Doctoral (Ph.D.) dissertation

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Gödöllő
2025

Hungarian University of Agriculture and Life Sciences

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TRANSBOUNDARY CONSERVATION FOR SMALL FELIDS: ASSESSING THREATS AND DISTRIBUTION OF PALLAS'S CAT AND EUROPEAN WILDCAT IN RELATION TO CONSERVATION BEHAVIOR

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DECLARATION

Signed below, Chimed Otgontamir, a student of the Szent István Campus of the Hungarian University of Agriculture and Life Science, studying for a doctoral degree (Ph.D.) in Doctoral School of Animal Biotechnology and Animal Sciences declare that the presented dissertation is my own work, and I have used the cited and quoted literature in accordance with the relevant legal and ethical rules. I understand that the three-page-summary of my dissertation will be uploaded on the website of the Campus/Institute/Course and my dissertation will be available at the Host Department/Institute and in the repository of the university in accordance with the relevant legal and ethical rules. There is no confidential data are presented in the dissertation.

Date: September 15 / 2025

Chimed Otgontamir

Signature:

DEDICATION

In loving memory of my dear father, Dagdan **Chimed**.

Table of Contents

List of Figures:

List of Tables:

List of Appendices:

List of Acronyms and Codes:

IUCN	–	International Union for Conservation of Nature
LEK	–	Local Ecological Knowledge
HNP	–	Hustai National Park
GMU	–	Game Management Unit
UTM	–	Universal Transverse Mercator
CLC	–	Corine Land Cover
TRI	–	Terrain Ruggedness Index
LC	–	Least Concern
EU	–	European Union
EEC	–	European Economic Community
GPS	–	Global Positioning System
m	–	meter
ha	–	hectare
km	–	kilometer
kg	–	kilogram

1. BACKGROUND AND RESEARCH PROBLEM

1.1. Introduction

The background of this study arises from the critical and ongoing conservation challenges faced by endangered small felids across their ranges, specifically in Hungary and Mongolia. Mongolia is home to a remarkable diversity of wildlife, from large carnivores and ungulates to small rodents and bats, many of which are globally threatened or endemic to Central Asia (Nyamsuren et al., 2022). Despite having a rich and varied ecosystem, the country has faced a notable decline in wildlife over the past few decades, primarily due to overhunting, habitat destruction, overgrazing by livestock, and illegal hunting and trade (Clark et al., 2006; Wingard & Zahler, 2006).

Among these, Pallas's cat (*Otocolobus manul* Pallas, 1776), also known as manul, is one of the most threatened species in the cat family, both locally and regionally. Mongolia is a critical stronghold for the species, harboring the largest known population within its global range (Ross et al., 2020; Nyamsuren et al.. 2022), highlighting the country's essential role in survival and continued existence of Pallas's cats. However, the population trend of the Pallas's cat is declining (Ross et al., 2020; Chimed et al., 2021), with various factors posing significant threats. The main threats to the species include habitat loss and fragmentation due to increasing human and livestock populations, infrastructure development, mining, illegal hunting, killings by herding dogs, decreasing prey numbers (primarily from poisoning), and climate change (Clark et al., 2006; Ross et al., 2019, 2020).

Another notable small felid is European wildcat (*Felis silvestris* Schreber, 1777) hence “wildcat”, which, much like Pallas's cat, faces its own set of conservation challenges. The wildcat is once widespread throughout Europe and now is one of the most at-risk species (Nowell & Jackson, 1996; Macdonald et al., 2010). The species has suffered due to increasing human pressure, which has gradually reduced much of its population over the last two centuries (Nowell & Jackson, 1996; Pierpaoli et al., 2003). As a result, its continental distribution is largely fragmented at local and regional scales, and several factors, such as habitat destruction, direct and indirect persecution, and hybridization with domestic cats (*Felis silvestris catus*), are currently threatening its population in Europe (Gerngross et al., 2022; Mitchell-Jones et al., 1999; Nowell & Jackson, 1996; Stahl & Artois, 1994). Central European countries, such as Hungary, are among the richest in Europe in terms of wildlife, with diverse geographical features like wide-open plains and forested hills that provide habitats for numerous carnivores, including the wildcat.

The background of the study, therefore, emphasizes the urgent conservation needs of small felids across different regions, particularly focusing on wildcats in Hungary and Pallas's cats in Mongolia. This research aims to contribute detailed insights into their distribution, habitat use, and the local and regional threats they face. By evaluating the potential threats and current distribution patterns of small felids in relation to key habitats, this research provides valuable insights into the ecological needs and conservation challenges faced by these threatened carnivores and contributes to identifying priority areas for their long-term persistence and effective conservation.

1.2. Research problem

1.2.1. Population decreases in felids and their vulnerability

Concerns over the decreasing number of biodiversity worldwide have led conservationists to work for the safeguarding of species that are at risk of extinction (Sanderson et al., 2002; Sheppard et al., 2024; Woodroffe & Ginsberg, 1998). Habitat loss is a global phenomenon affecting all species and is the most critical threat to all extant cat species (Gross, 2012b; Macdonald & Loveridge, 2010). As an animal group, they are homogenous in their genetic makeup and ecological roles, shaped by these shared traits, make them especially vulnerable to human-induced changes (Johnson et al., 2006; Morales & Giannini, 2010). Among mammals, felids are the most admired, paradoxically, the most endangered families, with populations generally declining and some species at risk of extinction (Cardillo et al., 2004; Lamberski, 2015; Macdonald & Loveridge, 2010). In this study, we will focus on two small-sized wild felids: the wildcat in Hungary and the Pallas's cat in Mongolia.

Both species are currently listed as 'Least Concern' on the IUCN Red List due to their wide distribution, although they have severely fragmented populations and a declining global population trend (Gerngross et al., 2022; Ross et al., 2020). Hungary hosts a significant and stable population of wildcats: however, the species' distribution has shrunk, with most of its former range vanishing and some areas experiencing permanent local extinction. Consequently, wildcat populations in Hungary have been completely restricted to the northwest and central regions of the country (Heltai et al., 2006; Mitchell-Jones et al., 1999). In Hungary, the wildcat has been 'strictly protected' since 2012, and long-term conservation and management for the species were recommended by Stahl & Artois (1994). One crucial proposal recommended regular monitoring of the distribution of wildcats. Similarly, the Pallas's cat is listed as a 'Near Threatened' species according to the Mongolian Red List of Mammals (Clark et al., 2006).

The species faces a substantial lack of basic information, including limited data on its regional distribution, threats, and population trends across its Central Asian stronghold (Ross et al., 2019, 2020). Understanding species distributions, identifying threats, and determining their occurrence are essential in conservation biology, particularly for species that are rare, threatened, or have experienced significant declines in their range (Rushton et al., 2004; Taubmann et al., 2016).

1.2.2. Conservation challenges to small felids

Conservation and research efforts have been heavily biased towards larger, more charismatic species, such as tigers and snow leopards, leaving many smaller-bodied felids with far less attention (Brodie, 2009). Studies on the effects of habitat loss and fragmentation in felids showed a similar trend (Zanin et al., 2015). For example, larger cats may be easier to study and face greater threats as apex predators, being heavily exploited for traditional medicine and trophy hunting (Macdonald & Loveridge, 2010; Ripple et al., 2014). Additionally, large felids' charismatic nature attracts more attention from both public and scientists (Macdonald et al., 2015). As a result, many smaller-sized, highly threatened, and elusive wild felids frequently overlooked than their larger-bodied counterparts (Brodie, 2009; Dickman et al., 2015). The wildcat and the Pallas's cat are examples of species that are severely understudied and much of their ecology is remaining poorly understood.

Another significant issue is that studying felines in their natural habitat is notoriously difficult due to their low population density, large spatial requirements, nocturnal lifestyle, and shyness (Brodie, 2009; Ross et al., 2020), notably small felids whose small size make them exceptionally challenging to detect. This poses a significant challenge for conservation biologists, as effective conservation efforts rely on extensive knowledge of a species' ecology (Macdonald et al., 2010; Ross et al., 2019b). Both wildcats and Pallas's cats are greatly hindered by a lack of detailed ecological knowledge, with crucial information on their potential presence, mortality, and threats lacking (Gerngross et al., 2022; Ross et al., 2020), thereby limiting conservation efforts.

1.3. Research gap and rationale

This study addresses the research gap regarding the limited knowledge and conservation challenges of endangered small-sized felids, which are crucial for contributing to further research and developing effective conservation strategies that ensure their long-term survival. Despite the unique conservation challenges and limited knowledge of these species, countries like Hungary and Mongolia are facing significant threats to small felids. These threats include alarming population declines, increasing mortality rates and habitat destruction, all of which are jeopardizing the survival of these elusive and ecologically vital carnivores.

These challenges highlight the urgent need for in-depth research and conservation efforts focused on species such as the wildcat and Pallas's cat. This gap marks a critical opportunity to deepen our understanding of small felids and their survival needs, especially distribution patterns, key habitats, and the existing and potential threats they face in Hungary and Mongolia.

This research is driven by the urgent need to address the declining populations of small-bodied wild felids, the significant threats, the ongoing conservation challenges, and the lack of crucial ecological knowledge about these endangered species. The distribution of wildcats in Hungary has not been investigated in the last two decades. This research presents updated data on current distribution, changes over time, and the first broad-scale information on land use. Similarly, this study is the first to examine the distribution of Pallas's cats in relation to land use and topographic factors in Hustai National Park, Central Mongolia. Furthermore, this study provides the first comprehensive assessment of the threats to Pallas's cats in Asia and wildcats in Europe. Their secretive behavior and small size make them harder to detect, underscoring the need for a re-evaluation of these threats**.** Mapping distribution and identifying the biotic and abiotic factors that influence it are essential for understanding their distribution patterns and guiding conservation efforts for these rare carnivores.

1.4. Aim of the study

The primary aim of this study is to investigate the distribution patterns of Pallas's cats in Mongolia and wildcats in Hungary, and to identify the major threats facing these species within their ranges, using a consistent methodology across both countries.

1.4.1. Research objectives and questions

Below are the specific objectives of the study, which were identified in relation to the research problem; each objective is coupled with one or more research question(s).

a) To conduct the existing and potential global threats to small felids: Assess and evaluate across their respective distribution ranges, ranking these threats according to their severity.

a_1- What is the most serious threat to Pallas's cats in Asia?

a_2- What is the most serious threat to wildcats in Europe?

b) To assess local knowledge of Pallas's cats and wildcats within their respective natural ranges.

b_1- What is the level of local knowledge regarding Pallas's cats and wildcats among communities residing in the species' distribution ranges?

b_2- Which factors influence the ability of respondents to identify Pallas's cats in Mongolia?

c) To utilize local knowledge to understand and evaluate perceived threats to small wild felids among their distribution ranges.

c_1- What are the major threats to Pallas's cats in Mongolia?

c_2- What are the major threats to wildcats in Hungary?

d) To investigate the distribution of Pallas's cats in Mongolia by evaluating the species' current distribution in Hustai National Park and examining key habitat variables that influence species occurrence.

d_1- What is the current distribution of Pallas's cats in the national park?

d_2- Which landcover variables influence the occurrence of the species?

d_3- Which topographic variables affect its occurrence within the study area?

e) To investigate the distribution of wildcats in Hungary by assessing their current distribution, analyzing changes over time, and examining landcover influences across the country.

e_1- What is the current distribution of wildcats on a broad scale?

e_2- How has the distribution of wildcats changed between 2004 and 2022 in Hungary?

e_3- Which landcover variables impact wildcat occurrence in the study area?

f) To investigate temporal activity pattern of Pallas's cats using camera trapping in Mongolia.

f_1- What is the daily activity pattern of Pallas's cats in the study area?

f_2- What is the annual activity pattern of Pallas's cats in the study area?

By addressing these objectives and questions, the research aims to provide a comprehensive ecological understanding of small-bodied wild felids in Hungary, Mongolia, and beyond, specifically examining their distribution and threat patterns which are fundamental for conservation effort and management of these overlooked cats.

1.4.2. Hypotheses

Regarding the overall threat status of the wildcat and Pallas's cat worldwide: **Ha** – Globally, the study species face similar threats, particularly habitat loss and lack of prey. However, we expected that hybridization will be the most critical threat to wildcats, as it has been recorded across most of its range.

In terms of the Local Ecological Knowledge (LEK) of respondents regarding both small felids in their ranges, we hypothesized: **Hb -** The LEK of respondents from Game Management Units will be higher than herders in Hustai National Park, notably their ability to identify the species. **Hc** – We expected hybridization to be the most serious threat to the wildcat population in Hungary while herding dogs and a lack of prey pose major threats to the Pallas's cat in Hustai National Park.

Hd – Steppe may be a potential land cover for the distribution of Pallas's cats, as they utilize various types of steppe habitats. However, we predict that Pallas's cat distribution in the area will result in associations with rugged areas, providing suitable shelter and protection from predators.
We formulated several hypotheses based on the field-based research: **He** – The distribution of the wildcat in Hungary, as well as globally, has been decreasing. As a result, we predicted that the species' distribution will either decrease or remain stable during the study period. Wildcats would typically use forested areas and open areas with water bodies, while avoiding human settlements due to noise, light, dogs, and the presence of humans. **Hf** – We expected that the daily activity pattern of Pallas's cats will exhibit nocturnal behavior, with a peak in activity around the crepuscular hours. The species might be active throughout the year, but it is expected to show more activity in the summer and autumn due to prey availability and environmental conditions.

2. LITERATURE REVIEW

This chapter provides an overview of the cat family, with particular focus on small felids, their ecology, conservation challenges, and specific needs. It highlights the status of small felid populations across Europe and Asia, examining primary threats, distribution patterns, and the diverse land-use types inhabited by species such as wildcats and Pallas's cats. The chapter also discusses the research methods used to study these elusive felids.

2.1. Introduction to cat family

The family Felidae comprises 38 species of wild, cat-like carnivores distributed across all continent except Antarctica and Australasia. Felids inhabit a wide variety of environments, ranging from steppes and deserts to boreal and tropical forests (IUCN, 2017; Macdonald & Loveridge, 2010). However, over 60% of all living felid species are found in Asia, with the continent's tropical and temperate regions supporting the highest diversity (Macdonald et al., 2010).

Many small felids are habitat specialists, particularly in tropical and forested environments, and are typically found in closed-forest and woodland areas (Nowell & Jackson, 1996). Felids are remarkably diverse in terms of taxonomy, with species ranging in size from the smallest rusty-spotted cat (*Prionailurus rubiginosus*), weighing less than 1 kg, to the massive Siberian tiger (*Panthera tigris altaica*) reaching over 350 kg. Generally, less than 10% of the habitats of wild felids are within protected areas (Nowell & Jackson, 1996), and these iconic and endangered predators typically live outside such zones. Predators are essential in maintaining the balance and function of ecosystems, greatly influencing their prey populations (Crooks & Soulé, 1999; Estes et al., 2011), and felids, in particular, play a crucial role in safeguarding habitats and biodiversity, as they are recognized as both umbrella and flagship species (Macdonald et al., 2010).

There are a few species with extensive ranges that span several continents, such as the wildcat (Macdonald et al., 2010). The species evolved from its common ancestor (probably *Felis lunensis*) around 2 million years ago, but the first appearance of wildcats in Europe dates back to 450,000–200,000 years ago, after which it occupied nearly the whole continent (Kitchener & Rees, 2009; Pecon-Slattery et al., 2006; Sommer & Benecke, 2006). The wildcat is a medium-sized carnivore resembling a domestic tabby cat, with a pelage that typically features a brown-gray or dark gray color pattern. It is somewhat larger and more robust than its domestic counterpart. It has a black dorsal line that abruptly ends at the base of the tail, which is broad and ends in a rounded tip. These external characteristics allow for the distinction between wildcats, domestic cats, and most hybrids (Beaumont et al., 2001; Kitchener et al., 2005) (Figure 1).

Figure 1: Study species - European wildcat (source: ©123RF/jmrocek).

The mating season occurs between January and March, with a gestation period lasting over two months. Females typically give birth to three or four cubs. The offspring usually disperse before winter, although females may remain in their mother's territory until they reach sexual maturity. In captivity, their lifespan is typically at least 15 years (Daniels et al., 2002; Nowell & Jackson, 1996). Wildcats are solitary and territorial species that aggressively defend their territory, marking it with feces and other signs (Biró et al., 2004; Corbett, 1979). Males have larger home ranges, typically ranging from 2 to 20 km^2 (Biró et al., 2004; Corbett, 1979), with low population density, less than 1 ind./km^2 (Yamaguchi et al., 2015).

The majority of European countries consider the wildcat a threatened species within their borders, leading to its inclusion in national catalogs and legal frameworks with varying levels of protection. The species is strictly protected under the Bern Convention and the European Habitats Directive (92/43/EEC) (Lozano & Malo, 2012).

Our other study species, Pallas's cat, commonly known as the manul, is a small, solitary, and terrestrial felid, and the only species in its genus. It is believed to have inhabited Central Asia and the Iranian Caucasus around 5.9 million years ago, after diverging from its common ancestor, the leopard cat (Li et al., 2016; O'Brien & Johnson, 2007).

Its thick coat of long, soft fur is highly variable but typically pale white or yellow-gray. The species is also distinguished from other small felids by its short, rounded ears, which are set widely and low on the head (Noonan et al., 2024) (Figure 2). The mating season occurs between December and March, with an average litter size of four to six kittens, born from the end of March through May (Ross, 2009). The offspring disperse at four or five months, but their lifespan in the wild is relatively short, averaging around six years (Ross, 2009; Ross et al., 2019).

Figure 2: Study species – Pallas's cat (photo by: Uuganbayar Munkhbat).

During the 14th Meeting of the Conference of the Parties to the Convention on the Conservation of Migratory Species (CMS COP14) in 2024, the Pallas's cat was listed in Appendix II, having previously not been protected by this convention. The species is also legally protected in 12 out its 16 range countries. Within its distribution area (16 countries), approximately 19.3% of the suitable habitats for the species are encompassed by 587 protected areas. Roughly 12% of the species' range in Mongolia occurs within protected areas (Clark et al., 2006).

2.2. Extinction vulnerability of cat family

Habitat loss, degradation, fragmentation, and isolation are some of the most significant threats to most wild-living species in modern times (Henle et al., 2004). Not all animals respond equally to habitat changes, and their vulnerability to human-induced threats is mainly determined by their life history and ecological traits. Consequently, some lineages are more vulnerable than others (Davidson et al., 2009; Henle et al., 2004; Zanin et al., 2015). Among the most at risk are paradoxically, the earth's most majestic and revered by humanity: the wild felids.

The increased risk of extinction faced by cat-like carnivores can be attributed to several factors. These include their low population density, high trophic levels (which place them at the top of the food chain), large home ranges (requiring expansive territories to support their hunting and survival), and slow population growth. Together, these factors contribute to their heightened vulnerability in the wild (Davidson et al., 2009; Zanin et al., 2015). Consequently, 18 of the 38 cat species are classified within the top three categories by the IUCN Red List, making up nearly half of all living wild felids (Gross, 2012a; IUCN, 2022).

2.3. Threats and conservation needs of small felids

Felids are widely recognized as high-profile mammals in today's conservation efforts due to their vulnerable status, key ecological roles, and remarkable charisma (Dickman et al., 2015; Macdonald et al., 2015; Zanin et al., 2015). However, many small cat species are still poorly understood (Brodie, 2009; Dickman et al., 2015), making it urgent to quantify threats they face and better comprehend how their spatial behavior affects their extinction vulnerability (Ross, 2009). Incorrectly identifying threats could lead to a mismatch between their actual severity and allocation of research effort (Lawler et al., 2006).

2.3.1. Threats to Pallas's cat

Pallas's cats are experiencing significant declines globally, and most remnant populations are small and isolated (Chimed et al., 2021; Ross et al., 2020). Although the species has a wide distribution and is unlikely to face widespread extinction in short term, its low population density and susceptibility to human-related disturbances may lead to local extinctions (Ross, 2009). From an ecological perspective, Pallas's cats has several characteristics that increase its risk of local extinction, such as habitat and feeding specialization, as well as low population density (Ross et al., 2010a, 2010b, 2012).

The main threats to Pallas's cats are habitat loss and fragmentation, along with a decline in prey abundance across its Central Asian stronghold (Clark et al., 2006; Ross et al., 2019a, 2020). Furthermore, intense livestock grazing, herding dogs, mineral extraction, road development, and fur trade represent the major causes of mortality for Pallas’s cats (Farhadinia et al., 2016; Ross et al., 2019a, 2019b). Threats are dynamic, evolving over time and across geographical spaces (Hayward, 2009). For example the Pallas’s cat in Mongolia threatened by direct persecution for the fur trade, illegal hunting, and use for medical purposes (Clark et al., 2006; Ross et al., 2020). Moreover, over the past two decades, the demand for cashmere and wool has led to an exponential increase in the number of livestock (*National Statistics Office of Mongolia*, 2022), which leads to habitat degradation (Ross et al., 2019b). Widespread eradication campaigns targeting small mammal populations have been conducted Mongolia to improve livestock pastures, resulting in a substantial reduction in the availability of primary prey, such as pikas, for Pallas’s cats (Barashkova et al.. 2019; Clark et al., 2006; Ross et al., 2020). Despite significant progress in understanding Pallas's cats’ ecology in recent years, many aspects remain poorly understood, including how populations might respond to threats (Ross et al., 2019b).

2.3.2. Threats to wildcat

The factors that threaten wildcat populations in Europe are habitat alteration and destruction, which is the most critical threat to this species (Nowell & Jackson, 1996; Stahl & Artois, 1994). The Council of Europe highlighted that habitat loss is the primary negative factor among the threats to wildcats and recommended maintaining natural forests in good condition (Council of Europe, 1993). Deforestation or the replacement of native habitats, such as the planting of coniferous or eucalyptus forests, have been linked to the decline of wildcat populations in regions like Great Britain, Eastern Europe, and the Mediterranean, as these altered landscapes often lack suitable conditions for the species’ survival (Langley & Yalden, 1977; Lozano & Malo, 2012).

Habitat destruction, particularly through urbanization and infrastructure development (e.g., roads, highways, railways, irrigation systems), leads to population fragmentation and isolation, significantly impacting genetic diversity and survival (Council of Europe, 1993; Nowell & Jackson, 1996; Stahl & Artois, 1994).

