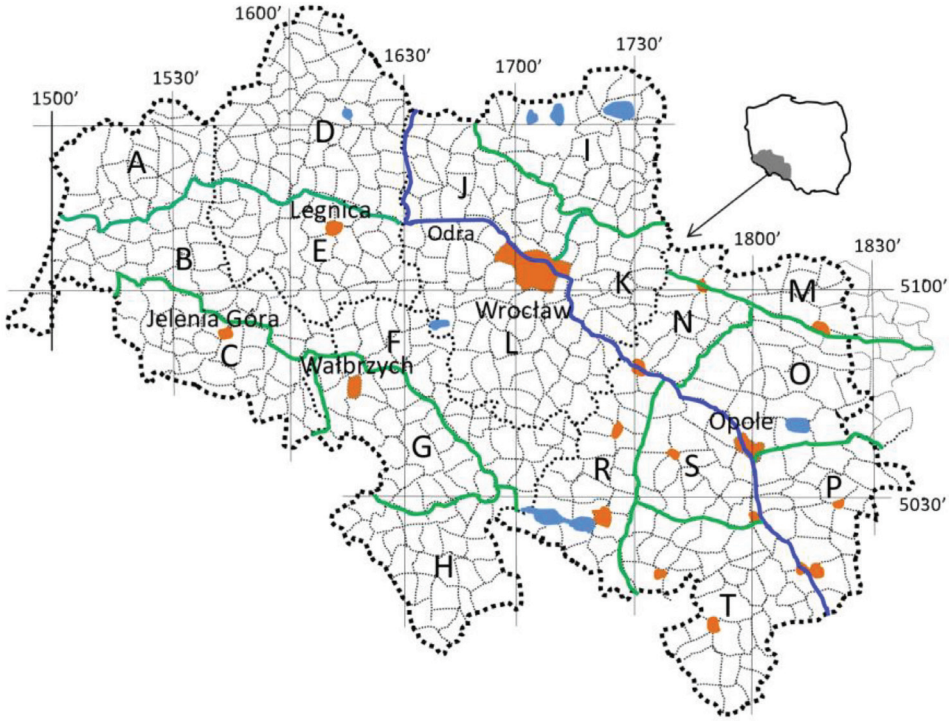

Figure 1. The study area, SW Poland, divided into hunting districts, 5 hunting regions and 19 ecoregions.

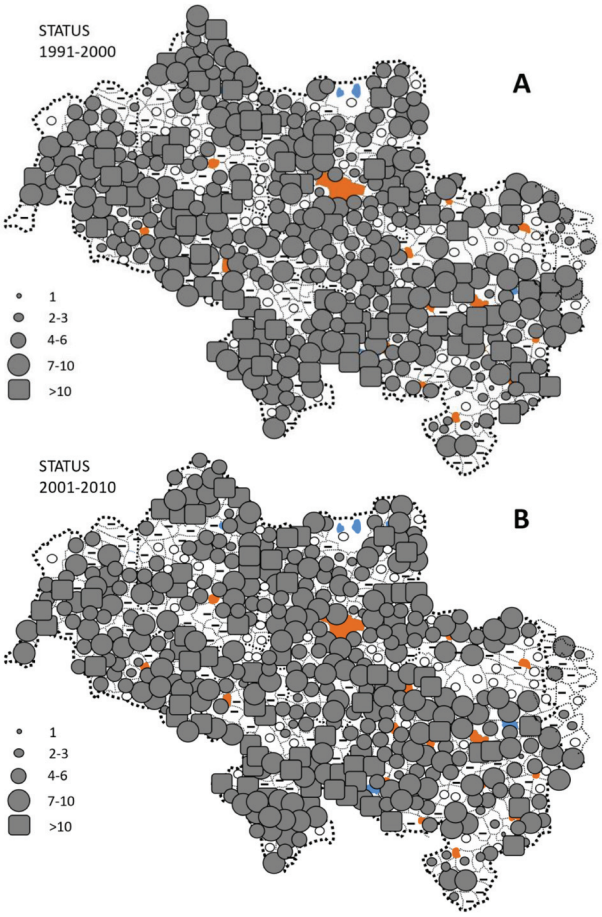

Figure 2. Estimated mean numbers of alive polecat per year in particular hunting districts in SW Poland during the years 2001–2010 (A) and 2011–2020 (B). White circles denote the lack of data, small dashes – no records.