Genetic introgression of domestic cats (*Felis silvestris catus*) into the wildcat population, and its impact on the species' gene pool is a growing concern and represents another significant threat (Nowell & Jackson, 1996; Pierpaoli et al., 2003; Stahl & Artois, 1994). The eradication of predators and the expansion of agriculture have contributed to the spread of feral and free-ranging cats, which are now found worldwide, often overlapping with the wildcat's range (Nowell & Jackson, 1996). The hybridization has been frequently recorded in Europe, particularly in Scotland, where long-lasting introgression has been observed, with a similar pattern seen in Hungary (Bastianelli et al., 2021; Biró et al., 2005; Pierpaoli et al., 2003). In case of other European populations, such as in Germany, the Iberian Peninsula, and the Mediterranean, hybridization is rare, with overall low levels of introgression (Pierpaoli et al., 2003; Tiesmeyer et al., 2020).

Additionally, the wildcat population is threatened by non-natural mortalities, including illegal hunting, secondary poisoning, trapping, and road and railway kills. Furthermore, the transmission of diseases from domestic cats and the rising population of ungulates pose considerable threats to the survival of wildcats (Bastianelli et al., 2021; Biró et al., 2005; Gerngross et al., 2022; Macdonald & Loveridge, 2010; Nowell & Jackson, 1996). Locally, studies conducted in Hungary since the 1980s have identified habitat degradation, illegal hunting, competition with domestic cats, and hybridization as the most serious threats to wildcats population (Stahl & Artois, 1994).

2.4. Distribution of small felids and their habitat use

2.4.1. Space use by Pallas's cat

The Pallas's cat is found from western Iran to East Asia, with core populations in Mongolia and China, inhabiting landscapes characterized by an extreme continental climate (Nowell & Jackson, 1996; Ross et al., 2020) (Figure 3).

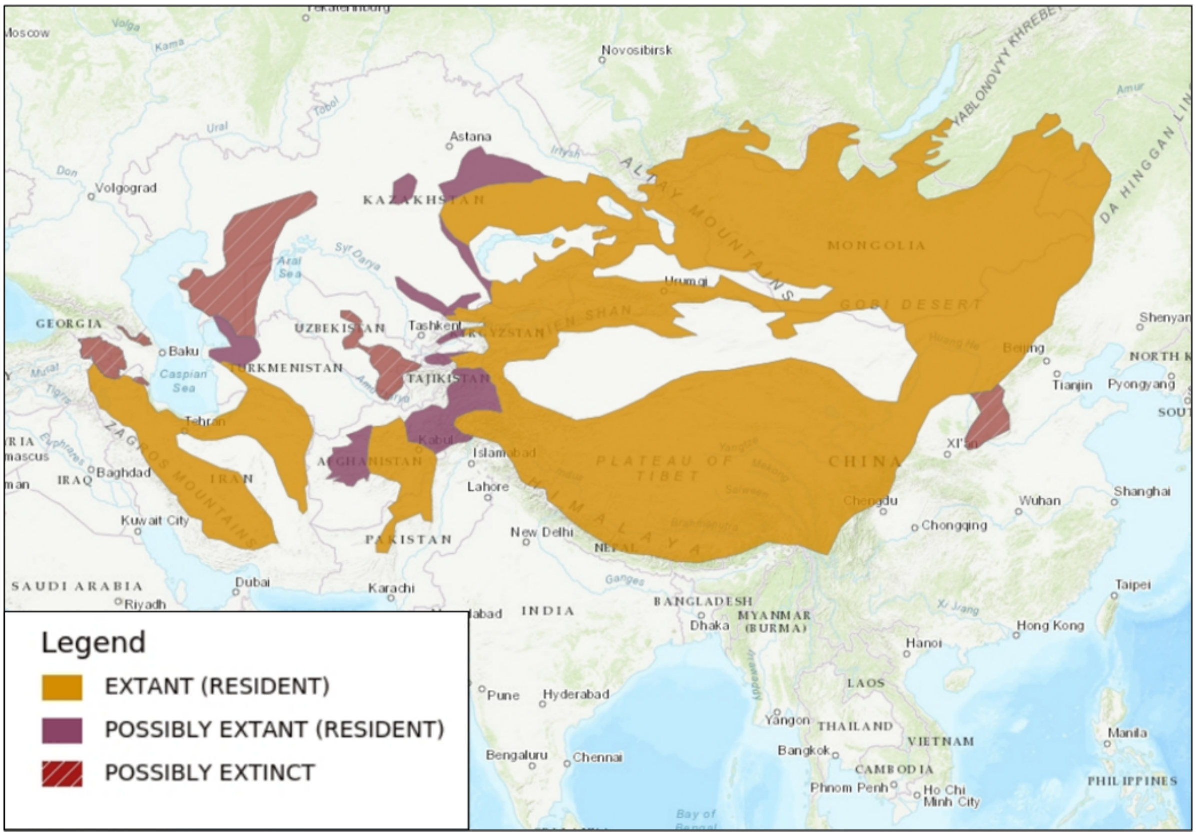


Figure 3: Distribution map of Pallas's cat (source: the IUCN, 2020).

In Russia, the population primarily occurs along the border with Mongolia and China, notably in Trans-Baikal, Altai, Tuva, and the Republic of Buryatia (Barashkova et al., 2017). In the southwest of the species' range, information is limited for the Caspian Sea region and the Southern Caucasus. However, Iran hosts the largest population of Pallas's cat in this region (Farhadinia et al., 2016; Ross et al., 2020).

Much of the distribution range remains unclear (Munkhtsog et al., 2004a), and some populations may have disappeared from parts of their historical range due to numerous threats (Ross et al., 2010b). In Mongolia, the species' potential habitats are predicted to extend from eastern Mongolia to the foothills and mountain ranges of the Mongolian and Gobi Altai in the west, excluding eastern Gobi Desert and forested areas (Barashkova et al., 2019). Central Mongolia is a stronghold for the species due to its suitable habitat and history of fur trade (Ross et al., 2019a; Wingard & Zahler, 2006), with an estimated density of 4 - 8 cats per 100 km² (Ross, 2009).

Examining the significance of nature reserves and different land use patterns on the distribution and occurrence of species is critical in conservation biology (Cardillo et al., 2004). The appropriate habitat for the Pallas's cat includes montane grassland, a mix of grassland, shrub steppe, and desert (Barashkova et al., 2019; Ross, 2009; Ross et al., 2012). However, they are habitat specialists, preferring areas with ravines, steep terrain, rugged features, dense vegetation, and hill-slopes (Chimed et al., 2021; Greco et al., 2022; Greenspan & Giordano, 2021; Ross et al., 2020). Also, the presence of predators, prey abundance, extensive talus, and steep slopes influence its habitat use (Barashkova & Smelansky, 2011; Ross et al., 2012, 2019a).

2.4.2. Space use by wildcat

The wildcat is a polytypic species with three wild subspecies, the African (*F. s. libyca*), European (*F. s. silvestris*), and Asian (*F. s. ornata*) wildcats, which inhabit Europe, Asia, and Africa (Nowell & Jackson, 1996). Europe is home to a large population of the European subspecies, whose range is divided into four main continental meta - populations: (1) Western-Central Europe, (2) Apennine Peninsula and Sicily, (3) Eastern-Central, Eastern, and Southeastern Europe, and (4) Iberian Peninsula (Gerngross et al. 2022; Mitchell-Jones et al., 1999) (Figure 4). Of these, the Iberian Peninsula, Italy, the Carpathians, Germany, and surrounding regions constitute the most contiguous range of wildcats (Biró et al., 2004; Gerngross et al., 2022). Eastern-Central Europe, which includes Hungary, Poland, Slovakia, and the Balkans, is home to another major group (Mitchell-Jones et al., 1999).

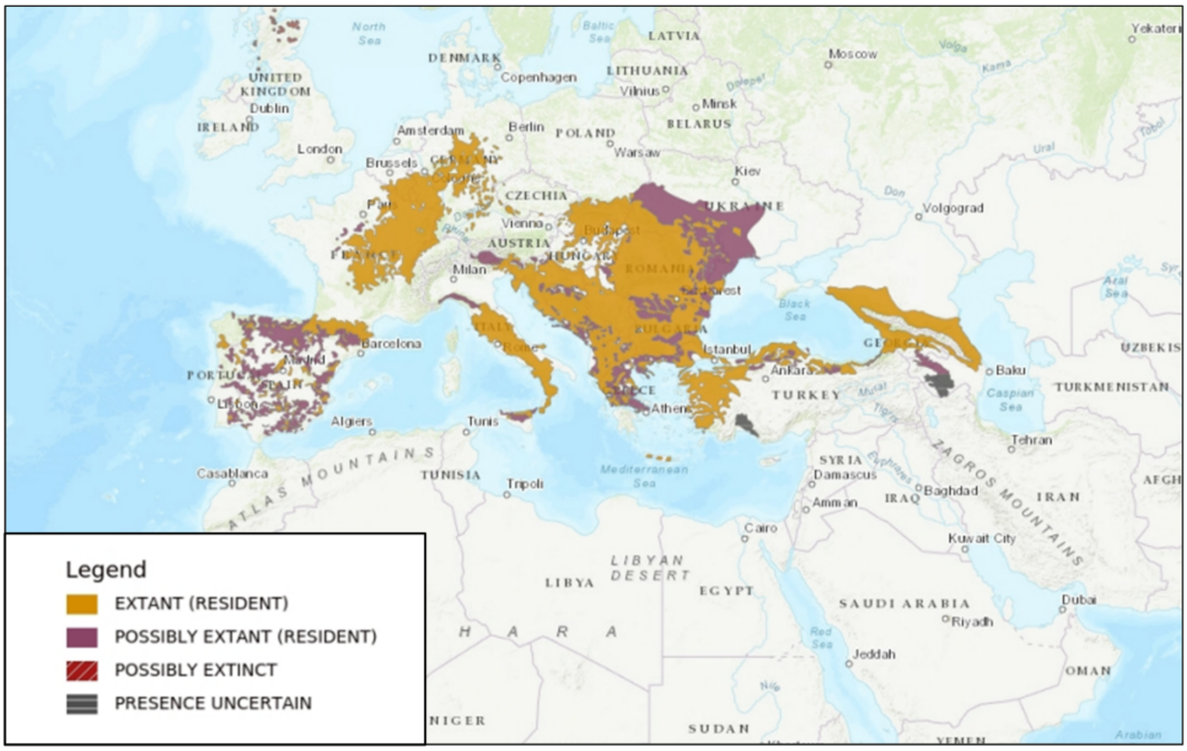


Figure 4: Distribution map of European wildcat (source: the IUCN, 2022).

In Hungary, the eastern, northern, and southwestern regions appear to retain stable and large populations of wildcats, which are spread across three core areas: the Transdanubian and North Hungarian Mountains, the floodplain forests of the Great Plain, and the Dráva Plain (Heltai et al., 2006).

Traditionally considered to be a forest specialist (Nowell & Jackson, 1996), the species uses a variety of forests, particularly deciduous and mixed forests with dense growth, beech woods, and oak (Anile et al., 2019; Klar et al., 2008; Silva et al., 2013). However, recent studies suggest a preference for wider range of habitats, including a variety of forests that connect open areas, grasslands, meadows, scrublands, agricultural lands, and pastures (Biró et al., 2004; Heltai et al., 2006; Klar et al., 2008; Monterroso et al., 2009). The species is now considered a habitat generalist and is known to utilize a wide range of habitats (Klar et al., 2008). Coniferous forests, grasslands, broad-leaved woodlands, and watercourses appear to be important habitats for wildcats in Scotland (Corbett, 1979; Daniels et al., 1998). In Mediterranean regions, scrub and pasturelands are regarded as essential habitats (Lozano et al., 2003), providing suitable conditions for hiding and foraging (Lozano & Malo, 2012). In Germany, the species' distribution is limited by forests, forest ecotones, and meadows (Klar et al., 2008). The availability of prey and shelter are the main factors influencing their habitat use (Anile et al., 2019; Klar et al., 2008; Silva et al., 2013).

2.5. Temporal activity patterns of small felids

2.5.1. Activity pattern of Pallas's cat

Studying animal activity patterns is essential for understanding the ecological dynamics that shape species behavior and survival, as temporal data reveal critical insights into feeding, mating, and movement habits, and how species partition time to reduce competition and coexist in shared habitats (Frey et al., 2017). Information on the activity patterns of Pallas's cats remains scarce across its entire range, and few detailed studies have been conducted. One of the only comprehensive investigations is a radio-collaring study by Ross (2009) in Mongolia, which tracked 13 females and 9 males. The study showed that the species is primarily crepuscular, with peak activity occurring at dawn and dusk. Seasonal variation was also observed, with increased daytime activity during the winter months.

Camera trapping is now increasingly used to evaluate animal distribution, population density, and local species diversity (Anile et al., 2021; Greco et al., 2022) and it is also considered a reliable tool for studying the temporal behavior of animal species (Rossa et al., 2021). For instance, research from camera trap studies by Anile et al. (2021) shows that Pallas's cat exhibits a crepuscular activity pattern in the summer (May–August), but becomes strictly diurnal in the autumn (September–November). These seasonal shifts in activity patterns likely represent an adaptive response to reduce the risk of predation by raptors, which are known to prey on Pallas's cats and are typically active around midday in summer (Anile et al., 2021; Ross, 2009). The species faces the challenge of avoiding predators while also maximizing its chances of a successful hunt in daylight hours (Ross et al., 2012).

More broadly, temporal behavior patterns in animals may change depending on habitat type, geographic latitude, presence of competitors, or mating opportunities (Karanth et al., 2017). Similarly, another finding from Greco et al. (2022) suggests that Pallas's cats also adjust their diel activity patterns by becoming more nocturnal to limit encounters with livestock, particularly large herds of goats and sheep. Since their habitat use often overlaps with pastoral activity, temporal avoidance, being active at different times, likely reduces the chances of direct contact with humans and herding dogs.

2.5.2. Activity pattern of wildcat

Wildcats are known to be strictly nocturnal predators (Lazzeri et al., 2022; Migli et al., 2021). Nonetheless, they can also display crepuscular or even diurnal temporal activity pattern. At the seasonal scale, wildcats are predominantly nocturnal in winter and autumn, but during spring their activity becomes more diurnal and crepuscular, likely due to the mating season (Ferretti et al., 2022; García et al., 2025). Female activity varies seasonally, especially as reproductive females limit nocturnal movements, and follows a cathemeral pattern (Ferretti et al., 2022; Migli et al., 2021).

In warmer months, particularly in Mediterranean regions, diurnal activity increases, influenced by shelter availability, offspring care, presence of water in summer, and prey activity rhythms (Lazzeri et al., 2022). Interestingly, certain non-natural elements, such as paved roads, appear to have no effect on diurnal activity when natural shelter is available, suggesting the species may tolerate some human-made structures (Lazzeri et al., 2022).

The daily activity of the wildcat is highest during the darkest nights and decreases on bright moonlight nights (Lazzeri et al., 2022). Males show peak activity in crepuscular hours, but they become highly diurnal during mating season, with activity peaks occurring around midday (García et al., 2025). Wildcats are facultative nocturnal mammals that exhibit considerable plasticity in their diel activity patterns, and they can be active during more than 20% of daylight hours (Lazzeri et al., 2022; Monterroso et al., 2014). Due to the presence of sympatric competitors and dietary overlap, wildcats tend to be active at different times of the day than larger species such as golden jackal (*Canis aureus*) and European badger (*Meles meles*) (Tsunoda et al., 2020). This spatial and temporal separation helps reduce direct encounters and competition among mesocarnivores, and also increases protection from potential predators for their kittens at the den (Monterroso et al., 2014; Tsunoda et al., 2020).

In addition to natural ecological factors, anthropogenic disturbances and the presence of domestic or invasive animals significantly influence wildcats' daily activity. Camera trap surveys by Anile et al. (2019) in Sicily showed that wildcats reduced their activity in areas occupied by mushroom collectors, feral pigs, and cattle. Specifically, wildcats tended to minimize overlap with mushroom collectors by reducing activity during periods of high human presence, while their activity overlap with feral pigs varied over time.

Overall, wildcats demonstrate flexible activity patterns shaped by reproductive needs, prey behavior, interspecific interactions, and human disturbances.

2.6. Local Ecological Knowledge about small felids

In biodiversity conservation, socio-ecological approaches are gaining recognition as the value of incorporating a human dimension into the effective species' management and ecosystems becomes more widely acknowledged. Local Ecological Knowledge (LEK) is increasingly recognized as a reliable, cost-effective, and non-invasive method for gathering information on the status, distribution, and ecology of local species, particularly rare and elusive ones found in remote areas that are difficult to detect using traditional methods (Greco et al., 2022). LEK is a valuable data source that can improve understanding of species presence or absence, offering an affordable alternative to large-scale surveys over large areas (Lunney et al., 2009; Pillay et al., 2011; Taubmann et al., 2015).

Monitoring wild species' status over large landscapes is time-consuming and costly using camera traps, sign surveys, GPS telemetry, and non-invasive genetic sampling, making them less suitable (Caruso et al., 2017; Janečka et al., 2011; Hoeven et al., 2004; Zeller et al., 2011). The monitoring of snow leopards (*Panthera uncia*) (Taubmann et al., 2015), Pallas's cats (Chimed et al., 2021, 2023), lions (*Panthera leo*), cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*) (Msoffe et al., 2007), and the assessment of human-felid conflict (Rutina et al., 2017), has previously been complemented by input from LEK. Furthermore, questionnaire and interview surveys can gather in-depth ecological information on species, providing important context across wide geographic regions (White et al., 2005). Interviews are widely used methods in conservation research, and the integration of LEK represent a valuable source of information regarding species distribution and biodiversity status (Lunney et al., 2009; Pillay et al., 2011; Bonfil et al., 2018). As such, they represent a promising tool for advancing the current understanding of the threats and distribution of small felids.

3. MATERIALS AND METHODS

3.1. Literature survey: Threats to wildcats and Pallas's cats

3.1.1. Literature search and paper selection

The study was carried out using publications that reported threats and threatening factors to wildcats and Pallas's cats. Publications were sourced from the Web of Science, Scopus, and Google Scholar assessed in January 2025. We searched the database and retrieved articles published in English, covering all available years. We considered only peer-reviewed papers, and the search was performed in title, keywords, and abstract. We also included additional publications from the references cited in the papers from our literature search, selecting those that provided information or data on threats to each species. For Pallas's cat, we conducted a global search, while the collection of wildcat publications focused primarily on its range in Europe. Newspapers, newsletters, websites, as well as articles whose abstracts and titles did not mention threats or threat factors were excluded.

We were able to obtain only 21 scientific articles on Pallas's cats from our entire literature search. Given the limited number of publications, we expanded our sources to include one dissertation and one master's thesis that documented threat types to Pallas's cats. Within the 21 papers and 2 thesis, some studies reported more than one type of threat. Overall, we analyzed 49 threats, including both existing and potential threats on Pallas's cats. In contrast, we managed to obtain a relatively greater number of scientific articles on wildcats, with a total of 88 articles and analyzed 93 distinct threats.

Obtained scientific articles were read thoroughly in detail, searching for threats and threatening factors to both cats. Due to limited number of publications on this topic, especially regarding the Pallas's cat, we did not filter or specify publication years for further analysis.

3.1.2. Threat classification and rankings

Based on the analyzed threats from the literature search, we identified 12 categories of threats to Pallas's cats, which were coded into 7 classes, while 13 categories of threats to wildcats were grouped into 6 classes (Table 1). Due to the variety of threat categories, we used the IUCN Threats Classification Scheme (IUCN, Threats Classification Scheme) to categorize threats and code them into groups.

Table 1: The number of recorded threats for each species, classified according to the IUCN threat classification system.

IUCN Category	Threat	Pallas's cat		Wildcat	
		Frequency	(%)	Freequency	(%)
Biological Resource Use	Overgrazing by livestock	7	14	-	-
	Traps/snares	1	2	1	1
	Illegal hunting & trade	5	10	-	-
	Hunting	-	-	2	2
	Ungulate pressure	-	-	2	2
	Decrease of prey	-	-	2	2
	Population declining	2	4	1	1
	Predator control	-	-	3	3
Invasive & Other Problematic Species	Predation by herding dogs	13	27	-	-
	Competition with other species	3	6	1	1
	Disease	2	4	21	23
	Hybridization	-	-	38	41
Climate Change & Severe Weather	Climate change	2	4	-	-
Transportation & Service Corridors	Roadkill	2	4	9	10
Human Intrusions & Disturbance	Human disturbance	2	4	3	3
Pollution	Secondary poisoning	9	19	-	-
	Primary poisoning	-	-	3	3
Residential & Commercial Development	Habitat fragmentation/loss	1	2	7	8

After that, we also differentiated the categorized threats into either existing threat, which were investigated and found to negatively affect the species, supported by results, or potential threats mentioned only in the introduction or discussion sections of the scientific articles. Among the collected publications, confirmed existing threats were reported in 13 papers on Pallas's cats and 73 papers on wildcats, while the remaining papers referred to potential threats that were not yet confirmed or studied.

To develop a ranked list of categorized threats to each species regionally, we analyzed the frequency of reported threats within each IUCN category from the collected publications. For example, the most frequently recorded threat category for both small felids was 'invasive and other problematic species', referring to non-native species predicted to negatively affect biodiversity due to their spread or increased abundance (IUCN, Threats Classification Scheme). Within this category, the highest recorded threat frequencies were 41% for wildcats (hybridization with domestic cat) and 27% for Pallas's cats (predation by herding dogs). Since the highest threat exceeded 40%, we used this value as a reference to create break line categories for ranking: 'Serious' (over 21%), 'Medium' (11–20%), and 'Minor' (1–10%). These rankings, based on the proportion of total threats documented in the literature review, were used to assess which threats were the most critical, urgent, and problematic.

3.2. Field-based research

We established an integrated field-based research method to achieve our objectives (a – f).

3.2.1. Study area

This study was carried out in Hustai National Park (HNP, 105°43'-106°08' E, 47°32'-47°50' N) in Central Mongolia (around 100 km south-west of the capital Ulaanbaatar) (Figure 5). HNP is situated at the southernmost point of the Siberian taiga in the Mongolian Dauria phytogeographical region, which is a pristine part of the steppe ecosystem in temperate Eurasia (Tseren-Ochir et al., 2018). The national park was established in 1992, covering approximately 60,000 of small mountains, meadows, and river valleys. The altitude ranges between 1100 m and 1842 m. The region is dominated by grassland and shrubland steppe. The climate is continental; temperature varies between -43°C and 38°C and the annual precipitation is 165 mm, with the majority of the precipitation falling in summer (Tseren-Ochir et al., 2018; Wallis de Vries et al., 1996). The national park contains relatively diverse wildlife species. Large ungulates assemblage includes the Altai wapiti (*Cervus canadensis*), the wild boar (*Sus scrofa*), the argali sheep (*Ovis ammon*), the Mongolian gazelle (*Gazella gutturosa*), and the Przewalski horse (*Equus ferus przewalskii*). Several sympathric carnivores with Pallas's cat in the study area inlcude the red fox (*Vulpes vulpes*), the corsac fox (*Vulpes corsac*), the Eurasian lynx (*Lynx lynx*), the gray wolf (*Canis lupus*), and the Siberian polecat (*Mustela eversmanni*) (Nyamsuren et al., 2016). The area is also home to approximately 110 semi-nomadic herders who herd four types of livestock: sheep, goats, horses, and cattle. A total of 120,000 livestock graze within and around the national park (National Statistics Office of Mongolia, 2022).

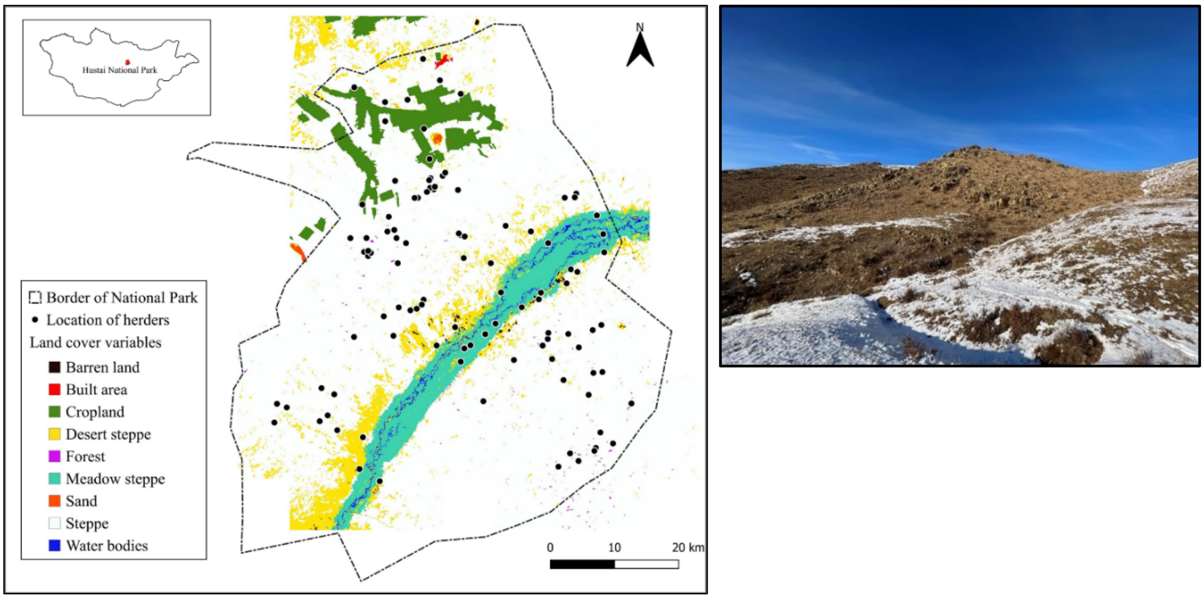


Figure 5: Location of Hustai National Park in Central Mongolia. Thin black line indicates the border of the national park, black dots represent the interviewed herder's locations, with the basemap of land cover types from the year 2020 created by Wang et al. (2022) and image (by: Davaa Lkhagvasuren) showing the physical attributes of the area.

3.2.2. Survey data collection

3.2.2.1. Interview-based survey

The study area was divided into 67 sampling units of 8 x 8 km square, each approximating the average female home range of the Pallas's cat (Ross et al., 2012). We carried out an interview-based survey between June and July in 2023 by visiting all known households in the Hustai National Park, Central Mongolia (Figure 6). The interviews were mostly carried out by a door-to-door approach with the head of the household in the presence of their family in each local household, through field encounters, and infrequently by participation in local community events. Before proceeding with each interview, we introduced our team and explained the research aims, which were to collect ecological information, such as local threats and the presence or absence of Pallas's cats in HNP, as part of this dissertation. Participants were informed that their responses would remain anonymous, that they could decline to answer any questions without providing an explanation, and that they could end the interview at any time. We interviewed the head of the household, beginning with informal conversations about herding and often also about Pallas's cats and other wildlife. Interview took about 15-20 minutes to complete.

Figure 6: (A & B & C): A & B: Conducting an interview with a herder in Hustai National Park and C: Completed interview forms. Photo by: Tsogt Batzaya (A & B).

3.2.2.2. Questionnaire-based survey

In Hungary, various research projects have been performed to study the occurrence of wildcats through game management units (GMUs) in the years 2004 and 2014 via postal mail and email. Besides that, in 2022 we distributed questionnaires online using the Google Form platform to the managers of GMUs in Hungary between February and April.

The reported wildcat occurrence was evaluated nationwide on a broad scale using the Universal Transverse Mercator (UTM) coordinate system, covering the study area over Hungary with grid cells of 10 x10 km each (Figure 7), representing an area similar to the estimated maximum home range of wildcats according to European mammal mapping (Mitchell-Jones et al., 1999).

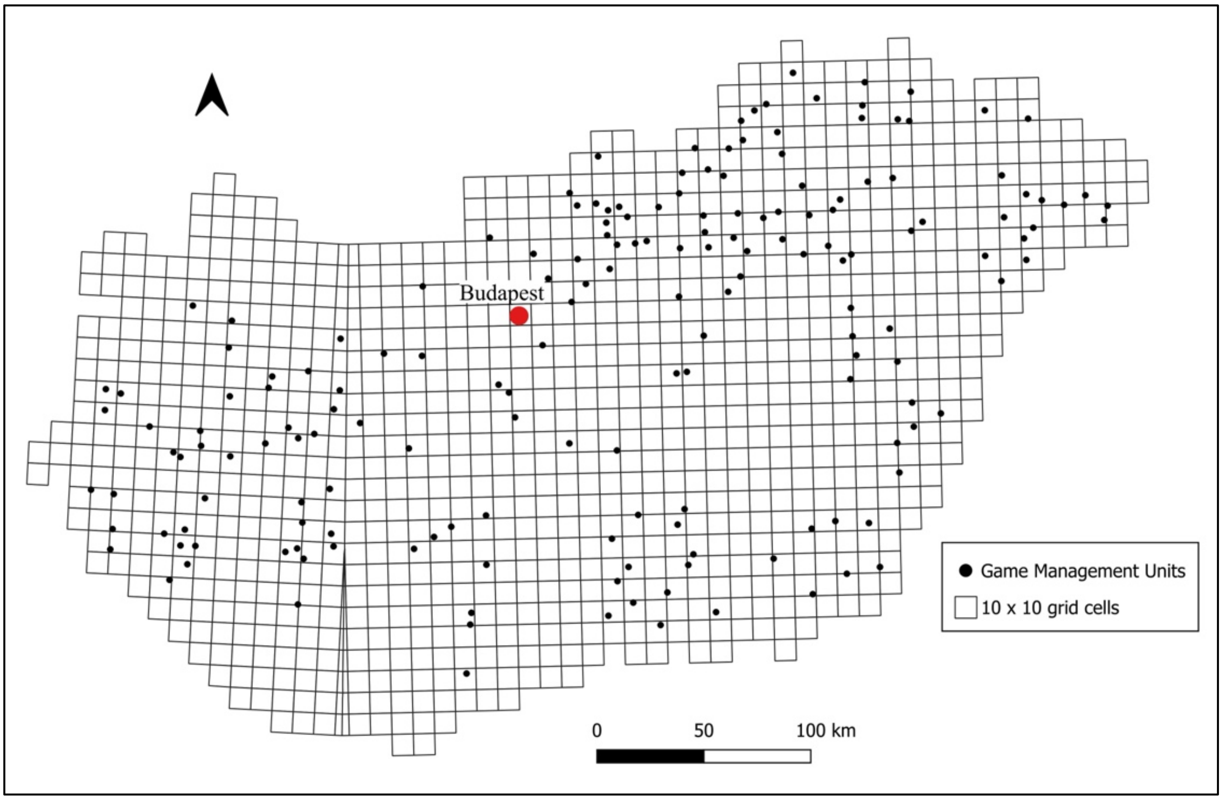


Figure 7: Map of the study area with 10x10 km grid cells. Black dots indicate Hungarian Game Management Units that participated in the survey, and the red dot represents the capital of Hungary.

All Hungarian GMUs have an individual code provided by the Hungarian Game Management Database that is connected to every respondent (Csányi et al., 2010), and we localized the data geographically using the UTM cells.
We used 6.25 km^2 of coverage as the detection threshold in each grid cell, which was selected by Heltai et al. (2006), based on the information provided by the Hungarian Hunting Act, which states that the allowed size of a game management unit is 30 km^2. However, in the worst scenario, the smallest hunting area might be 25 km^2, and this area can be divided into four equal 6.25 km^2 parts. We considered that if we had information from at least 6.25% of a UTM grid cell on wildcat presence, then we could confirm the detection of wildcats in the total area of the relevant UTM cell. Consequently, if the area of one or more game management units reporting wildcat presence reaches a total coverage of 6.25 km^2 inside one UTM cell, a valid detection can refer to the total area of the cell. Multiple detections of wildcats in the same grid cell were merged into one detection for that grid cell and time period.

3.2.3. Design of interview

The survey consisted of eleven questions encompassing four main sections related to the species threats and occurrences. The first theme covered details about the respondents' attributes, followed by questions regarding the ability to identify the Pallas's cat; the third part dealt with the questions about threats; and the final section featured questions on species' detections around the year (Appendix B). All survey questions had a combination of single- and multiple-choice answers in a close-ended format. In the opening question, the participants were required to provide a detailed description of Pallas's cat and second to verify from a set of photographs showing among other small felids (Figure 8). If the respondent misidentified the species, the interview was not proceeded further and was not considered credible, data from that interview was excluded in the analysis. This is a standart method in interview-based surveys apperas to be a reliable way to include information only from people that are familiar with the study animal (Chimed et al., 2021; Garcia-Alaniz et al., 2010).

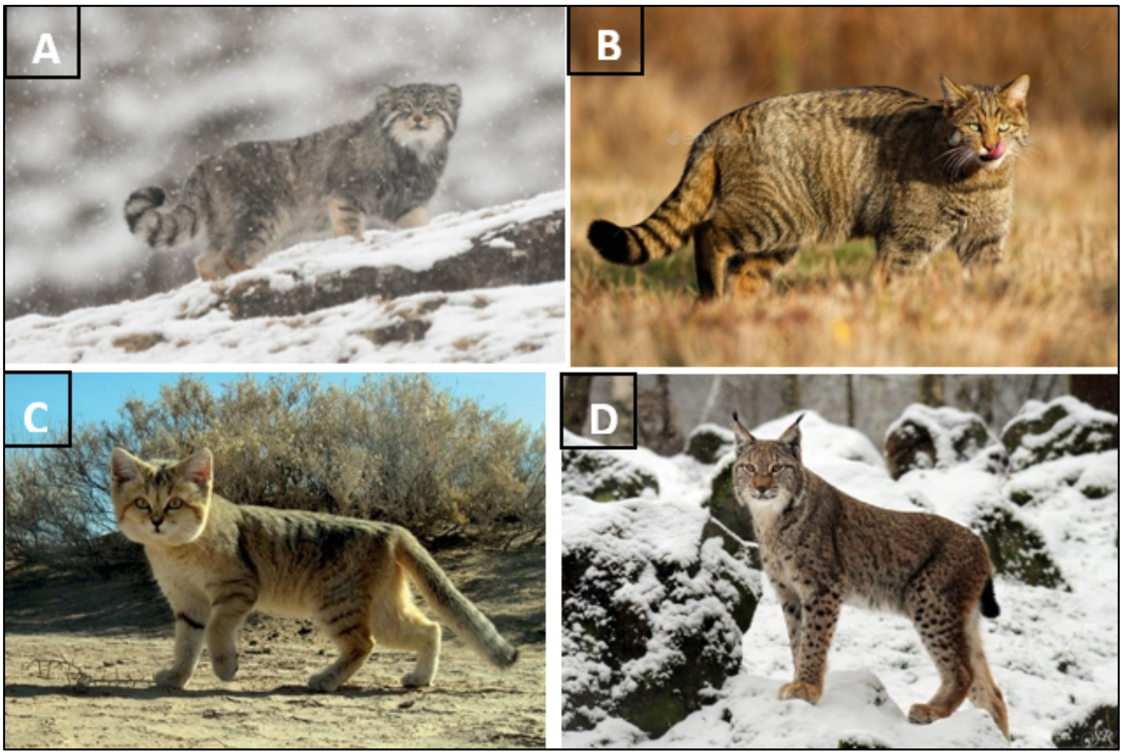


Figure 8: Cat imagery from Pallas's cat survey.

3.3.4. Design of questionnaire

The survey included an introduction page and three pages of questions in Hungarian, divided into four themes: the first section asked about respondents' GMU code, the second encompassed ecology and population trends of wildcats, and the third comprised threats to the species. The last theme dealt with the occurrences of the wildcat in the given management areas in three time periods (2004, 2014, and 2022). Instances of direct sightings, clearly identifiable pugmarks, and scrapes were all considered as species detections in the wildcat occurrence survey (Appendix C). Format of questionnaire had close ended with single- and multiple answer options.

3.2.5. Camera-trapping data collection

Activity patterns of Pallas's cats in Altanbulag soum, Tuv province, central Mongolia, were investigated by motion-sensitive cameras (Uovision Green30) from 30 June 2022 to 23 May 2024. This study region is next to and very comparable to Hustai National Park; nevertheless, the research was conducted outside of its buffer zone. In the summer of 2022, we installed 5 camera traps in unprotected areas, then deployed 6 additional cameras in the following summer of 2023 (Figure 9).

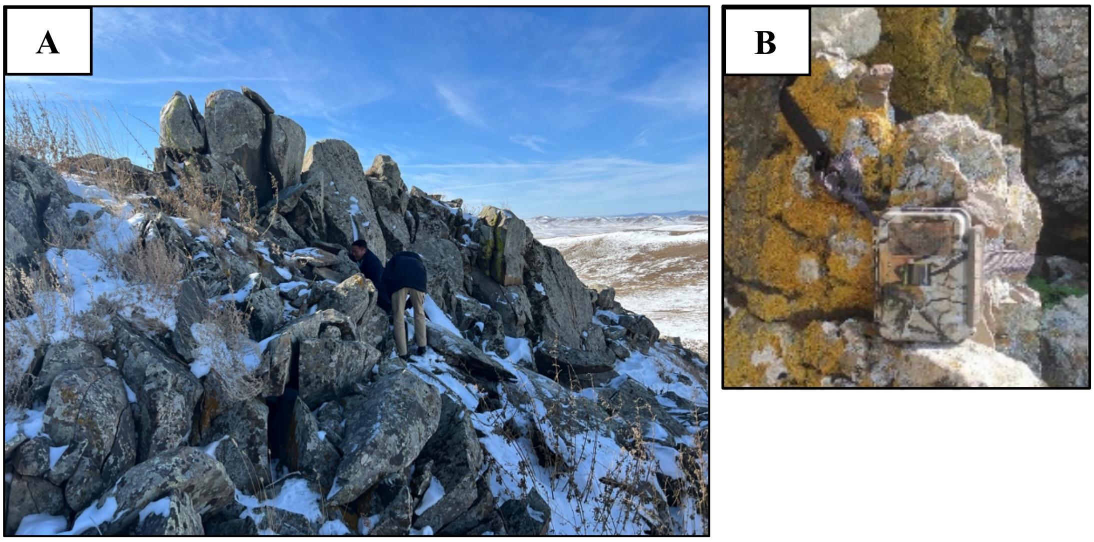


Figure 9: (A & B): A: Study area: and B: Used motion-sensitive camera in the survey. Photo by: Davaa Lkhagvasuren (A), Chimed Otgontamir (B).

We set up a total of 11 camera traps, covering around 80 km^2. Motion sensitive cameras were installed approximately 25 cm above ground mostly in pairs at 5 locations near or under rock features and cavities with signs of Pallas's cats such as feces (Figure 10).

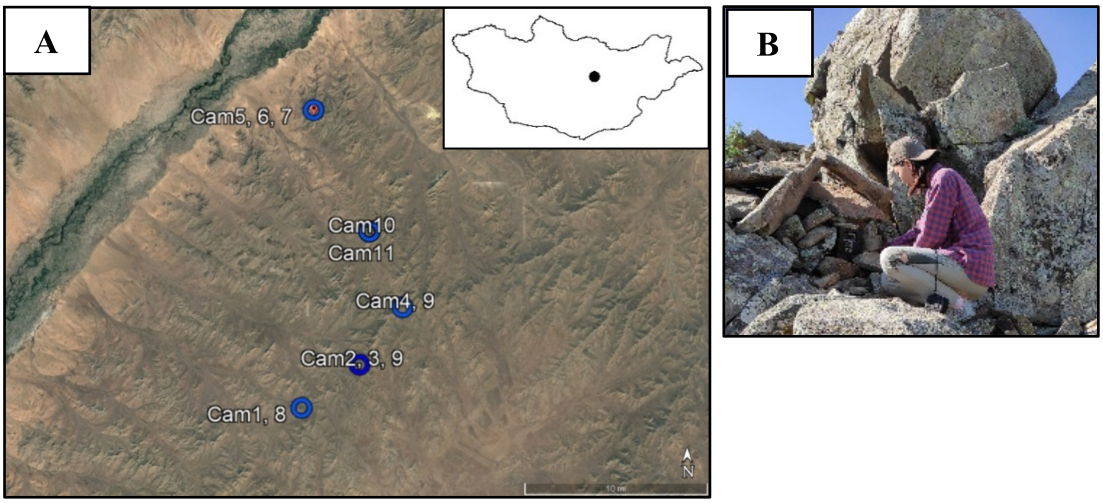


Figure 10: (A & B): A: Locations of camera traps in Altanbulag soum, Tuv province, Mongolia (black dot represents the study area): and B: Setting up camera traps near rocks and cavities with signs of Pallas's cat presence.

The purpose of this survey design was to detect Pallas' cats while moving, approaching notable rock features or patrolling along marking sites (Li et al., 2013). Three consecutive pictures were captured when animals triggered the cameras, but no bait or lure was used.

During the study period cameras were checked several times to ensure the angle remained consistent and batteries were charged. However, cameras could not be checked during the last year of the survey due to heavy snow cover, making it impossible to reach the study place; thus, some cameras were switched off. Alkaline batteries were used, which outperform other types at cold temperatures. Unfortunately, only the cameras on six sites worked properly during the study time of camera deployment, and these data are included here (Cam1, Cam2, Cam3, Cam5, Cam 10, and Cam11). Others were lost unfortunately.

3.3. Data analysis

This section highlights the technical tools and methods used to analyze the data gathered during the field research period. The analysis included both basic descriptive techniques and complex statistical tests relevant to scientific studies. We used descriptive analysis to outline general respondent demographics and the attributes of responses to individual questions. The Chi-square test was applied to analyze relationships between categorical data.

3.3.1. Field-based research

3.3.1.1. Distribution of Pallas's cat: Interview – based survey.

We gathered data from observations of Pallas's cats during the interviews, which were recorded using binary values to indicate presence (1) or absence (0). For each respondent we created a circular buffer of 5 km radius around their household by using the buffer tool in QGIS (Figure 11). The observation data were added as attributes to each corresponding buffer object besides additional respondent-related data such as gender, age, occupation, and the time passed after settling down in the area. We used 5 km as our buffer as the herders said that they rarely ventured more than 5 km from their households. To generalize Pallas's cat occurrence, we clipped these buffers with the intersecting lines of the 8 x 8 km square grid cells (Figure 11). As a result, circular segments were formed for each grid cell (N = 415). These segments were handled as observations for statistical modeling.

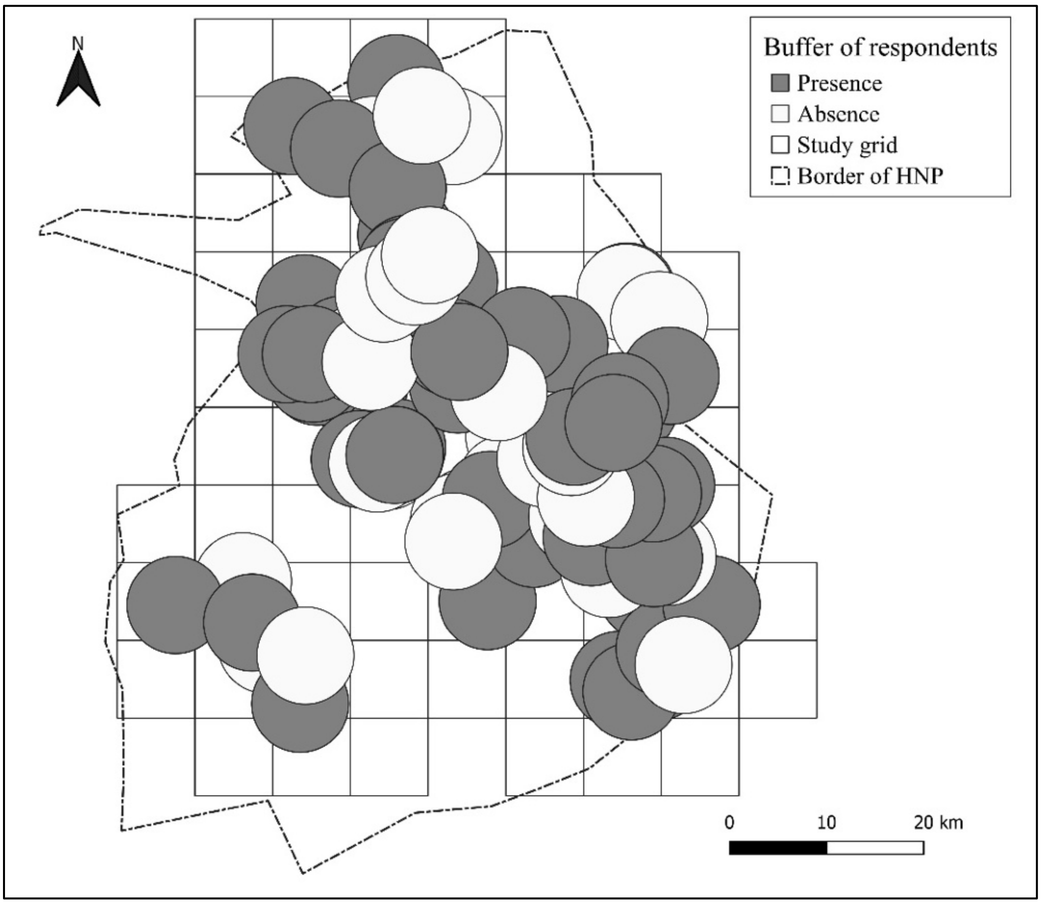


Figure 11: Created 5 km buffers colored by responses for the occurrence of Pallas's cats in Hustai National Park. Grey buffers are presence, and white buffers are absence of Pallas's cats.