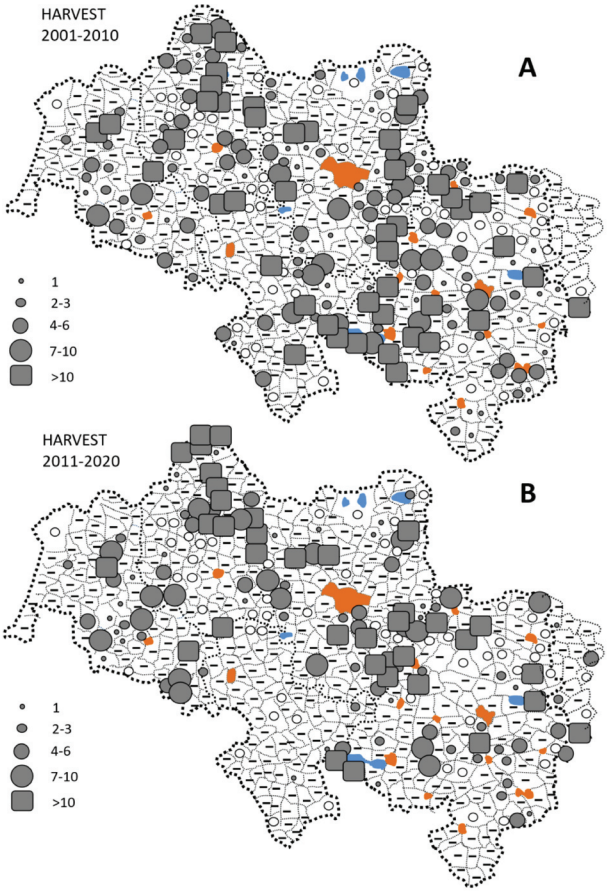

Figure 3. The number of harvested polecats in particular hunting districts over ten years period in SW Poland during the years 2001–2010 (A) and 2011–2020 (B). White dots denote the lack of data, small dashes – no records.

RESULTS

The polecat is widely distributed in SW Poland (Figures 2AB, 4A). Both hunting bags statistics and estimations generated by hunting clubs indicate a sharp increase in the numbers of this species hunted between 1997 and 2003. However, in the subsequent years (2004–2019), a decline was noticeable in Wrocław, Wałbrzych and Opole hunting regions (hereinafter, the HRs), while in Legnica and Jelenia Góra hunting regions the population growth levelled off (Figures 2–5).

The population density of the polecat ranged from 0.01 to 0.17 animals per 1000 ha in particular ecoregions in SW Poland (Table 1). It was the highest (0.17) in the northern part of Legnica HR and in Oleśnica, Brzeg and Nysa Lands (0.08–0.10) (Table 1).

In 2000–2010, no animals were recorded (seen alive) in 62 hunting districts (including 18 in Opole HR). No polecats were also recorded (seen alive) in a similar number of hunting districts (65, including 23 in Opole HR) in 2011–2020 (Figure 2). In 2001–2010, no animals were harvested (shot) in 141 hunting districts, while in 2011–2020 in 160 (59 and 39, respectively, in Opole HR) (Figure 3). In 2001–2010, more than 10 animals were harvested (shot) in 47 hunting districts, while in 2011–2020 in 35 hunting districts (19 *vs*. 10, respectively, in Opole HR) (Figure 3).

In 2011–2020, no polecats were recorded in 38 hunting districts (including 9 in Opole HR). In 14 hunting districts (including 3 in Opole HR), there were 21–30 polecats. In all other hunting districts, the number was lower than 20 (Figure 4A). In the same period, more than 50 polecats were harvested in 8 hunting districts, and 41–50 polecats in 12 hunting districts. In all remaining hunting districts, the numbers were lower (Figure 4B). During the years 2011–2020, a decrease in the number of harvested polecats took place in 82 hunting districts (mostly in the south, 25 in Opole HR and 14 in Wałbrzych HR). An increase in the number of harvested polecats was recorded in 48 hunting districts (including 12 in Opole HR). The harvesting remained stable in 18 hunting districts (Figure 4C).

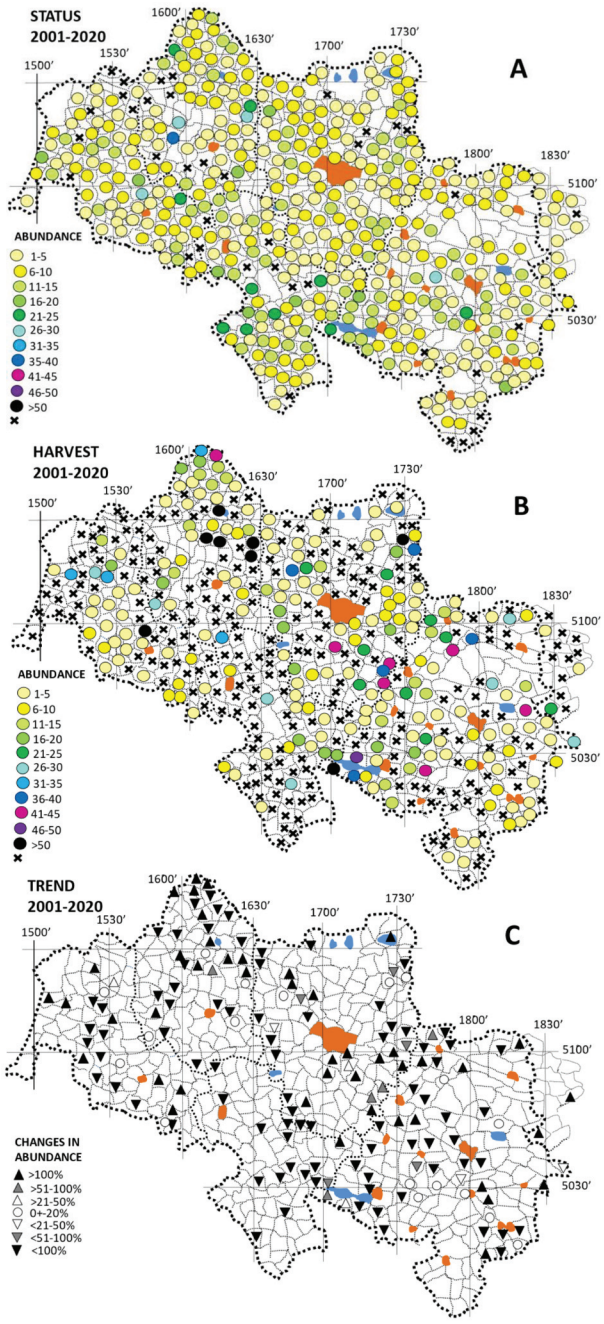

Figure 4. Abundance (mean number of alive polecats per year) (A), overall harvest (number of polecats shot over 10 years period) (B) and population trends (C) of the polecat in particular hunting districts in SW Poland during the years 2001–2020. The status refers to estimated mean number of alive polecats occurring in a particular hunting district, while harvest refers to the total number of polecats harvested (shot) in a particular hunting district during the years 2001–2020.

From 1981 to 2010, the number of harvested polecats slowly but steadily increased in SW Poland. The increase was very sharp in 2001–2003. However, since 2011, the harvest begun to slightly decline (Figure 5C). In Opole HR, a steady increase in the number of polecats took place in harvesting during the years 1981–2012, and a sudden decrease in subsequent years. In Wrocław