We selected environmental variables including land cover and topographic to test the occurrence of Pallas's cats in the national park. We calculated the mean elevation and Terrain ruggedness index for the segments as well as the spatial cover of available land cover types. We used Terrain ruggedness index tool in QGIS to obtain mean terrain ruggedness index for the segment polygons. Terrain ruggedness index and elevation was calculated from the 90 m resolution Digital Elevation Model (Robinson et al., 2014) using QGIS v. 3.32.3 (QGIS "Geographic Information System" 2022). We evaluated the occurrence of Pallas's cats in function of these covariates with mixed effects logistic regression in R software v. 4.1.2. (R Core Team 2021) using the *glmmTMB* package (Brooks et al., 2017).

The recent and most relevant land cover data from 2020 was obtained using the publicly available dataset of Wang et al. (2022) that contains eleven land cover types and nine of these were used to our study (Table 2, Figure 12).

Table 2: Area and relative cover of the relevant land cover types on the study area.

No.	Land cover type	Area (hectares)	%
1	Steppe	355298	81
2	Meadow steppe	31079	7
3	Desert steppe	28811	6.6
4	Cropland	19315	4.4
5	Water	2413	0.5
6	Barren land	716	0.2
7	Sand	468	0.1
8	Forest	450	0.1
9	Built area	199	0.1

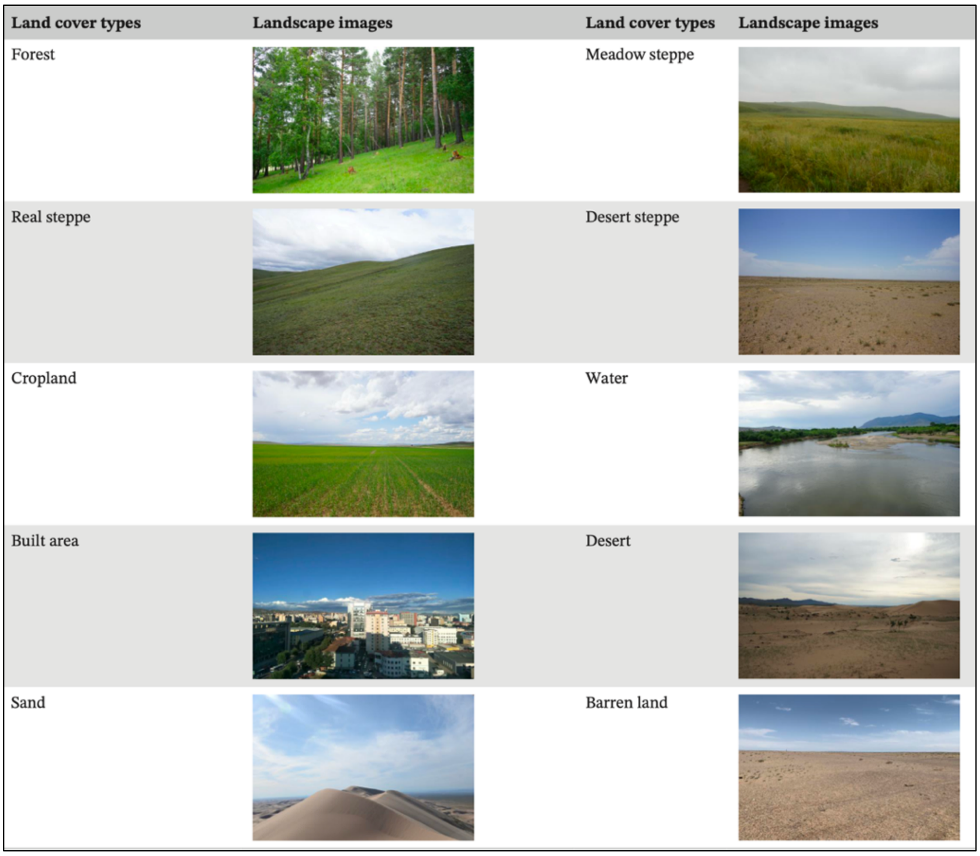


Figure 12: Landcover classification system in Mongolia by Wang et al. (2022), was used in our study, excluding the desert class.

Steppe, desert steppe, and meadow steppe are all types of grassland with varying vegetation coverage, while barren land is characterized by the absence of vegetation. More precisely, the steppe or real steppe is a grassland area with slightly more vegetation than desert steppe, which has the lowest cover. In contrast, meadow steppe occurs near rivers, lakes, and other water sources and has the highest vegetation cover among grassland types (Wang et al., 2022). Grid cell identity was used as random intercept factor in the model and all variables were scaled. The relative percent cover of land cover types was calculated for the segments. We used likelihood ratio tests following a stepwise selection to select the final model that provides sufficient explanatory power and reasonable interpretability. Before model fitting, variables were tested for collinearity and correlated variables were excluded from analysis. The percentage cover data of meadow steppe significantly and negatively correlated with steppe ($r = -0.85$, $p < 0.001$) and elevation significantly correlated with Terrain ruggedness index ($r = 0.74$, $p < 0.001$). In other words, when meadow steppe cover increases, steppe cover decreases, and vice versa. Since these variables were strongly correlated with others (steppe and terrain ruggedness, respectively), they were removed from modeling to avoid multicollinearity, which can distort the model's results. This non-collinearity was verified by calculating the variance inflation factor (VIF) of each model using the *performance* package (Lüdecke et al., 2021) to sort out variables with critical multicollinearity. Model visualizations were created with the *sjPlot* (Lüdecke et al., 2024) and *ggplot2* (Wickham, 2016) packages. All statistical analyses were performed using the R statistical software. The occurrence probability map for the Pallas's cat was created in QGIS.

3.3.1.2. Distribution of wildcat: Questionnaire - based survey.

We created detection histories for each grid cell and each sampling period by creating a dichotomous variable on wildcat occurrence, where a value of 1 indicated the presence and of 0 the absence of the species in the UTM cell based on the responses. CORINE Land Cover database (*CORINE Land Cover*, 2006, 2012, 2018) was used for each corresponding survey year to find and evaluate which habitat types influenced wildcat occurrence. Seven different land cover types were selected, which are the most common and dominant land cover classes throughout Hungary. The percent cover of land cover classes was calculated relative to the total area of each relevant UTM cell and used as an explanatory variable in the statistical analysis. Additionally, we calculated the richness of the land cover types by counting the available Corine Land Cover classes per UTM cell and the evenness, Shannon-index and inverse Simpson diversity indices of the land cover types based on their areal data. Wildcat occurrence was analyzed as a function of these explanatory variables using binomial logistic regression in R (*R Core Team*, 2021). The best model structure was chosen using likelihood ratio tests to select which variable was a significant predictor of wildcat occurrence.

The coefficients of the fitted logistic regression model were expressed in their exponentiated form resulting in the more comprehensible odds ratio (OR). This metric ranges from 0 to infinity, where OR=1 functions as a threshold to divide negative and positive associations. If $0<OR<1$ the preferred event of interest (i.e. wildcat is present) is less likely to occur; if $1 < OR$ the preferred event is more likely to occur. Values farther from 1 in a given direction represent a stronger association (Agresti, 2019). In addition, we directly compared the area of the land cover classes between UTM cells with and without wildcat occurrence by performing Welch's two-sample t-tests. The figures were created using the ggplot2 (Wickham, 2016) and ggpubr (Kassambara, 2020) packages, while the diversity indices were calculated using the vegan package (Oksanen et al., 2020) in R. We created maps to visualize the presence and absence of wildcats in the three time periods using QGIS v. 3.32.3.

3.3.1.3. Activity pattern of Pallas's cat: Camera-trapping.

We counted the number of images of Pallas's cat and other wildlife captured by the camera traps. Each photograph of trapped animals was identified by species and recorded with time and date. All the domestic animals were considered as a single category of livestock (including goats, sheep, horses, and cattle). We excluded small rodents, birds, and marmots from the analysis because they were too small for our camera trap to detect at a height of 25 cm above ground or recorded infrequently, and the obtained images were blurry to identify species. Camera trap data were analyzed by grouping detections if Pallas's cat occurred within ten and thirty minutes in one capture, which is a widely used method in camera trapping (Li et al., 2010).

We normalized the data in order to fairly compare the results collected from different camera traps. Since our target species was the Pallas's cat, we only normalized data from the cameras that recorded the images of the species. Out of all the deployed cameras, only four successfully documented images of Pallas's cats. We normalized their data by dividing the number of independent detection events by the number of days each camera was effectively functioning, and then multiplied the result by 100 to express detections per 100 camera-days.

The number of detections for the target species was insufficient to analyze activity patterns for each camera individually; for example, Cam2 and Cam3 each detected only one event.

Therefore, we combined the detection data from all cameras to analyze the overall temporal activity. We averaged the number of captures within the adjacent two hours as the number of captures for each species to build the daily activity curves followed by Li et al. (2013). The daily and annual activity index were calculated with the following formula:

$$\text{Activity index of time point: } A = \frac{\text{(captures at this time point)}}{\text{(captures in the whole time frame)}}$$

The beech marten and steppe polecat were excluded from the annual activity analysis due to infrequent captures, whereas all five species (Pallas's cat, grey wolf, beech marten, steppe polecat, and red fox) were included in the daily activity pattern analysis.

4. RESULTS

4.1. Literature survey: Threat assessments and rankings globally

4.1.1. Distribution of the research to wildcats in Europe and Pallas's cats in Asia

Most of the articles were published in the 2000s, with the highest number appearing in 2009 for both felids. Research on the threats facing these species has steadily gained more attention from the scientific community over time, particularly for the wildcat. The species has been the subject of significantly more publications compared to Pallas's cats, consistently receiving research attention, notably after the 2000s. The number of recent publications (2001–2025; n = 74) is considerably higher, while older studies (1977–1999; n = 14) are fewer in comparison. In contrast to wildcats, research on Pallas's cats was initially quite rare but has also increased in the recent years. However, no studies on Pallas's cats were published prior to 2000 (Figure 13). Studies of wildcats in Europe focused more on hybridization and disease (n = 38 and n = 21, respectively), and all confirmed that these are direct or existing threats. Likewise, among research concerning Pallas's cats, predation by herding dogs (n = 13) has received the most attention as a direct threat, while secondary poisoning (n = 9) has been considered a potential danger in Asia.

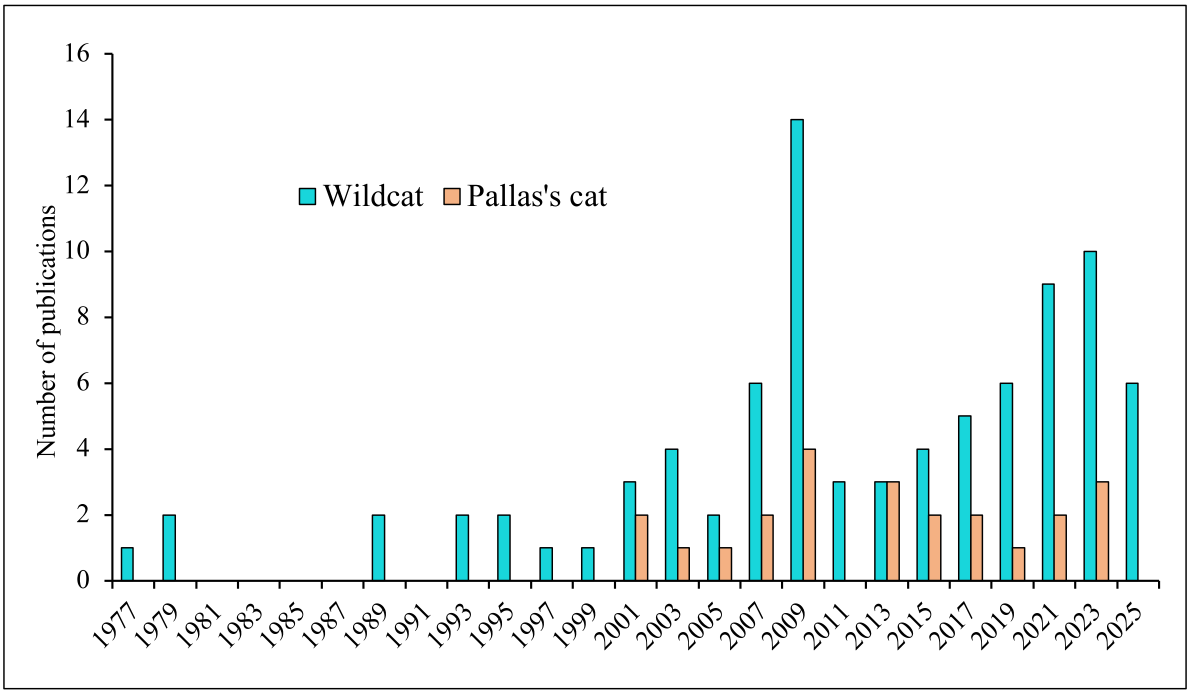


Figure 13: Number of publications per year focusing on threats to wildcats in Europe (n = 88) and Pallas's cats in Asia (n = 21) based on selected publications of the search.

Pallas's cat: A total of 21 publications from 5 countries were involved, indicating a relatively limited number of original research articles focused on the threats to Pallas's cats in Asia. Our literature search results show that the majority of studies were concentrated in the species' strongholds, with 7 studies conducted in Mongolia and 6 in Iran. The remaining studies were investigated in Russia (n = 4), China (n = 3), and India (n = 1) (Figure 14).

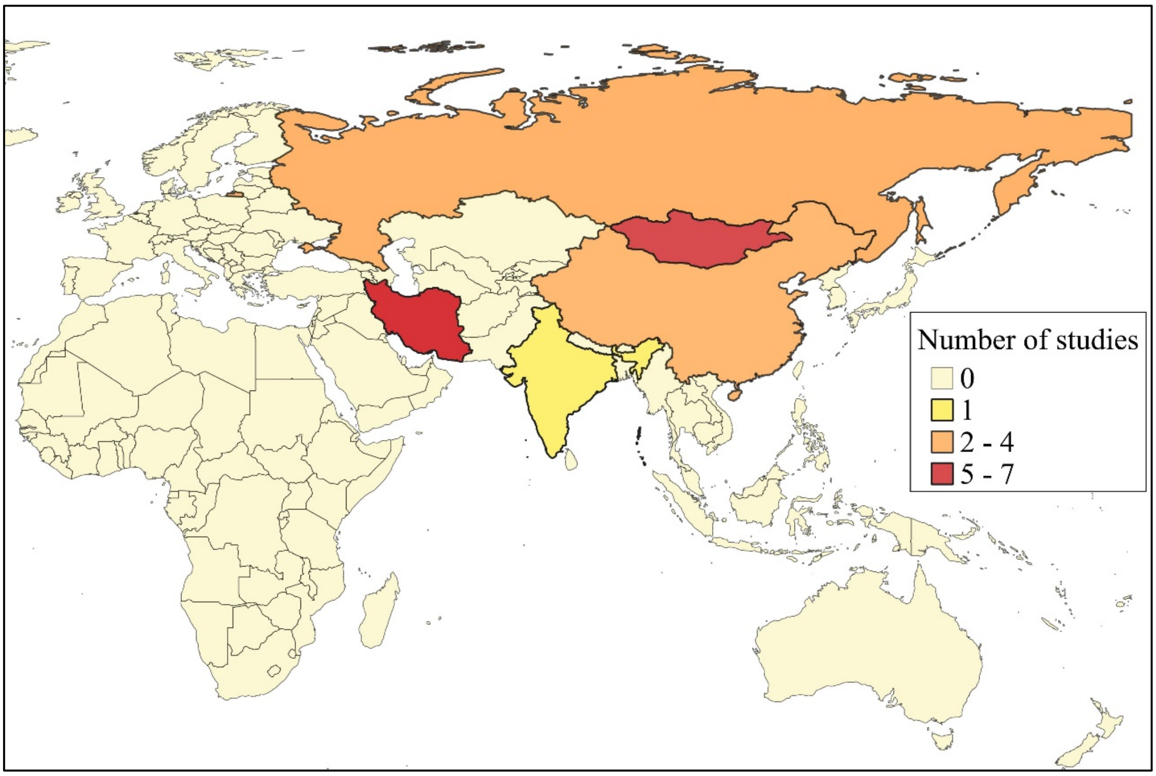


Figure 14: Number of publications (n = 21) reported direct and potential threats to Pallas's cats in Asia based on the selected publications of the search.

Wildcat: Altogether, the 88 studies included originated from 12 European countries. The geographical distribution of the studies shows that most were conducted in Germany (n = 17), followed by Scotland (n = 14), Spain (n = 13), and Italy (n = 11). Additionally, more than five studies were conducted in Hungary (n = 9), while France and Portugal each contributed six studies. Greece, Belgium, Luxembourg, Turkey, and Switzerland were represented by between one and three publications about threats to wildcats (Figure 15). We found that 85% (75 out of 88) of the studies were predominantly conducted in Western and Southern Europe, with a specific focus on Germany and Scotland, as well as the Mediterranean region and the Iberian Peninsula.

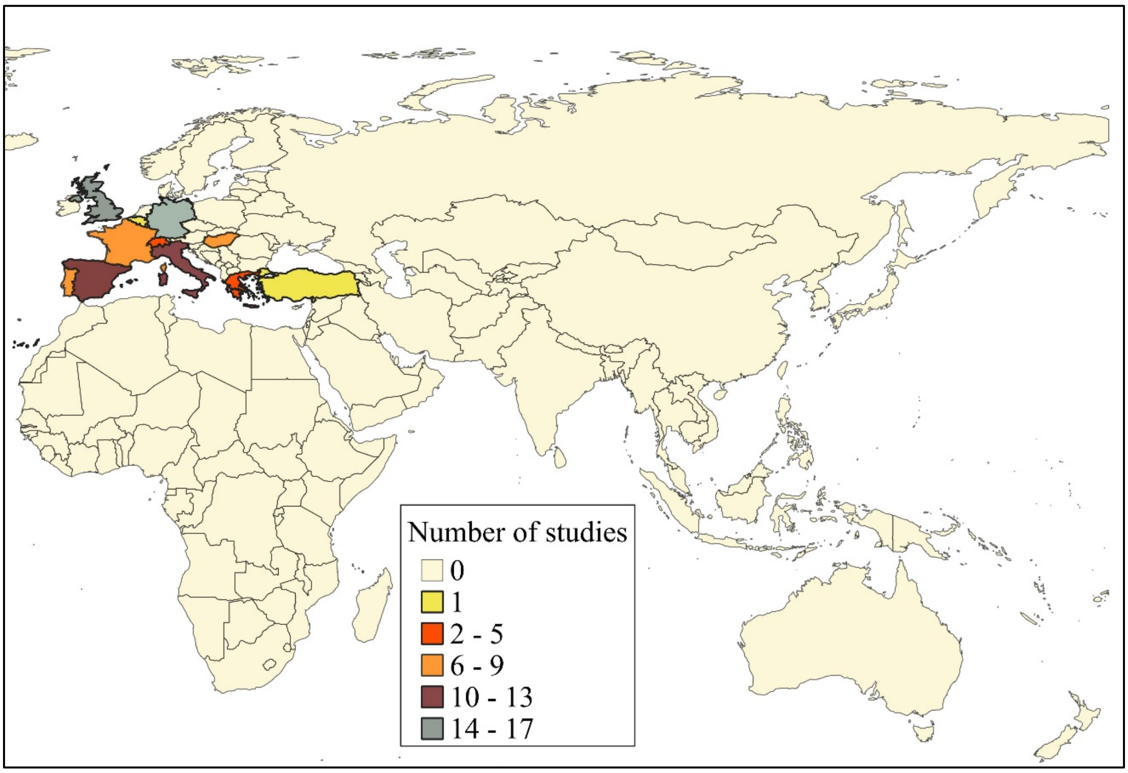


Figure 15: Number of publications (n = 88) reported direct and potential threats to wildcats in Europe based on the selected publications of the search.

4.1.2. Threat assessments

A total of 23 sources, including 21 scientific articles and 2 theses, were evaluated, mentioning 49 threats to Pallas's cats. In contrast, 88 scientific articles were found in the literature survey, identifying 93 threats to wildcats. According to the IUCN Threats Classification System, the categorized threats are shown in Figure 16.

Among these, the group invasive and other problematic species represents the most significant threats to both species (64% of threats to wildcats and 37% to Pallas's cats), including hybridization with domestic cat, disease, herding dogs, and competition with other species. This was followed by "biological resource use," the second most frequent threat category, which accounted for 11% and 31% of threats to wildcats and Pallas's cats, respectively (see Table 1 for more details). Secondary poisoning was a significant threat for Pallas's cats (19%), while roadkill was notable for wildcats (10%). Other threat categories were less prominent for both cats (Figure 16).