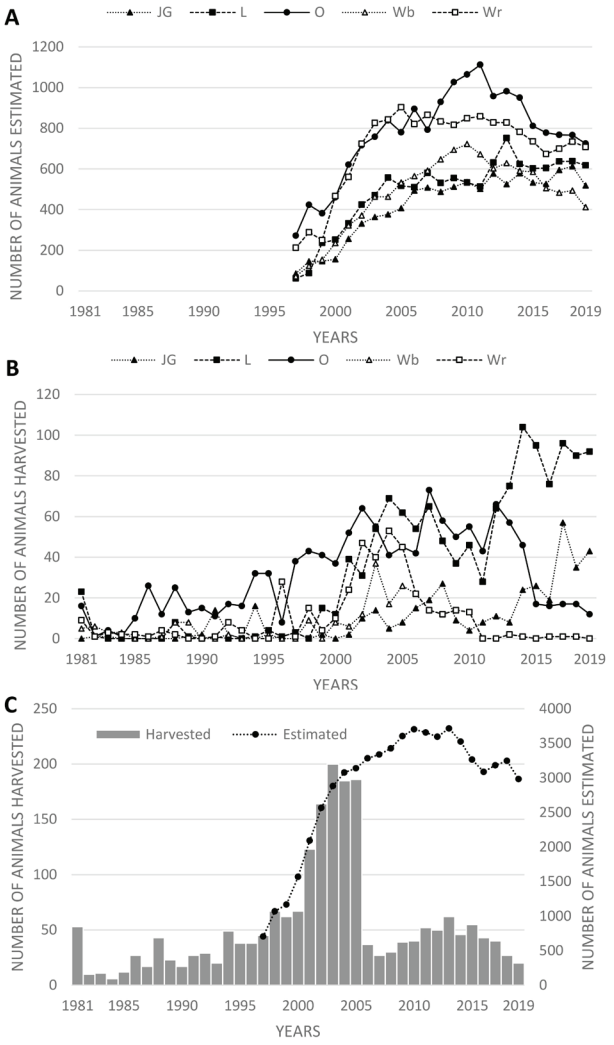

Figure 5. Changes in the number of estimated (A) and harvested (B) polecats in particular hunting regions (A, B) and the whole SW Poland (C) during the years 1981–2020. Explanation of abbreviations: JG – Jelenia Góra Hunting Region (HR), L – Legnica HR, Wb – Wałbrzych HR and Wr – Wrocław HR.

HR, 10–50 animals were shot per year in the years 1998–2010, but no harvest took place in other years before and after this period. A similar pattern was in Wałbrzych HR. In Legnica HR, the increase began in 1998, while in Jelenia Góra HR it begun in 2002 (Figure 5B). Overall, the polecat was therefore widespread and relatively common in SW Poland.

DISCUSSION

In Europe, polecat populations have differing trends (Konjević 2005; Reimoser et al. 2006; Birks 2008; Sidorovich 2011; Berzins and Reutte 2014; Costa et al. 2014; Croose 2016; Croose et al. 2018; Osinga et al. 2022). In the 1885/1886 hunting season, 12 individuals per 100 km^2 on average were harvested in SW Poland

(Pax 1925). Therefore, in total c. 3600 polecats were shot in that single hunting season in the whole region (29 358 km^2). Later on, the polecat appears to be much less common in this region: in 1965–1969 (4 hunting seasons), only 194 individuals were harvested in the area of 8535 km^2 of the Opole HR (Kopij 1996); in 2004–2008 it was recorded in 285 out of 871 forest districts, and the number of polecat families was estimated at 321 (Kopij 2016); the number of harvested polecats (per one hunting season) in 2001–2020 (Figure 5) was lower than that recorded at the end of the 19th century (Pax 1925) by an order of magnitude.

The main methods used to study and monitor polecats are live trapping (e.g. Birks 1997), radio-telemetry (Baghli and Verhagen 2003), collection of road casualties, sightings and analysis of hunting bag and pelt harvesting data (Birks 2008; Berzins and Reutte 2014; Costa et al. 2014; Croose 2016; Osinga et al. 2022). The hunting bag analysis, applied also in the present study, is the most commonly applied method over larger areas. It is also often used to assess population trends. It reflects rather poorly the actual population size, as it contains data on the number of shot animals, not those who are alive. However, if hunting bag data are collected by the same methods over several years, they might be used to calculate relative differences of numbers in time and space (Longbein et al. 1999). In such case, it is however important to keep in mind that bags may reflect population trends as much as shooting efforts. By assuming that the effort was constant over the years 1980–2020 in the present study, the recorded population trend is fairly reliable. The hunting effort might be influenced by the current fur/pelt prices. The number of harvested animals might increase when the prices increase, and they might decrease with the decrease of these prices. For example, in 2015, 9.3 million mink skins were sold in Poland at an average price of 158 PLZ, while in 2019 the production decreased to 6.6 million mink skins (average price 96 PZL). In April 2016 there were 689 active fur farms in Poland, in February 2020 the number decreased to 497 (https://jutrobedziefutro.pl/2020/03/04/polska-branza-futrzarska-w-najwiekszym-kryzysie-od-lat-tak-zle-jeszcze-nie-bylo).

The factors controlling polecat populations are not well-understood. The following are the most important: degradation and modification of habitats, changes in prey availability, competition with other carnivores, secondary poisoning, shooting and trapping, hybridization (Croose et al. 2018). In SW Poland, the drainage of wetlands and removal of hedgerows from farmlands are the main habitat changes negatively affecting polecat populations.

Rabbits comprise an important prey of the polecat in Mediterranean countries and Britain (Lode 1997; Santos

Table 1. Population densities (individuals per 1000 ha) of the polecat (average from 2001–2020). Symbols in the first column (A, B, C…) refer to these in Figure 1.