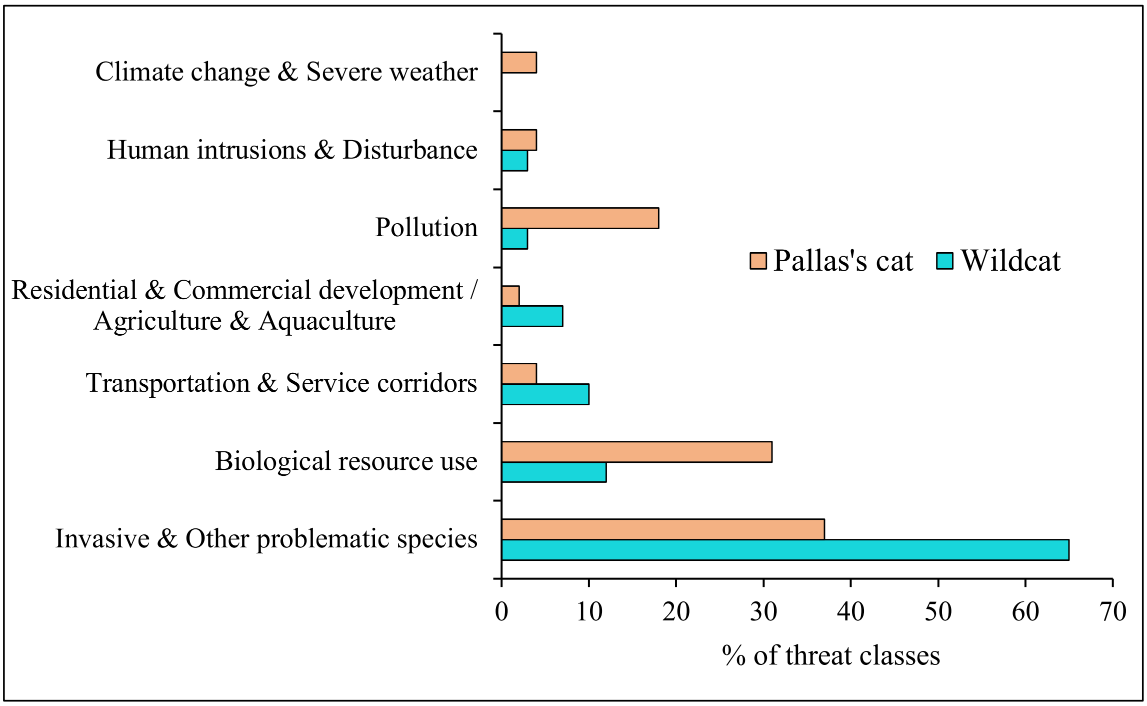


Figure 16: Classified threats to both cats, based literature search (n = 88 sources for wildcats, n = 23 sources for Pallas's cats) using the IUCN Threats Classification System.

4.1.3. Threat rankings

Pallas's cat: Overall, seven threat categories were recorded, with 'invasive and other problematic species' and 'biological resource use' ranked as serious threats to Pallas's cats (Table 3). Specifically, the first threat category encompassed the most frequently documented threat, predation by herding dogs (27%) as direct threat to the species. The species' mortality due to herding dogs have been recorded in Iran (n = 5), Russia (n = 3), Mongolia (n = 2), and China, Kyrgyzstan, and India (n = 1 each).

The latter category included overgrazing by livestock (15%) and illegal hunting and trade (10%), both considered potential threats**.** All livestock pressure-related records were reported from Iran (n = 3), Mongolia (n = 2), and China and Pakistan (n = 1 each). Moreover, secondary poisoning was evaluated as a medium potential threat to Pallas's cats. The small mammal poisoning campaign was reported in Central Asia, mainly in China (n = 3), Mongolia (n = 2), with single cases recorded in Nepal, Pakistan, and Iran. The other threats shown in Table 3 were classified as 'minor' threats and have been rarely addressed in the existing literature.

Table 3: Threat rankings for Pallas's cats and wildcats are categorized as Serious (Red), Medium (Orange), and Minor (Yellow).

Threats	Pallas's cat	Wildcat
Invasive & Other problematic species	Serious	Serious
Biological resource use	Serious	Medium
Transportation & Service corridors	Minor	Minor
Residential & Commercial	Minor	Minor
Pollution	Medium	Minor
Human intrusions & Disturbance	Minor	Minor
Climate change & Severe weather	Minor	

Wildcat: Among the collected scientific articles, six threat categories were identified for wildcats and ranked according to their severity (Table 3). Of these, only one category, 'invasive and other problematic species', was ranked as a serious threat, with hybridization (41%) and disease (23%) emerging as the primary concerns. Most hybridization cases were predominantly documented in Hungary and Great Britain (n = 7 each). Five cases were reported in both Portugal and Germany, with four cases documented in France and Italy. Similarly, most disease studies were conducted in parts of Western Europe, including Germany (n = 6 cases) and Great Britain (n = 4), as well as regions of Southern Europe such as Spain (n = 4), Greece, and Italy (2 cases each). In addition, 'biological resource use' category ranked as a medium-level threat, including more than eight threat types (see Table 1 for more details). Although, considered relatively minor, the remaining categories still posed notable threats such as roadkill to the wildcat population in Europe (Table 3).

4.2. Field-based research

4.2.1. Respondent demographics

Pallas's cat: We carried out 107 interviews in Hustai National Park. Table 4 presents a breakdown of all respondent attributes. 86 of the respondents (80%) were male and 21 (20%) were female. Most of the respondents were herders (85%) and rangers (12%) and only 3 (3%) of the respondents had other professions (biologist, biotechnologist, and accountant). The most respondents were in the 36 - 45 age category and the age ranged from 24 to 65 years. A decisive majority of respondents (74%) had lived in their nearby area for over 20 years (Table 4).

Table 4: Participant demographics (n = 107)

Category	Sub-category	Frequency	Percentage (%)
Occupation	Herder	91	85%
	Ranger	13	12%
	Other	3	3%
Gender	Male	86	80%
	Female	21	20%
Time spent	1-5 years	3	3%
	6-10 years	7	7%
	11-15 years	8	7%
	16-20 years	10	9%
	more than 20	79	74%
Age	18-25	4	4%
	26-35	14	13%
	36-45	34	32%
	46-55	32	30%
	56-65	23	21%

4.2.2. Species awareness

4.1.2.1. Respondents' ability to identify the study species: Both cats

79% (85) of all respondents identified correctly Pallas's cats in the given photographs while 21% (22) were unable to recognize the species that answers were discarded (Figure 17). The remaining answers were retained though as they were deemed to still be potentially valuable for the final analysis. On the contrary, 95% of all respondents were able to identify the wildcat correctly from the photos provided while a mere 5% (10) of surveys were discarded due to contradictory answers, leaving 196 surveys available for the final analysis (Figure 17). No additional impact variables for the species identification were gathered.

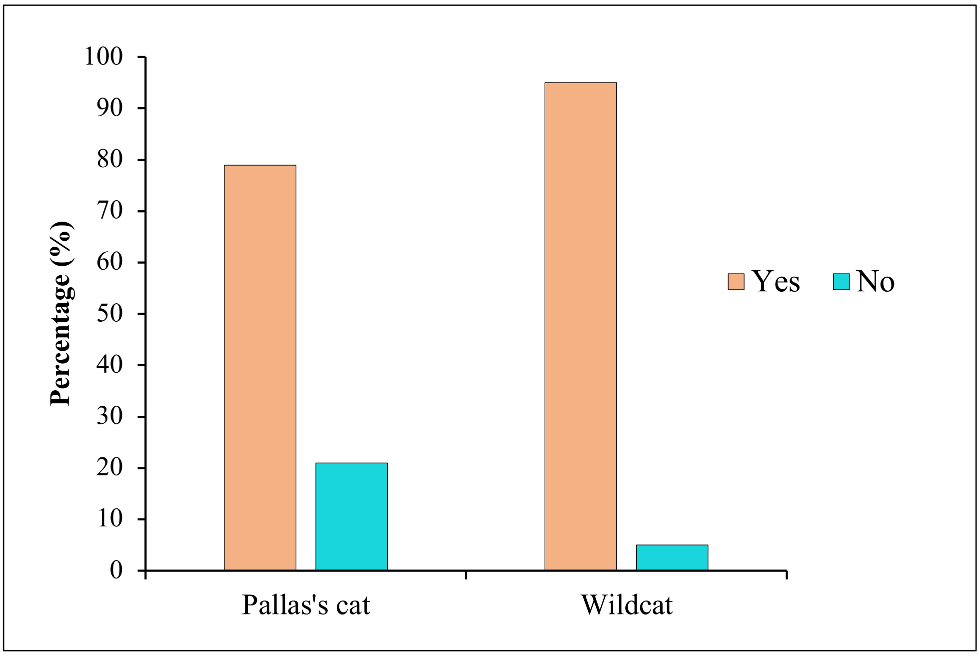


Figure 17. Proportion of respondents who correctly identified the Pallas's cat (n = 107) and wildcats (n = 206) by selecting 'Yes'.

4.1.2.2. Influential factors in ability to identify Pallas's cats

Respondents who encountered Pallas's cat previously and male participants were more likely to identify the species correctly. There was no significant impact of either age, occupation, or years lived in the area (Table 5).

Table 5: Analysis of influential factors on ability to identify Pallas's cats

Variable	**χ^2 test (DF)**	**p**
Gender	χ^2 (2) =8.9	0.01
Age	χ^2 (8) =4.2	0.84
Occupation	χ^2 (4) =8.7	0.06
Time spent	χ^2 (8) =6.2	0.62
Previous sighting	χ^2 (2) =41	< 0.001

4.1.2.3. Species status: Population trend

Among participants 34% of them believed the wildcat's population increased, however 31% was reported there is no change to the status of the species in the last 10 years. On the contrary, the population trend of Pallas's cats has been showing a declining trend according to the responses (38%) (Figure 18).

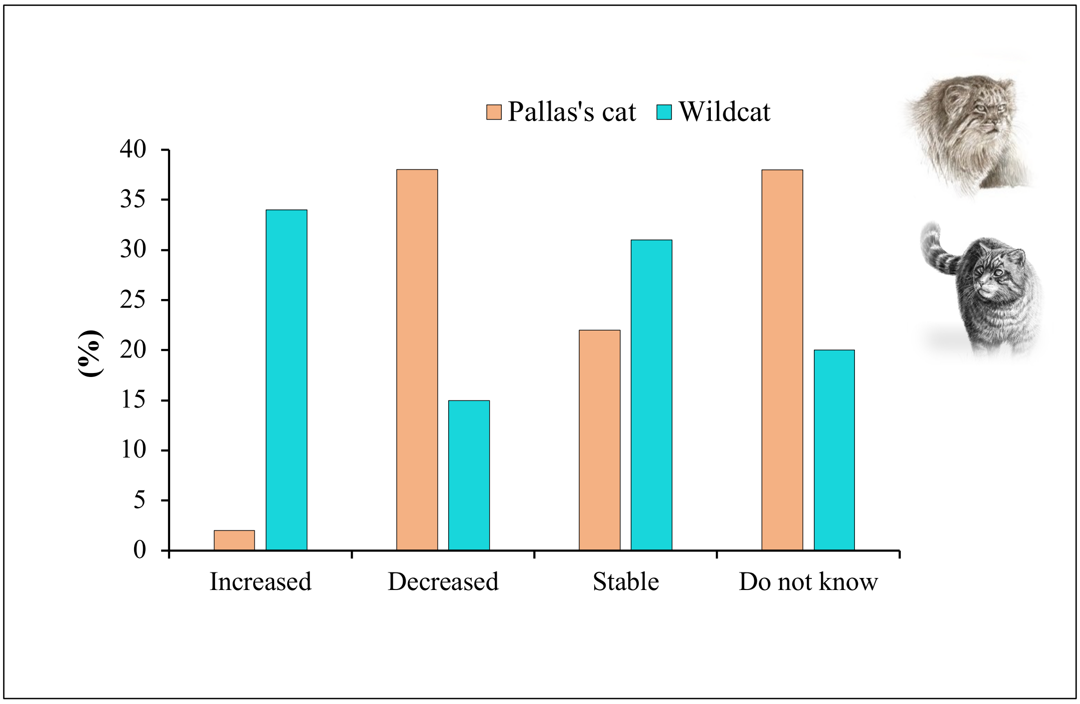


Figure 18: Graphical proportions of perceived population trends for the wildcat and Pallas's cat based on respondents' answers.

4.2.3. Perceived threats locally

Pallas's cat: 65% (59) of all participants from the Pallas's cat sample reported that there were no threats to the species in the HNP and the remaining believed there were one or more threats (35%). Among the respondents who indicated threats to Pallas's cat, the most serious one was lack of prey (11%) followed by lack of habitat (10%) and herding dogs (6%). Poisoning was the least commonly indicated in our survey (Figure 19).

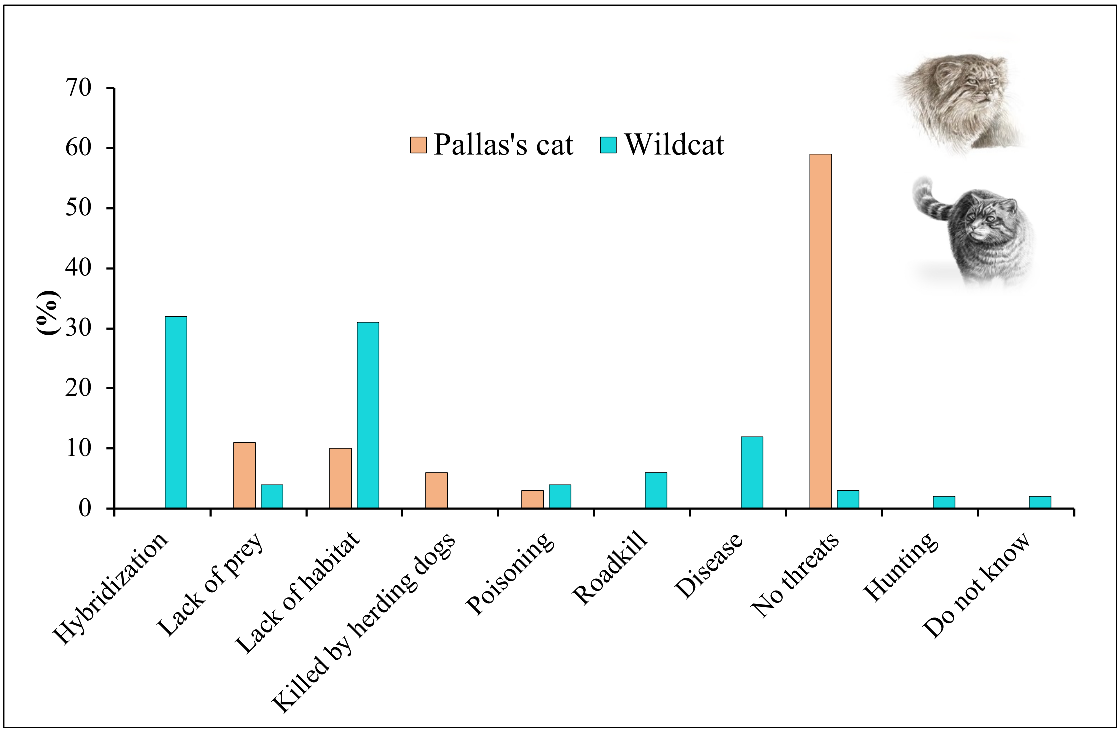


Figure 19: Graphical representation of threats to both cats based on the answers of the respondents

Wildcat: 99% of all respondents (n = 196) from the wildcat sample believed there were one or more threats to the species and only 1% believed there was none. Respondents identified hybridization with feral cats (32%) as the top threat to wildcats, followed by habitat loss (31%). Other moderate threats included disease (12%) and roadkill (6%), respectively. The least serious threats reported in the survey were lack of prey, poisoning (both 4%), and hunting (2%) (Figure 19).

4.2.4. Pallas's cat distribution and influencing factors

A total of 107 respondents participated, of which 85 were deemed able to reliably identify Pallas's cats. The herders that were deemed to identify the Pallas's cat reliably reported 56 observations of Pallas's cats in the year of 2023. For the final analysis, we used 85 (79%) of these interviews, excluding 22 (21%) respondents who were unable to correctly recognize Pallas's cats.

Adding grid cell as a random effect significantly increased model performance based on the likelihood ratio test ($\chi^2 = 4.9$, $p = 0.027$). The percentage cover of steppe ($\chi^2 = 6.4$, $p = 0.011$) and terrain ruggedness index ($\chi^2 = 3.4$, $p = 0.054$) remained the only variables that provided significant explanatory power to the model explaining the variation in occurrence of Pallas's cats as fixed effects (Table 6).

Table 6: Effects of different landscape types on Pallas's cat occurrence, analyzed by a mixed-effects logistic regression using grid cell identity as a random (intercept) factor. Variables were scaled for the model and expressed as standardized estimates. Significant effects are highlighted in bold.

		95% Confidence Interval			
	Standardized estimates	lower	upper	z value	**p**
Steppe	0.45	0.09	0.81	2.51	**0.013**
Terrain Ruggedness Index	0.26	-0.01	0.53	1.82	0.064
Water	0.2	-0.08	0.48	1.42	0.157
Forest	0.38	-0.21	0.97	1.27	0.202
Sand	0.16	-0.13	0.45	1.11	0.271
Barren land	-0.14	-0.4	0.13	-1.03	0.304
Cropland	0.09	-0.14	0.34	0.81	0.419
Built area	-0.06	-0.26	0.13	-0.63	0.529
Desert steppe	0.04	-0.2	0.28	0.33	0.738

Variance of random effects (Cell grid): 1.008

The low variance inflation factor did not indicate any problems of multi-collinearities (VIF: 1.57, confidence interval: 1.37 - 1.77). Steppe cover significantly and positively associated with Pallas's cat occurrence (Table 6), i.e. higher percentage cover resulted in a significantly higher probability of occurrences with one or more individuals of the species (Figure 20).

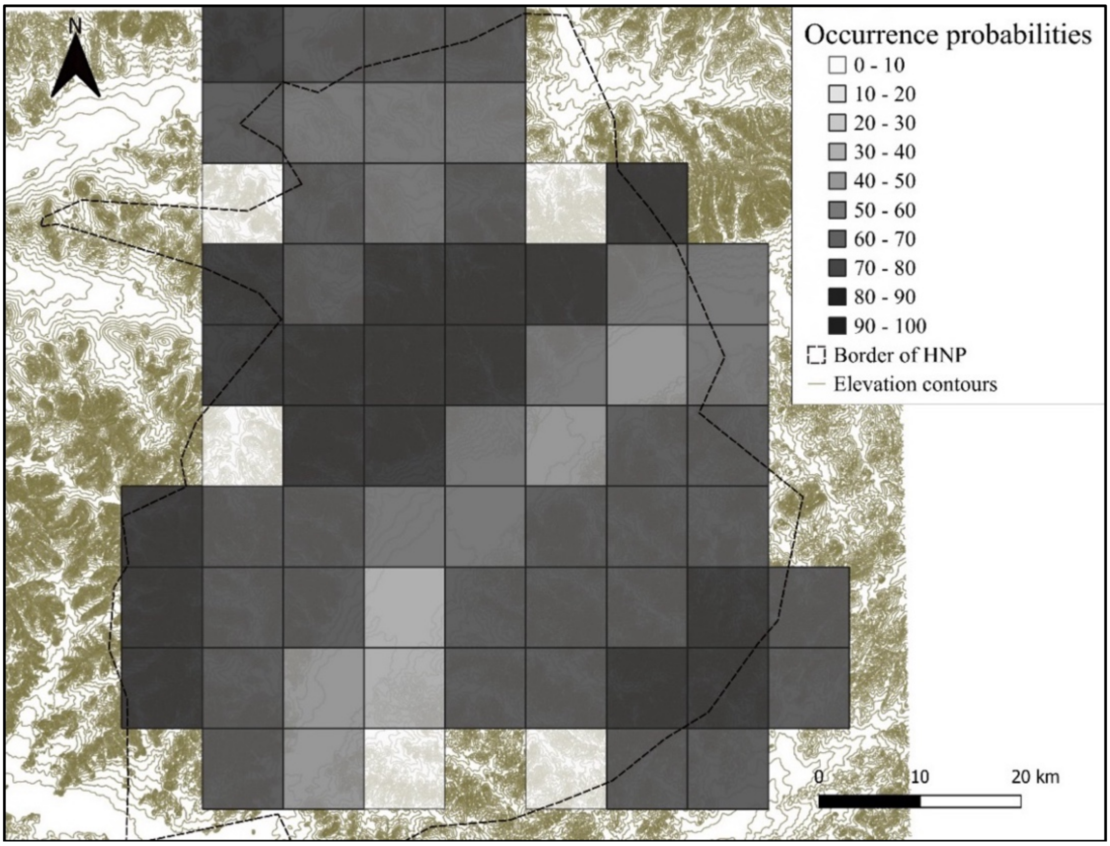


Figure 20: Occurrence probabilities of Pallas's cat in Hustai National Park estimated from the mixed logistic regression model.

The predicted error tends to be decreasing at higher steppe cover values (Figure 21a). Terrain ruggedness index, while near significance, may also play an important positive role in the species' occurrence (Figure 21b). The 95% confidence interval indicates that its importance can be highly variable depending on the terrain relief and land cover type. Terrain ruggedness index average values were 22.95 ± 9.4 SD with presence and 19.06 ± 10.8 SD with absence.