#	Region	Hunting districts	Surface area [ha]		% forests	Popul. density
			general	forests		
	Jelenia Góra Hunting Region					
A	Lower Silesian Forests	5, 7, 12, 15, 16, 20	33211	27782	83.7	0.01
B	Silesian-Lusatian Lowland	31, 33, 39, 40, 43, 52	25500	6438	25.2	0.01
C	West Sudeten Mts.	54, 55, 66, 71, 78, 80	28332	20249	71.5	0.04
	Legnica Hunting Region					
D	Northern (lowland) part	1, 2, 17, 18, 33, 35	22795	8467	37.1	0.17
E	Southern (hills) part	62, 67, 69, 71, 72, 78	29400	3754	12.8	0.07
	Wałbrzych Hunting Region					
F	Sudeten Upland	6, 7, 21, 31, 38, 39	26700	3730	14.0	0.01
G	Middle Sudeten Mts.	10, 18, 23, 25, 28, 30	26715	10576	39.6	0.02
H	East Sudeten Mts.	54, 67, 69, 70, 72, 82	16191	9491	58.6	0.01
	Wrocław Hunting Region					
I	Barycz Valley and Trzebnica Hills	2, 7, 8, 13, 15, 16	30127	10091	33.5	0.01
J	Głogów-Milicz Depression	10, 30, 32, 45, 47, 59	27803	9090	32.7	0.02
K	Oleśnica Plain	71, 85, 86, 95, 96, 107	27283	9154	33.6	0.10
L	Wrocław Plain	67, 79, 90, 100, 113, 116	28938	1884	6.5	0.08
	Opole Hunting Region					
M	Northern part of the Opole Province	3, 7, 12, 14, 15, 16	32497	4375	13.5	0.07
N	Brzeg Land	17, 19, 20, 21, 50, 51	33704	11738	34.8	0.10
O	Stobrawa Forests	28, 33, 34, 35, 36, 39	38926	32444	83.3	0.05
P	East-central part of the Opole Province	82, 83, 91, 123, 126, 129	41259	20721	50.2	0.01
R	Nysa Land	74, 76, 78, 114, 120, 122	34320	2258	6.6	0.09
S	Niemodlin Forests	47, 59, 64, 67, 96, 101	41259	20721	50.2	0.04
T	Głubczyce Plateau	105, 109, 132, 133, 138, 146	34320	2258	6.6	0.02

et al. 2009; Sainsbury et al. 2020), while frogs are in Poland and Switzerland (Malecha and Antczak 2013; Wilson and Delahay 2001; Sainsbury et al. 2020). The widespread declines of these prey, also in SW Poland, might negatively affect the local polecat populations. The decline in other prey populations, such as the European hamster *Cricetus cricetus,* might also negatively affect polecats.

The polecat is regarded as a pest in some areas (especially where pheasants are bred by hunters for release as hunting game) and it is still persecuted by game keepers and farmers. Such pheasant breeding sites are fairly widespread in SW Poland and may greatly contribute to the declines of the polecat around such sites (functioning as ecological traps). The polecat is prone to poisoning by PCB (polychlorinated biphenyls), second-generation anticoagulant rodenticide (SGAR) and bromadiolone used in agriculture to control rodents (Sainsbury et al. 2018). Since these poisons are harmful to the environment, their use should be restricted or abolished altogether.

In SW Poland, the polecat may compete for the same food resources with alien predators, such as the racoon dog *Nyctereutes procyonoides*, American mink *Neovison vison*, and raccoon *Procyon lotor*, and possibly with the indigenous beach marten *Matrtes foina* and otter *Lutra lutra* (Baghli and Verhagen 2003; Hammershoj et al. 2004; Lariviere and Jannings 2009; Ryšavá-Nováková and Koubek 2009; Eeraerts et al. 2022). Especially important in this regard is the American mink which often occupies the same habitat as the polecat. Harrington and MacDonald (2008) and Brzeziński et al. (2010) documented, however, that these two carnivores may coexist in such habitats even under fairly high population densities as they can shift their daily feeding activities.

The polecat is known to hybridize with the domestic and feral ferret *Mustela putorius furo*. For example, 31% of polecats in the UK and 6–19% in Germany are actually polecat × ferret hybrids (Croose 2016; Costa et al. 2014). The occurrence of these different forms (wild polecat, domestic ferret, feral ferret and polecat/ferret hybrids) is largely unknown in SW Poland, as well as in other parts of this country.

Since the polecat is in decline in SW Poland and possible also in other parts of the country, the following conservation measures should be considered: raising public awareness, preservation and restoration of suitable habitats (polecats are strongly associated with riparian and wetland habitats), establishment of ecological corridors (e.g. hedgerows in farmlands) and reduction of rodenticide use. Mitigation measures should be implemented to reduce road collisions, while trap use in predator control should be abolished. The polecat should be considered for partial legal protection in the whole of Poland.

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