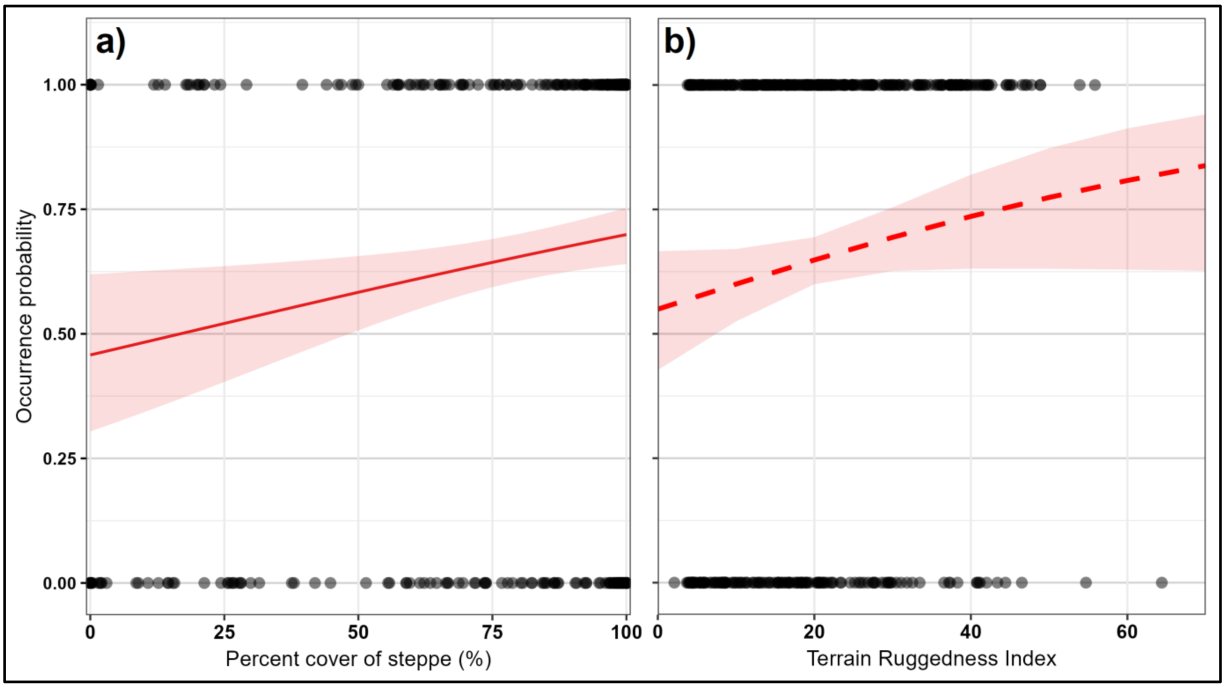


Figure 21: Effects of steppe cover and terrain ruggedness index on Pallas's cat occurrence in Hustai National Park. The effect of (a) the percent cover of steppe was statistically significant, whereas the effectof (b) the terrain ruggedness index was only a tendency. Regression lines including heir 95% confidence band are based on the model estimates provided in Table 6.

4.2.5. Wildcat distribution and associated land cover factors

Game management units in Hungary reported wildcats' presence and absence in three distinct time periods, showing a clear decline in responses from 2004 to 2022. Given that only 200 respondents completed the questionnaire in 2022, we included only those who reported from the same units in all three years to analyze wildcat distribution changes.

The rate of positive answers was correlated with the total number of responses, but due to low number of repetitions, it remained non-significant (r = 0.93, p = 0.28). Although the number of respondents decreased over time, this sample loss was spatially balanced. Therefore, the number of covering UTM cells of interest remained stable during the study (Table 7), which provided the sampling units to our analyses instead of direct responses. The area represented by the relevant UTM cells was 1.801 thousand hectares in 2004 and exceeded 1.985 thousand hectares in 2014 and 2022.

Table 7: The total number of respondents and the related UTM cells per survey year with the relative proportion of reported wildcat occurrence.

Year	**2004**		**2014**		**2022**	
	n	presence %	n	presence %	n	presence %
Respondents	551	52	354	51	200	86
UTM cells	182	67	201	66	201	85

The increase of wildcat detections was also reflected in the UTM grid scale. The majority of the studied cells had at least one GMU connected to it that reported wildcat detection in each survey year (Table 7).

The covered area of detections slightly increased from 1207 thousand ha to 1304 thousand ha between 2004 and 2014 and reached 1688 thousand hectares in 2022. Overall, about half of the studied UTM cells (51.1%) could be coded as "occupied" by wildcats based on data from 200 respondents across all three survey years within the corresponding GMUs (Figure 22), indicating a stable presence. Wildcat appeared as present starting from 2014 in 9.9% of the cells and were only detected first time in 2022 in 12.5% of the UTM cells.

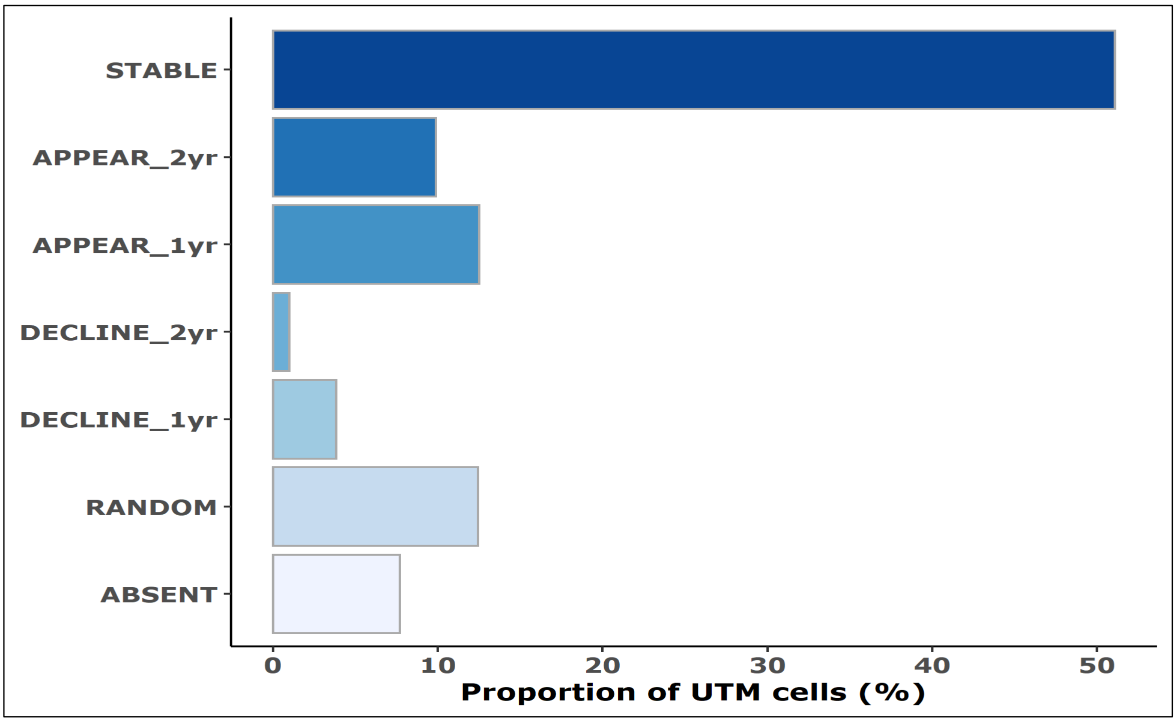
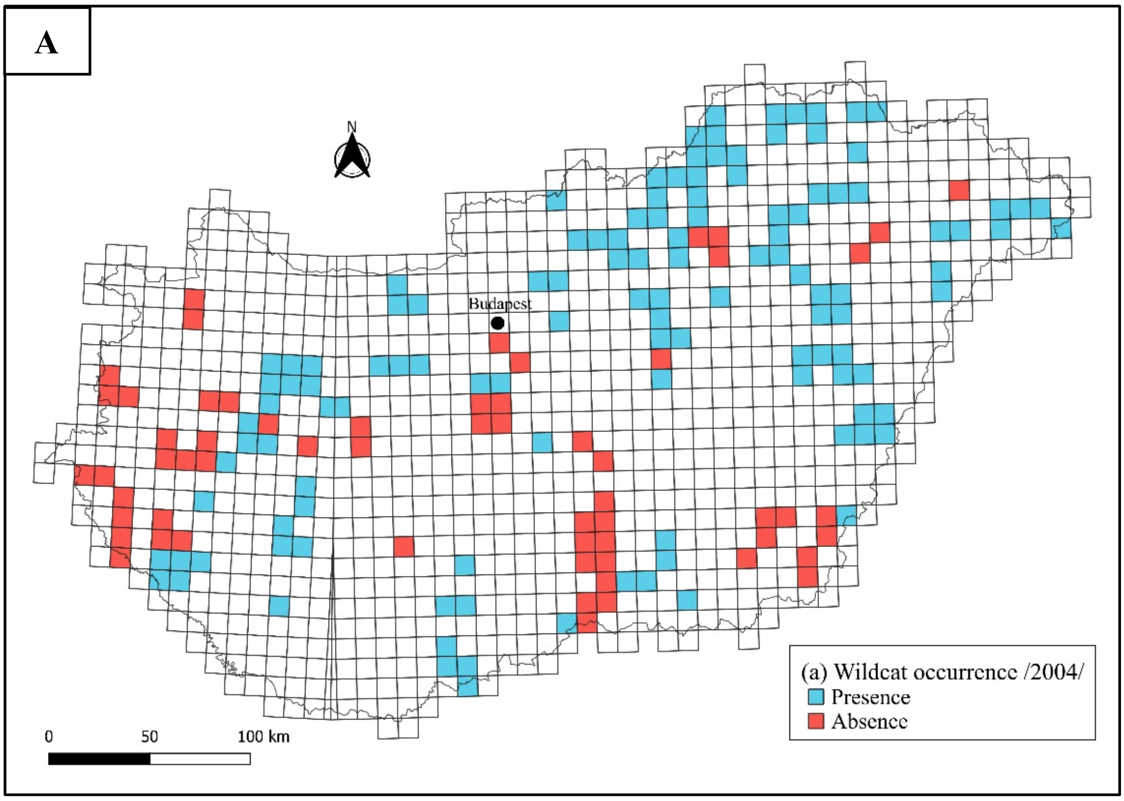


Figure 22: Trends of wildcat occurrence during the survey's time frame based on the relative proportion of the studied UTM cells. **STABLE** = wildcats were reported present in each survey year, **APPEAR_2yr** = wildcats were reported present in the last two survey years, **APPEAR_1yr** = wildcats were reported present in the last survey year only, **DECLINE_2yr** = wildcats were reported present in the first two survey years only, **DECLINE_1yr** = wildcats were reported present in the first year of the survey only; **RANDOM** = wildcats temporarily disappeared or reappeared in 2014, **ABSENT** = wildcat was reported absent in each survey year.

The number of regions in which wildcats disappeared was slightly lower: after nearly two decades, wildcats were reported absent in 2022 in 1% of the grid cells, while 3.8% of the cells had wildcat detections only from 2004. There were many GMUs and thereby UTM cells (12.4%) in which the wildcat detections were quite sporadic: wildcats were detected in 2014 in contrast with their absence in the previous and subsequent survey years or reappeared after a temporary absence in 2014. Consecutive absence was reported in 7.7% of the UTM cells (Figure 23).



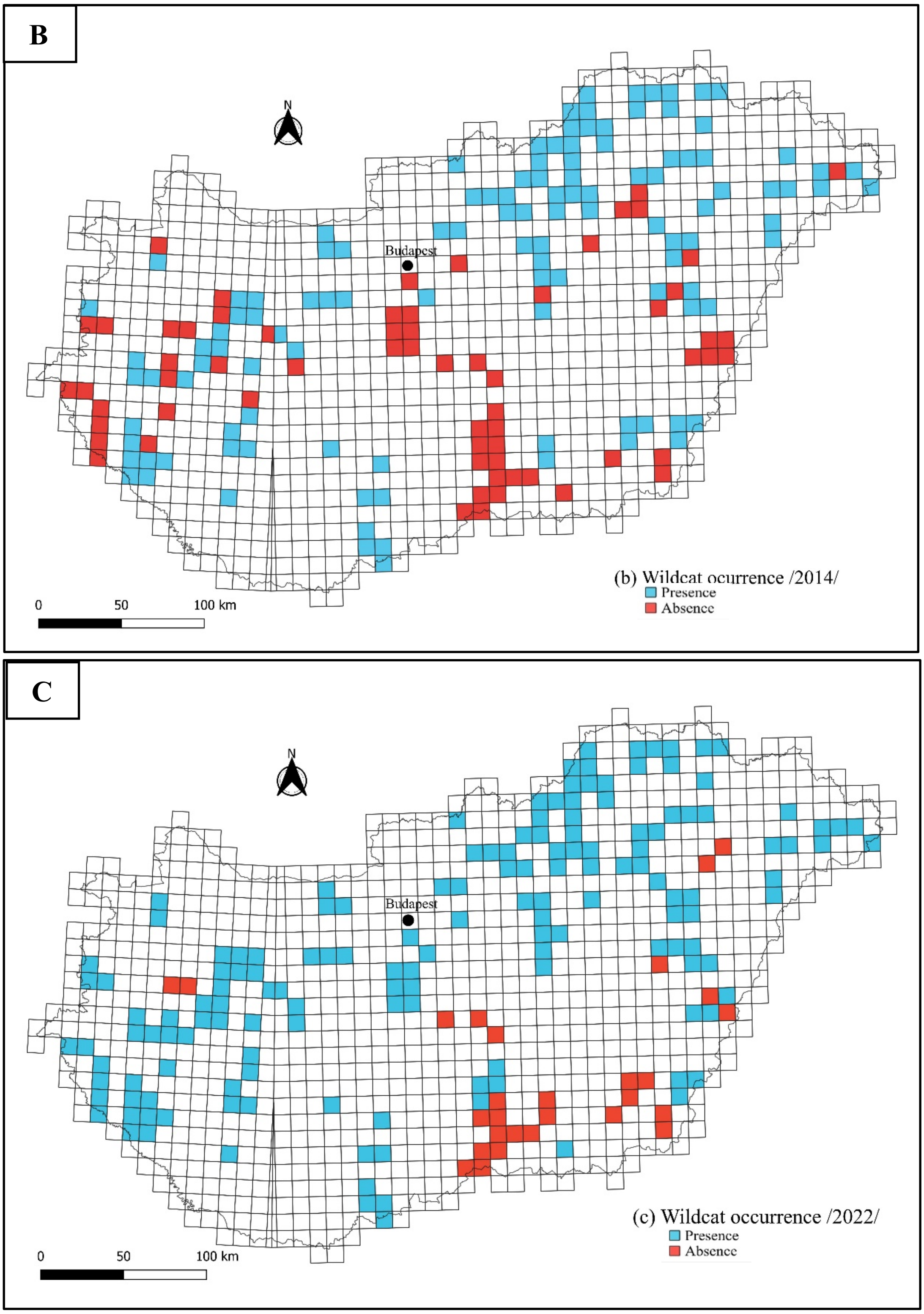


Figure 23*:* Reported occurrence for wildcats in Hungary between 2004 and 2022 (**A - C**)

The most common and dominant land use type was non-irrigated arable land throughout the studied UTM cells and 48 ± 24% cover. The average area of broadleaved forest was also high (1.942 ± 1.845 ha) but less dominant in the UTM cells (19 ± 19%), while pasture was the third most frequent land cover type with a much smaller mean area (749 ± 509 ha) and cover (7 ± 5%).

The mean cover of the other land cover types remained under 5%. The studied UTM cell had four or five different land cover types present inside their area on average (mean: 4.64 ± 1.5).

The diversity of the available land cover types remained nearly the same across all time periods (Shannon-index: 0.83 ± 0.36; inverse Simpson index: 2.04 ± 0.78; evenness: 0.54 ± 0.19), indicating relatively low variability over the years. During the model selection, likelihood ratio tests revealed that the diversity indices were not good predictors of wildcat occurrence (richness of land cover types: $\chi^2 = 0.01$, $p = 0.93$; evenness: $\chi^2 = 0.29$, $p = 0.58$; Shannon diversity: $\chi^2 = 0.16$, $p = 0.69$). The survey years and the percent cover of the land cover types constituted the final set of explanatory variables.

The logistic regression model found a significantly increasing trend on the larger time frame between 2004 and 2022 in wildcat detections (Table 8).

Table 8: Temporal changes in the reported wildcat presence and effects of land cover types on wildcat occurrence estimated using binomial logistic regression. Year 2004 was used as reference category for the variable Year. The coefficients and their corresponding confidence intervals are expressed in odds ratios, the exponentiated form of the default 'log of the odds output of the model.

		95% Confidence Interval			
	Estimate	**Lower**	**Upper**	**Z value**	**p**
Intercept	1.50	0.44	5.12	0.65	0.519
Year					
2014	0.92	0.57	1.47	-0.35	0.724
2022	3.47 ***	1.99	6.03	4.4	< 0.001
Relative proportion of land cover types					
Road, rail and associated land	0.60	0.29	1.25	- 1.36	0.172
Non-irrigated arable land	0.99	0.98	1.01	- 0.78	0.433
Pastures	1.02	0.98	1.07	1.05	0.295
Broad-leaved forest	1.06 ***	1.03	1.08	4.77	< 0.001
Coniferous forest	0.92	0.80	1.06	-1.13	0.260
Mixed forest	0.87 *	0.78	0.97	-2.43	0.015
Water bodies	1.00	0.94	1.06	0.00	0.999

*** $p < 0.001$ * $p < 0.05$

Among land cover types, the broad-leaved forest cover positively associated with wildcat occurrence, but the estimated odds remained low nevertheless, staying near to the threshold of 1 (OR=1.06, 95 confidence interval: 1.03-1.08). On the contrary, mixed forest cover (woodlands where the standing volume of coniferous and broad-leaved tree species was nearly equal) turned out to be negatively associated with wildcat presence, but also with a weak OR. Non-irrigated arable land as the most dominant land cover type in vast majority of the UTM cells had no effect on wildcat occurrence, similar to the remaining minority land cover types (Table 8).

For each survey year, the area of broad-leaved forest was significantly higher ($p < 0.001$) in the UTM cells with wildcat presence (2004: 2215 ± 2073 ha; 2014: 2384 ± 1967 ha; 2022: 2149 ± 1888 ha) than those without it (2004: 1370 ± 1192 ha; 2014: 1062 ± 1111 ha; 2022: 671 ± 528 ha). The percent cover of this habitat reflected the same contrast between occupied (2004: 22 ± 21%; 2014: 23 ± 20%; 2022: 21 ± 19%) and non-occupied (2004: 13 ± 12%; 2014: 10 ± 11%; 2022: 6 ± 5%) grid cells. Mixed forests had a higher area in non-occupied cells (2004: 602 ± 786 ha; 2014: 659 ± 808 ha; 2022: 630 ± 668 ha) than in those where wildcats were present (2004: 189 ± 168 ha; 2014: 169 ± 125 ha; 2022: 263 ± 454 ha), supporting the findings of the logistic regression model. The same tendency was true in the case of coniferous forests in 2004 and 2014 (Figure 24), but their effect on wildcat occurrence was not confirmed using the model.

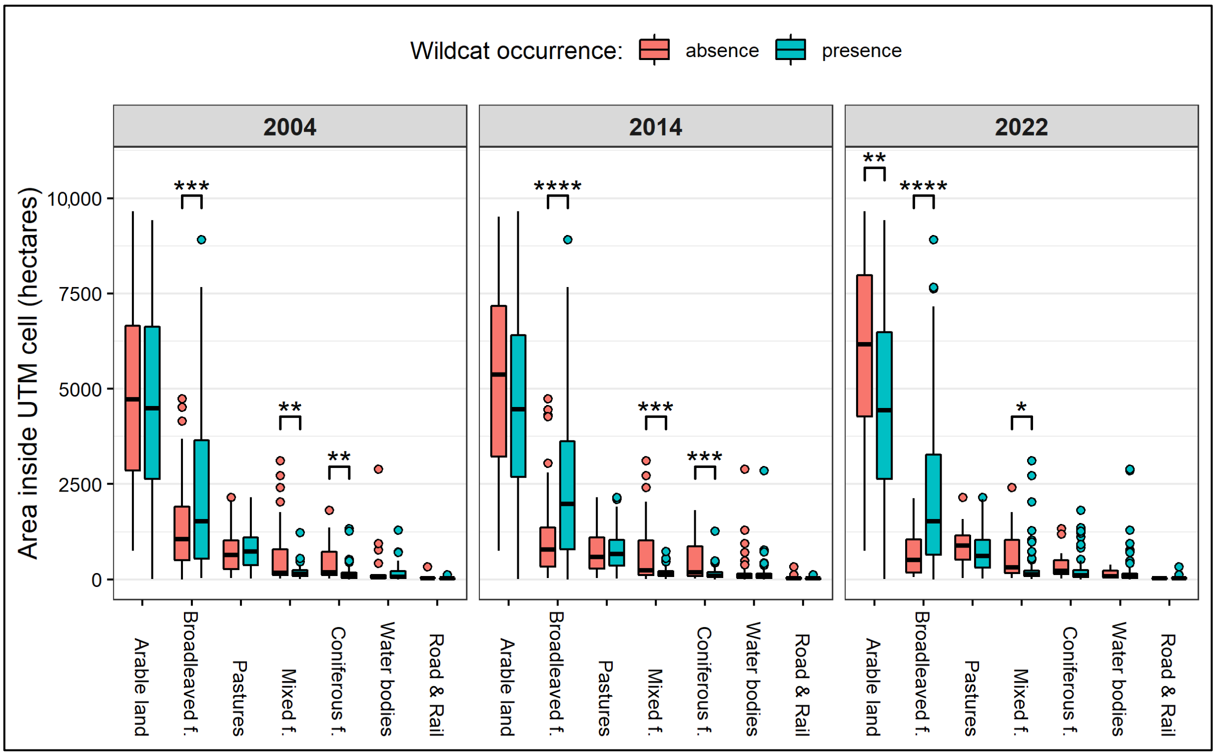


Figure 24: Box plot comparing the area of land cover types in UTM cells with and without reported wildcat presence. Asterisks represent the significant pairwise differences indicated using Welch's two-sample t-test. **** $p < 0.0001$, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

4.2.6. Camera trap captures

In 317 trap days from July 1, 2022, through May 13, 2023, we obtained 1141 captures of carnivores including Pallas's cats (567 captures), grey wolves (262 captures), red foxes (259 captures), beech martens (43 captures), Eurasian polecats (10 captures). Our targeted species was the most frequently photographed carnivore followed by grey wolves and red foxes. Furthermore, 145 images of herbivores were captured with wapiti (130 captures) and Argali (15 captures). A rodent species recorded was the Siberian marmot (200 captures) (Table 9, Figure 25, Figure 26).

Table 9: Number of captures of each species captured by camera trapping.

Group	English name	Latin name	IUCN	Red List	Capture
Large carnivores	Grey wolf	*Canis lupus*	LC	NT	262
Small carnivores	Red fox	*Vulpes vulpes*	LC	NT	259
	Pallas's cat	*Otocolobus manul*	LC	NT	567
	Beech marten	*Martes foina*	LC	DC	43
	Steppe polecat	*Mustela eversmanni*	LC	LC	10
Herbivores	Wapiti or Elk	*Cervus canadensis*	LC	CR	130
	Argali	*Ovis ammon*	NT	EN	15
	Livestock				13214
Rodents	Siberian marmot	*Marmota sibirica*	LC	EN	200

[1]IUCN endangered species category (Red List): LC: least concern, NT: near threatened
[2]Category of Mongolian Red List of Mammals: NT: near threatened, DC: data deficient, CR: critically endangered, EN: endangered

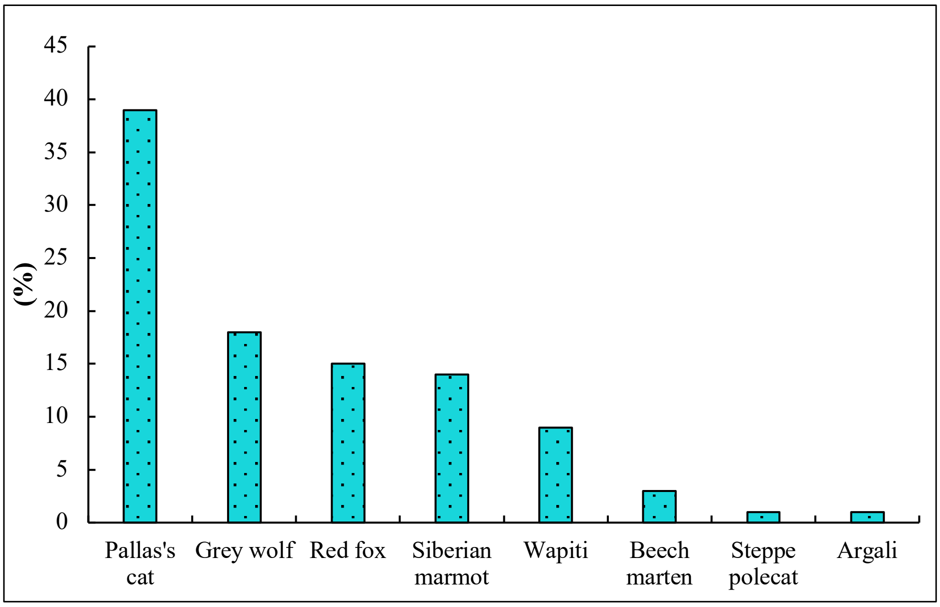


Figure 25: Captured wild animals by camera trapping, in percentage (excluding livestock).

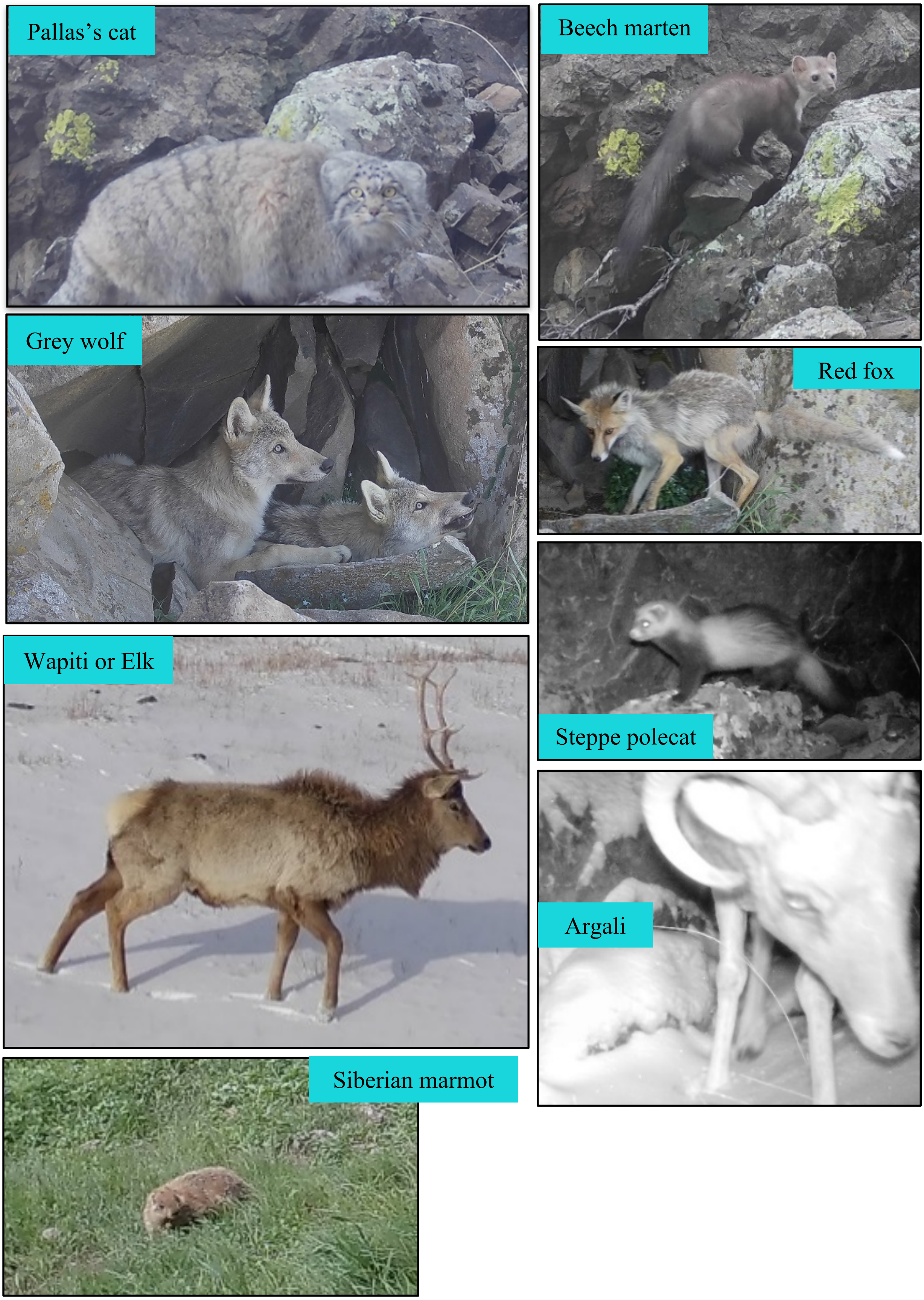


Figure 26: Captured species by camera trapping.

Table 10 showed the number of captures for each species at each site, including all six sites in Central Mongolia.

Table 10: Number of captures of each species on six sites.

Group	Species	Cam1	Cam2	Cam3	Cam4	Cam5	Cam10	Cam11
Large Carnivores	Grey wolf	232	6	4	0	20	0	0
Small Carnivores	Red fox	179	17	13	0	50	0	0
	Pallas's cat	93	2	68	0	404	0	0
	Beech marten	0	0	0	0	43	0	0
	Steppe polecat	0	0	0	0	10	0	0
Herbivores	Wapiti or Elk	0	76	0	0	30	10	14
	Argali	0	0	0	0	15	0	0
	Livestock	473	4212	4987	2068	187	87	1200
Rodents	Siberian marmot	0	0	0	200	0	0	0

In addition to carnivores and herbivores, resident bird species such as the common kestrel (*Falco tinnunculus*), with 38 captures, were observed. Migratory bird species identified in the images included the Eurasian hoopoe (*Upupa epops*) with 145 captures, the red-billed chough (*Pyrrhocorax pyrrhocorax*) with 10 captures, and the ruddy shelduck (*Tadorna ferruginea*) with 3 captures (Figure 27). Finally, a total of 13,214 photographs of various livestock species, including horses, goats, sheep, and cattle, were captured.

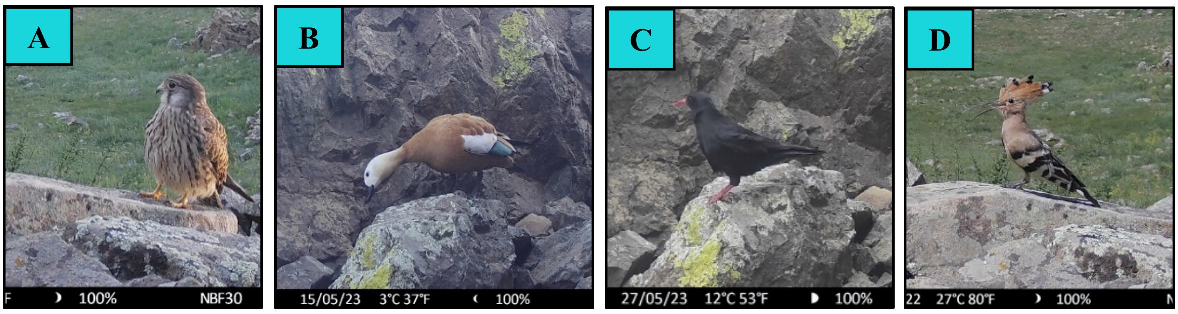


Figure 27: Captured resident and migratory birds by camera-trapping: A: common kestrel, B: ruddy shelduck, C: red-billed chough, D: Eurasian hoopoe.

4.2.6.1 Temporal activity patterns of Pallas’s cats and other species

A total of four camera traps captured images of the target species during the study period: Cam1 (n = 93), Cam2 (n = 2), Cam3 (n = 68), and Cam5 (n = 404 captures) (Figure 28).

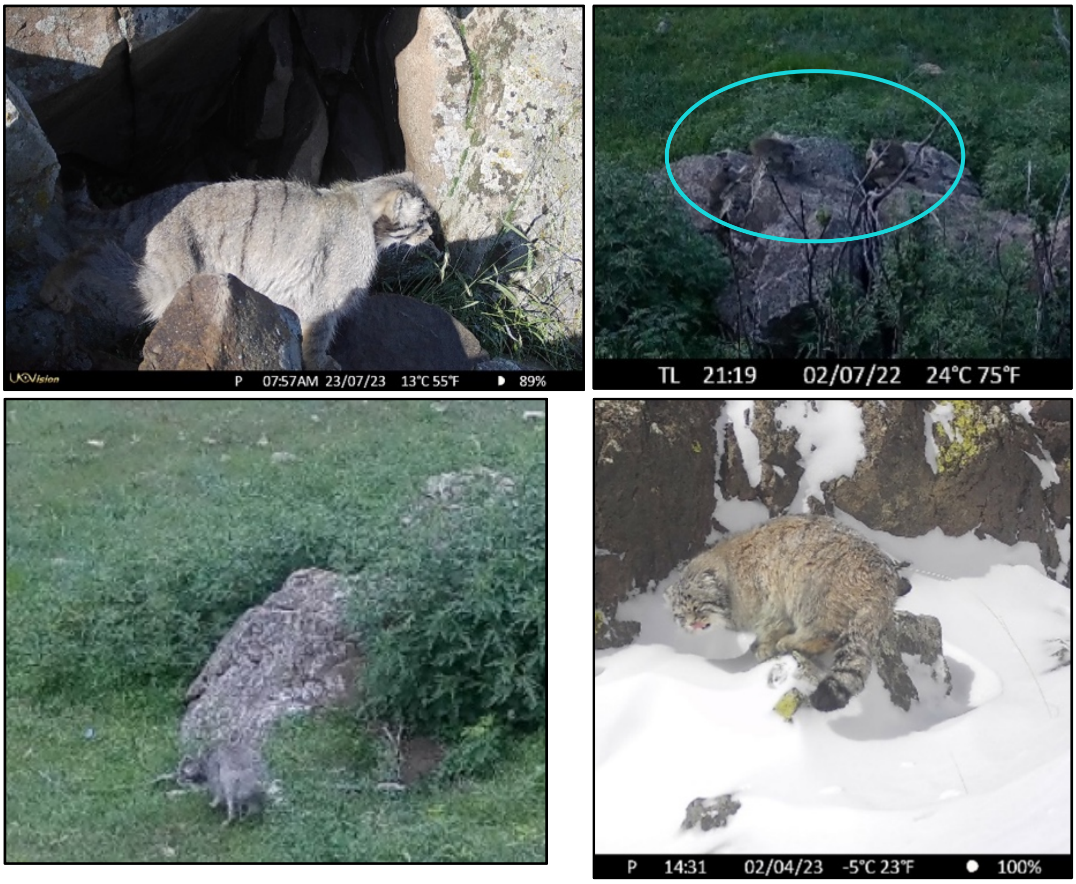


Figure 28: Captured Pallas’s cats by Cam1, Cam2, Cam3, and Cam5.

Cam5 in particular recorded a high number of Pallas’s cat images as well as the highest capture rate (27 captures per 100 days over an active period of 240 effective study days). Cam1 also showed notable records, with 18 captures per 100 days over an active period of 71 days**.** While Cam2 and Cam3, worked for just one day with few captures due to battery failures. No images were recorded by the other cameras.

Daily activity pattern: Among the large and small carnivores, Pallas's cats were active both day and night, showing a slight crepuscular trend, similar to the daily activity patterns of red foxes. Pallas’s cats’ highest activity peaks were being recorded at 20:00 and minimum activity being recorded during midday (Figure 29). Grey wolves appeared to be most active at dawn and dusk, whereas beech martens passed by the rock before dawn, with activity peaking in the morning.

Daily patterns indicated that steppe polecats typically appeared only at night, during crepuscular hours (Figure 29).

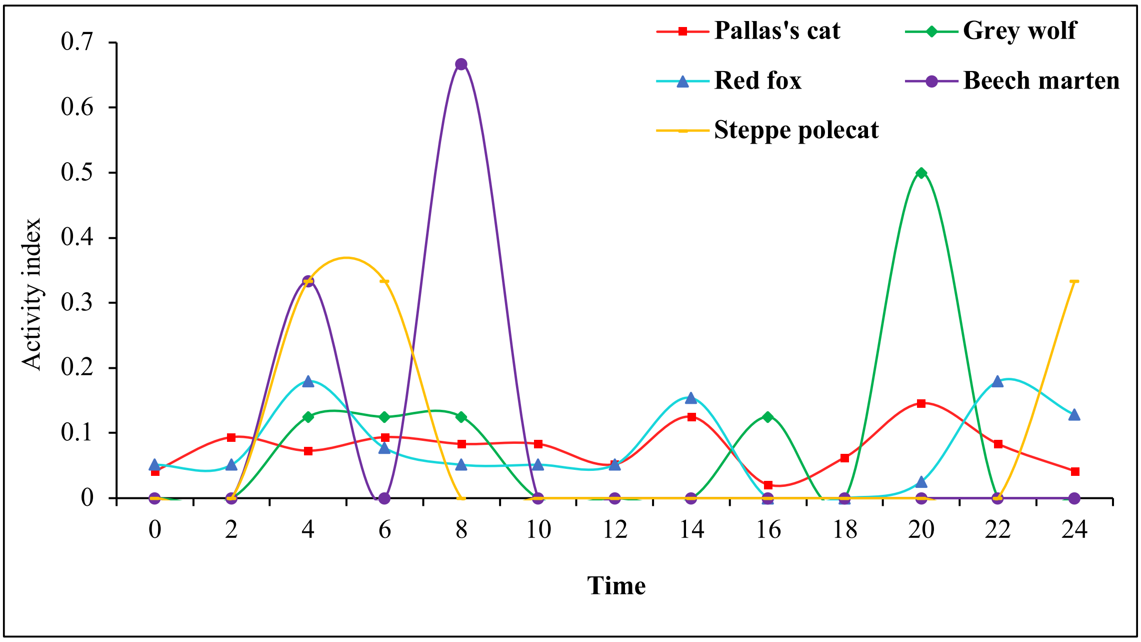


Figure 29: Daily activity patterns of Pallas's cat (n=567), grey wolf (n=262), red fox (n=259), beech marten (n=43), and steppe polecat (n=10).

Annual activity pattern: As for the annual activity patterns, Pallas's cats visited all four sites throughout the year, except in September and October, with their activity peaking in January. Similarly, red foxes were present during the same months and showed a peak in summer. In contrast, grey wolves occurred in winter, but they were mainly active between June and August (Figure 30). Among large carnivores, annual patterns showed that both grey wolves and red foxes were mainly active in July.

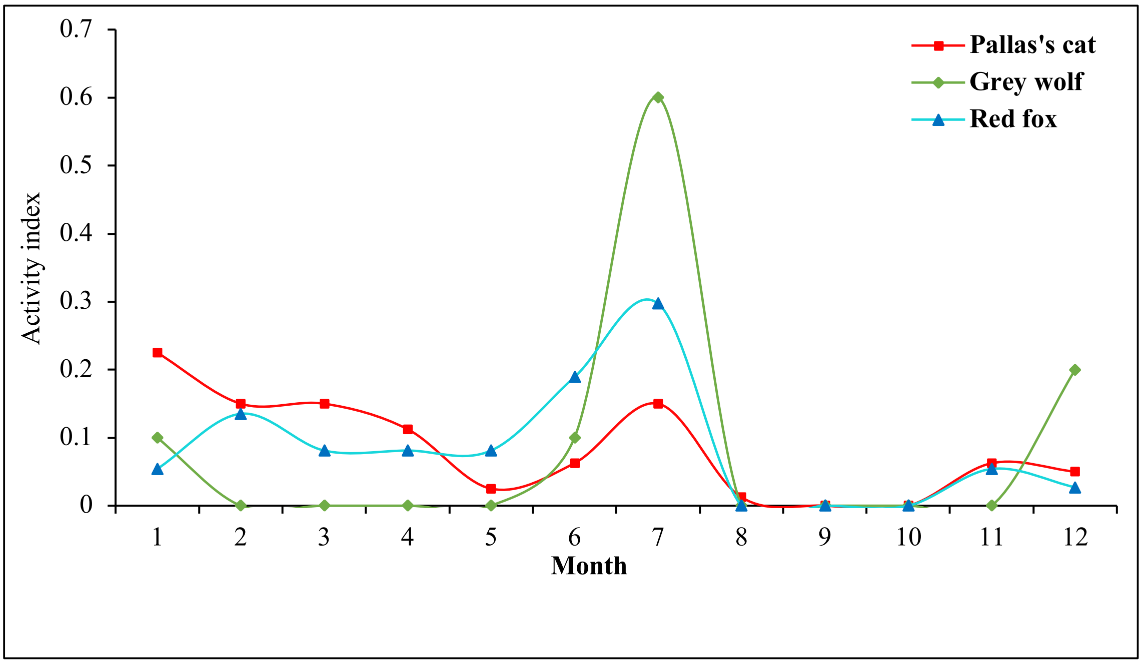


Figure 30: Annual activity patterns of Pallas's cat (n=567), grey wolf (n=262), and red fox (n=259).

5. DISCUSSION

5.1. Threats to small felids

A systematic analysis of threats to small wild felids allowed us to identify a broad range of both perceived and observed threats. Our results suggest that the wildcat was perceived as more endangered by all potential threats to small felids, which may represent its more vulnerable threat status compared with the Pallas's cat, although both are currently classified as *Least Concern* on the IUCN Red List (Gerngross et al., 2022; Ross et al., 2020). Nonetheless, the wildcat population appears to be increasing in the current results, which were also confirmed by Otgontamir et al. (2024) in Hungary while the Pallas's cat population is more likely in decline. Moreover, the participant who identified the Pallas's cats correctly believed that the species face threats, suggesting that it may be at a higher risk of extinction than currently recognized. Thus, species like Pallas's cats require further investigation to identify localized threats even if they are not globally threatened. Both interview findings and literature survey results showed that the most serious threats to Pallas's cats in Mongolia and Asia are predation by herding dogs and the lack of prey due to secondary poisoning.

On the other hand, hybridization with domestic cats was identified as a serious threat to wildcats in Europe, such as in Hungary, based on the literature and questionnaire survey. The species' response to anthropogenic change is highly dependent on its behavioral characteristics, which vary among species, populations, and even individual felids (Gartner & Weiss, 2013; Macdonald, 2016).

5.1.1. Literature survey: Threats and conservation behavior of small felids

5.1.1.1. Threats to Pallas's cat

Based on a systematic literature review, the categories invasive and other problematic species, and biological resource use were identified as the most critical threats to Pallas's cats in Asia. In other words, non-native animals have harmful effects, and the small felid faces danger from both deliberate and unintentional hunting (*IUCN, Threats Classification Scheme*), when considered within broader context.

The primary driver of the 'invasive and other problematic species' threat, ranked as serious for Pallas's cats, was predation by herding dogs. This threat was notably emphasized in the literature review. Herding dogs and overgrazing by livestock are among the most serious threats to Pallas's cats and are consistent with anthropogenic threats related to land use, driven by the dramatic expansion of animal husbandry throughout the species' range (Barashkova et al., 2017;

Damdinsuren et al., 2008; Ross et al., 2020). Increasing livestock numbers in Mongolia result in an increasing number of herding dogs, which is one of the most important causes of human-related mortality in Pallas’s cats (Barashkova et al., 2017; Barashkova & Smelansky, 2011; Ross, 2009; Ross et al., 2012). Dog-caused mortality of the species has also been reported in other parts of its range such as Russia (Barashkova & Smelansky, 2011) and Iran (Farhadinia et al., 2016).
Another threat category, ‘biological resource use,’ which includes overgrazing by livestock, illegal hunting, and illegal trade, was also identified as a significant threat in this classification.
Habitat loss, primarily due to the expansion of livestock numbers, infrastructure development, mining activities, and the conversion of steppe grasslands into arable farmland, constitutes a major threat to Pallas’s cats (Ross et al., 2019b). The species' populations are increasingly fragmenting, and isolated subpopulations are likely to disappear without our knowledge as a consequence of habitat loss and degradation (Ross et al., 2020). Increasing numbers of livestock can lead to habitat loss and degradation for Pallas’s cats (Ross et al., 2020). Their habitat is largely used for domestic livestock grazing across much of the species’ distribution range, including Mongolia, China, Iran, and India, where studies have widely reported habitat degradation caused by grazing (Dhendup et al., 2019; Pal et al., 2019). Traditional pastoralism is widespread, notably in Mongolia, where livestock numbers have increased dramatically over the past two decades, reaching 57.6 million free-ranging domestic animals (including goats, sheep, cattle, horses, and camels) as of 2024 (*National Statistics Office of Mongolia*, 2022). Herders in Mongolia move between camp sites less frequently today compared to 30 years ago, and their lifestyle is becoming more sedentary. This has likely led to increased grazing pressure around herder camps and watering holes, which, in turn has affected grassland quality (Pringle & Landsberg, 2004). Additionally, Pallas’s cats shows behavioral shifts, becoming more nocturnal to avoid livestock (Greco et al., 2022). The presence of livestock can negatively impact Pallas’s cats by reducing the availability of main prey, such as rodents, due to pasture exploitation (Ross et al., 2012).
Pallas's cats are susceptible to habitat loss and fragmentation, which is determined by their level of habitat specialization, with those relying on one or a few habitat types (Devictor et al., 2008). The species is a habitat specialist, selecting complex habitats with an area of rocky areas and ravines that provide hiding cover for mating, feeding, giving birth, protection from predators, and raising of young, which further limits habitat availability (Ross et al., 2010a, 2010b, 2012). Besides the species is unable to dig their burrows and highly reliant on existing cavities such as burrows of sympatric predators or marmot as its need of denning (Ross et al., 2020; Ross et al., 2010b). However, the population of Siberian marmots, which overlaps the Pallas’s cat’s range in Mongolia has declined sharply from 20 million (Wingard & Zahler, 2006) to 5 million due to overharvesting over the last decade (Batbold, 2002). This severe drop of marmots may have a dramatic impact on

Pallas's cats ability to find critical shelter habitats (Ross et al., 2010b; Zielinski, 2015). Specialist and highly selective species are more vulnerable to extinction (Purvis et al., 2000) like Pallas's cats.

Hunting and illegal hunting is another potentially important threat to Pallas's cat although hunting is prohibited in all range countries except Mongolia (Ross et al., 2020). Yet, the current study has reported illegal hunting of Pallas's cats as medium-level threat, whereas Murdoch et al. (2006) confirmed illegal hunting occurred locally, with herders using their skin, fat, and body parts for medical purposes (Murdoch et al., 2006; Ross et al., 2020). Pallas's cats have been overhunted due to its skin trade around the 1950s in Mongolia and Russia (Clark et al., 2006; Wingard & Zahler, 2006), but since 1980 the international trade in its pelts has ceased (Ross et al., 2020). However, illegal trade still occurs from the species' range countries (Kretser et al., 2012), and local people have mistakenly shot them for marmots, which are commonly hunted in most of Pallas's cats range (Ross et al., 2020). Moreover, the species accidentally trapped snares set for other animals (Ross, 2009). The information of illegal hunting and illegal trade in Pallas's cats and body parts and also the effect on individual populations is poorly known in Mongolia.

Small mammal poisoning campaigns have led to prey loss for Pallas's cats in Central Asian strongholds (Ross et al., 2020), and this secondary poisoning is another concern for the species. Small rodents, for example, Brandt's vole (*Lasiopodomys brandti*) and pikas, have been targets of extensive poisoning campaigns across Mongolia to reduce their populations (Zahler et al., 2004). Unfortunately, the aerial application of bromadiolone has had serious negative impacts not only on the targeted species but also on non-targeted wildlife, including predators, raptors, livestock, and even human health (Winters et al., 2010). Pikas and Brandt's voles are important prey for a wide range of carnivores, such as Pallas's cats (Samjaa et al., 2000) and predators are at a higher risk of ingesting contaminated prey (Berny, 2007; Brakes & Smith, 2005). Besides, poisoning of small mammals occurs on a local scale in China, Russia, and Kazakhstan. As a result, pika populations have sharply declined, particularly in China, where the poisoning program is ongoing. However, it is likely that instances of small mammal poisoning have decreased over recent decades (Lai & Smith, 2003; Palden et al., 2016; Ross et al., 2019), but no information is available on the current prevalence in Mongolia.

One large challenge to the Pallas's cat is the lack of knowledge regarding population trend (Ross et al., 2020). Although, understanding of the species' ecology has improved continuously, we still have limited knowledge of many aspects of its basic ecology (Ross et al., 2019). The species has recently been observed for the first time in several countries, such as Nepal (Shrestha, 2014) and Bhutan (Thinley, 2013), raising concerns about its continued presence (Ross et al., 2019). Except for its historical range, Pallas's cats may have disappeared from some former areas, posing a risk of continued local extinction without our knowledge (Ross et al., 2019). Monitoring and population assessment of Pallas's cats have received little attention, especially since data on the species' population trends in Mongolia are lacking (Clark et al., 2006; Ross et al., 2020). The literature survey on Pallas's cat in Asia reveals a critical gap in regional research, highlighting that the species remains severely understudied, especially concerning threat patterns and the underlying causes.

5.1.1.2. Threats to wildcat

The most significant threat to the species is hybridization with feral and domestic cats, which leads to a severe loss of genetic integrity (Daniels et al. 2001; Tiesmeyer et al. 2020). According to the literature survey, hybridization poses the greatest threat to wildcats across Europe, indicating that this phenomenon is a global concern for this small felid. The domestic cat does not derive from the European wildcat; however, hybridization between the two species has been observed in various part of its range, notably in Scotland and Hungary, where high levels of admixture were found (Pierpaoli et al., 2003). While relatively low levels of introgressive hybridization have been observed in Central and Southeastern Europe (Tiesmeyer et al., 2020), these variations in admixture levels among regions can be attributed to factors such as population history, differences in ecological barriers, and environmental conditions (Mattuci et al., 2016, Pierpaoli et al., 2003; Gil-Sanchez, 2015). For example, cat keeping is common and shows an increasing trend in Hungary, where cat owners believe that domestic cats have a less negative impact on wildcat conservation than they actually might (Pongrácz et al., 2024). This perception may also contribute to the growing hybridization phenomenon in the country**.** Archaeozoological data suggest that domestic cats first appeared in Central Europe during the Roman period and became more widespread in medieval times, serving both as a valuable tool for controlling vermin and pests and as a traded commodity for their pelts (Ewing, 1981; Faure & and Kitchener, 2009). The Roman Empire played a key role in the expansion of the domestic cat throughout Europe, the Mediterranean region, and North Africa, following its domestication journey that began approximately 9,000 years ago in the Near East. Nieto-Blázquez et al. (2022) suggested that the interbreeding between wildcats and domestic cats occurred around the time the domestic cat was introduced during the Roman period.

Hybridization refers to the mating between two different taxonomic groups (Adavoudi & Pilot, 2021), and occurs when populations that have been reproductively isolated for some time meet and interbreed (Futuyma, 2005). The rate of hybridization in wildcats may be increasing due to decreasing wildcat population density, the widespread presence of domestic cats, and habitat loss and fragmentation (Kilshaw, 2011; Nussberger et al., 2018).

The wildcat is considered a habitat generalist and appears to use a wide range of habitats (Klar et al., 2008), making it less susceptible to habitat loss. However, given the species' extremely restricted range and alarmingly low number of remaining genetically pure individuals, habitat loss is likely to rapidly separate its populations (Kilshaw, 2011). Additionally, behavioral differences in habitat use between wildcats and hybrids play a significant role in the hybridization process, potentially increasing opportunities for feline virus transmission (Macdonald, 2016). Disease, another primary human-caused threat to wildcats, is likely exacerbated by domestic cats, which raise the risk of transmission (Gerngross et al., 2022). It was also one of the most frequently recorded serious threats to the wildcat in Europe in the current results. Studies have revealed that wildcats, particularly in Western European countries such as Germany, Scotland, and the Iberian Peninsula, are affected by lungworms, nematodes, feline leukemia virus, and other endoparasites. Disease outbreaks frequently occur near human settlements due to the large populations of feral and domestic cats. However, in some countries like Turkey, a certain percentage of domestic cats are systematically eradicated (Gerngross et al., 2022). Nonetheless, behavioral insights can be applied to support wildcat conservation efforts. For example, Miyazaki et al. (2017) used urinary extract from domestic cats as a lure to manipulate the behavior of both wild and free-roaming cats, which could be helpful for conservation and effective behavior-based management of small endangered felids.

Among the human-related threats to wildcats, road and railway kills were the major causes of mortality (Bastianelli et al., 2021; Gerngross et al., 2022), a finding that was also confirmed in our results. Piechocki (1990) reported that most wildcat deaths in Central Europe due to road kills occurred during the mating season. Around 130 wildcats were released into the wild for reintroduction in Central Europe but 18 of them were killed by cars, mostly in Germany (Nowell & Jackson, 1996; Stahl & Artois, 1994). It is possible that mainly young wildcats were involved in the reintroduction, which may have made them more susceptible to road killings than resident individuals. However, road kills are influenced by various factors, including species population density, road density, and habitat types in the area (Barrientos & Bolonio, 2009; Grilo et al., 2009).

Decline in prey availability was considered a medium-level potential threat in these results, and wildcats are facultative specialists that consume a variety of prey depending on availability (Malo et al., 2004). In Hungary, the primary components of wildcat diet are small mammals such as common vole and field mouse with occasional prey including birds, lagomorphs, and grass-like plants (Biró et al., 2005). They have higher feeding flexibility and are considered selective predators in the given habitat, making them potentially more adaptable to changes in prey availability (Jose María, 1999; Ruta, 2018).

Hunting and poisoning were considered less significant among the human-caused threats to wildcats. Historically, the species was regarded as vermin and hunted across Eurasia to protect livestock, while its pelage was a valuable resource for the fur market (Council of Europe, 1993; Stahl & Artois, 1994). This direct persecution was the primary cause of the species' extinction in countries like Austria, but there is no longer any interest in its fur trade today (Gerngross et al., 2022).

Although primary and secondary poisoning were reported less frequently in this study, rodenticide use is still present (Guitart et al., 2009) and has increased on farms in Great Britain (Garthwaite & Thomas, 2003).

5.2. Field-based research

5.2.1. Distribution of Pallas’s cat

Key components of conservation planning for rare and elusive species include mapping their distribution and identifying the biotic and abiotic factors that influence it (Kittle et al., 2018; Greenspan et al., 2020). Range maps play a crucial role in understanding the distribution and conservation needs of a species (Karanth et al., 2009). The Pallas’s cat is a widespread species with a patchy distribution, ranging from western Iran to eastern Mongolia (Ross, et al., 2020). Central Mongolia is thought to be a stronghold for Pallas's cats, based on the availability of suitable habitat and its historical fur trade (Wingard and Zahler 2006; Ross et al., 2019a); however, only a few studies have been performed and research in the region remains limited (Murdoch et al., 2006; Ross et al., 2010, 2012). Despite previous studies on Pallas's cats, the distribution and conservation status of the species in Hustai National Park are still unclear.

Our results showed that the distribution of the Pallas’s cat within the national park was significantly and positively correlated with steppe habitats in this montane steppe region, which is consistent with the species' typical habitat, comprising montane grasslands and steppe (Ross et al., 2019a). Additionally, the Pallas's cat has also been documented in dry steppe areas (Bangjie, 1984) and Dhendup et al. (2019) suggested that the species could be widespread across a range of diverse steppe habitats. Our study also showed that the distribution of Pallas’s cats was associated as a trend with terrain ruggedness. Earlier studies indicated that Pallas’s cats appear to prefer steep and rugged areas with high coverage of rocky terrain and ravines (Greenspan and Giordano 2021; Ross et al., 2020). Furthermore, Chimed et al. (2021) revealed that the distribution of the Pallas's cat was positively correlated with terrain ruggedness and Greco et al. (2022) also found that Pallas’s cats are associated with steeper slopes and natural vegetation. Studies on the Pallas's cat in Iran have shown that they prefer lower altitudes and a diversity of topography (Lorestani et al., 2022).

Hustai National Park is one of the most well-protected areas in Mongolia and serves as a key site for biodiversity, particularly abundant in prey for Pallas's cats (Batsaikhan et al., 2016; Tseren-Ochir et al., 2018). Although an earlier study on Pallas's cats in the national park found a limited effect of prey availability on home range size (Ross et al., 2012), the species' distribution in our study area may be influenced by prey availability, which is an important factor determining its distribution (Greenspan and Giordano, 2021).

Monitoring the status of mammal species over large landscapes is time-consuming and costly using methods such as camera traps, GPS telemetry, and non-invasive genetic sampling; therefore, interviews based on local knowledge offer a relatively quick and cost-efficient alternative for monitoring species occurrence and distribution on large scales (Zeller et al., 2011; Caruso et al., 2017; Ghoshal et al., 2017; Madsen et al., 2020). Research has shown that interview-based study is an effective methodology, not only for species conservation but also for assessing animal distributions, particularly for mammals (Turvey et al., 2013; Parry and Peres 2015, Taubmann et al., 2015; Sheppard et al., 2024).

Our data is consistent with the preliminary understanding of the distribution of Pallas's cats in HNP. However, we acknowledge that combining interview-based surveys with other research and monitoring techniques could be more effective. Information on the occurrence of the Pallas's cat in our study is limited by local ecological knowledge, which may lead to overestimation in species distribution and result in bias and inaccuracy (Gil-Sánchez and McCain 2011; Caruso et al., 2017). To address this limitation, we aimed to reduce the potential for false positives by asking interviewees to describe the study species and subsequently identify the target species from a set of photos featuring four small felines, following Chimed et al. (2021). In our study, 79% of respondents were able to correctly identify the Pallas's cat in HNP, demonstrating a significantly higher level of species recognition compared to the 44% of respondents who could accurately identify the species in the herder communities of southern Mongolia (Chimed et al., 2023). Nonetheless, interview-based data gathered from LEK may not always accurately provide the true status of a species. The ability of locals to recognize the targeted species does not necessarily ensure the reliability of the occurrence data they provide, particularly for elusive or rare species (Frey 2006; McKelvey et al., 2008). Therefore, we advise caution when using LEK to assess the distribution of small species.

5.2.2. Distribution of wildcat

The population of wildcats in Europe has recovered slowly, notably in Central Europe and Italy (Anile et al., 2019; Klar et al., 2008), whereas in the Iberian Peninsula and in Scotland, the population is declining (Gil-Sánchez et al., 2020; Lozano & Malo, 2012). Our study suggests that the distribution area of wildcats in Hungary has increased over the past two decades, and the bulk of their distribution is across the Great Plain, the North Hungarian Mountains, and the Transdanubian Mountains. These results are similar to earlier studies showing stable wildcat populations in the forests of the floodplains in the Great Plain, as well as in the Dráva Plain and the Mecsek, Villányi, Transdanubian, and North Hungarian Mountains (Heltai et al., 2006). However, we found no occurrence of wildcats in the central and western parts of Hungary, or in some areas of southern Hungary, across the three distinct time periods, which aligns with the findings of Heltai et al. (2006), who recorded that the species had disappeared from many regions of Hungary, in particular the central and north-western areas.

Wildcats are typically considered a forest species (Nowell & Jackson, 1996). Our results showed that the occurrence of wildcats in Hungary was most strongly associated with broad-leaved forest cover, with these forests significantly increasing the likelihood of wildcat detection. This result is supported by previous studies, such as Mattucci et al. (2013) who found that the distribution of the wildcat is closely linked to broad-leaved forests. On the other hand, the wildcat is considered a habitat generalist (Silva et al., 2013), using various types of habitats. Studies, particularly in western Europe (e.g., Germany and Scotland), have shown that their presence is linked to coniferous forests, grasslands, and scrubland, while being limited by forests, forest ecotones, and meadows (Corbett, 1979; Daniels et al., 1998; Klar et al., 2008). In contrast, in Mediterranean countries, scrub areas are considered key habitats for their distribution (Lozano et al., 2003). Nevertheless, we found that broad-leaved forests are the most important habitat for wildcats, positively impacting their distribution at a broad scale. This finding is supported by an earlier small-scale study conducted in Hungary (Biró et al., 2004).

Mixed and coniferous forests showed a negative association with wildcat occurrence, as previously reported by Silva et al. (2013), for example in Scotland. The study suggested that this pattern might result from classifying woodlands into separate categories such as coniferous and mixed forest rather than treating woodland as a single land cover type. Similarly, in our study, we also used these land cover types as independent variables to assess their impact on wildcat occurrence in Hungary. This classification may have contributed to the observed negative correlation with the species' occurrence.

Wildcats avoid pasture areas because grassland-covered areas are often connected to agricultural lands, where farmers are present, and these areas are less suitable for their prey due to intensive grazing (Daniels et al., 2001). However, agricultural landscapes with diverse structures can be suitable habitats for wildcats, even supporting their successful reproduction (Jerosch et al., 2018). In contrast, wildcats use open pastures and cattle pastures for hunting, as these areas support higher prey density, such as that of the montane water vole (Lozano et al., 2006; Rodríguez et al., 2020). But we found no significant association between pasture areas and wildcat occurrence in Hungary.

Wildcats avoid residential areas, including roads, rail networks, and adjacent land, which may contribute to its absence (Klar et al., 2008). Likewise, Silva et al. (2013) found no evidence to suggest that urban areas and roads have a significant impact on wildcat presence. They even avoided human settlements, as shown by radiotelemetry data in Hungary (Biró et al., 2004). This may be due to the presence of dogs, and humans, as well as the combined effects of light and noise, all of which can influence their spatial behavior (Klar et al., 2008).

5.2.3. Activity pattern of Pallas's cat – Camera trapping

During the survey period, we detected Pallas's cats both during the day and at night, with activity peaking around dusk. The species was consistently active at night, but we observed a slight increase in crepuscular hours. Earlier studies revealed that the activity of Pallas's cat was mainly crepuscular, especially throughout summer (Anile et al., 2021; Ross, 2009), which is concordant with our results, though the highest activity was observed in January. The activity peak in January may be due to their mating season.

Besides that, Anile et al. (2021) also found that Pallas's cats showed diurnal activity between September and November, as captured by camera traps in Mongolia. Unfortunately, there was no detection of Pallas's cats in our survey during autumn because some cameras were lost, and others failed due to dead batteries. Likewise, daytime activity of Pallas's cats recorded in western Mongolia (Greco et al., 2022), is consistent with our findings; in our study, Pallas's cats were active during the day but showed reduced activity around midday. Anile et al. (2021) and Ross et al. (2012) corroborated that Pallas's cats face the dilemma of avoiding predators while also increasing the likelihood of a successful daytime hunt.

Species within the same group tend to exhibit similar activity patterns. For example, red foxes showed temporal activity patterns comparable to those of Pallas's cats. On the other hand, grey wolves were typically nocturnal, with activity levels peaking at dawn and dusk (Merrill & Mech, 2003). Similarly, in our study, their peaks of activity pattern occurred during crepuscular hours. This behavior may represent an adaptation to avoid competition or predation from other sympatric species, resulting in temporal niche partitioning where one species shifts its activity to an opposite phase (Noga & Tamar, 2003). The steppe polecat is strictly nocturnal and was detected only at night, with activity highest at 00:00 and 05:00 according to our limited records. Likewise, the beech marten was observed on several occasions, with all recorded activity occurring after midnight and peaking at 8:00 in the morning.

As shown in Figure 30, the annual activity of the three species reflected the highest intensity in the summer, showing a clear rise at that time of year. This pattern might be influenced by prey availability, environmental conditions, and reduced human presence in the area, as herders move to different camps in that season.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of our literature survey, we identified key geographical and threat-related patterns for both the wildcat and Pallas's cat across continents. Scientific articles on threats to Pallas's cats are limited, using the wildcat as an example**,** highlighting the need to bridge these knowledge gaps. Although current data are insufficient to fully assess the scope and severity of threats, this study represents an important first step. Our findings emphasize the distinct conservation challenges faced by each species and how anthropogenic threats influence small felid survival. In order to minimize negative impacts, monitoring and controlling feral and free-ranging domestic cat populations, implementing Trap-Neuter-Return (TNR) programs, promoting indoor cat keeping, and raising public awareness about the risks of allowing pet cats to roam freely are essential. Additionally, herders should use trained livestock guardian dogs which are less aggressive towards wildlife, while promoting controlled grazing practices that balance both conservation and pastoral needs such as changing camps seasonally and reviving nomadic traditions to prevent the unprecedented loss of the world's most majestic predators, both big and small.

Over the last two decades, the distribution of wildcats in Hungary appears to have expanded and show a significant association with broad-leaved forest habitats. The country provides important habitat for the species, in particular close to nature old-growth broad-leaved forests rather than plantation forests. Further research is needed to fully understand its habitat use and distribution on a broader scale. Conservation efforts should prioritize habitat management, including the protection and maintenance of core areas with stable populations, to safeguard the wildcat and its critical habitats in Hungary.

The distribution of Pallas's cat in Hustai National Park was higher in areas with a greater proportion of steppe habitat, underscoring the importance of this habitat as a key area for the species in Central Mongolia. Its presence also tended to increase in more rugged habitats of the study area. As the first preliminary estimate of the species' distribution in the park, more research using direct methods is required to better understand these processes. Despite any shortcomings, we hope our findings will serve as a foundation for future conservation efforts targeting this elusive cat.

The Pallas's cat was active both day and night, with peak activity occurring around dusk (e.g., 20:00) and the highest annual activity recorded in winter, notably in January. Winter, particularly January, may be the best time for camera-trapping surveys to investigate its temporal activity patterns, as Pallas's cats tend to show peak activity during this season.

7. NEW SCIENTIFIC RESULTS

- Based on the literature review, hybridization with domestic cats emerged as the most significant direct threat to wildcats across Europe, whereas predation by herding dogs posed a serious threat to Pallas's cats within their range countries. Additionally, overgrazing by livestock is recognized as another major potential threat to Pallas's cats in Asia.

- Hybridization with domestic cat was reported as a major local concern for wildcats, while lack of prey emerged as the most frequently reported threat to Pallas's cats. Drawing on community knowledge, habitat loss was also emphasized as a shared challenge for both species in Hungary and Mongolia.

- Wildcat detections differed significantly between 2004 and 2022, with a clear increasing trend observed over the broader time frame. In Hungary, wildcat presence was strongly associated with broad-leaved forests among various land cover types, underscoring the importance of these habitats as key areas for the species within the country.

- This study provided the first assessment of Pallas's cats in Hustai National Park, Central Mongolia, revealing a significant correlation between their presence and steppe habitat. A higher percentage of steppe cover was associated with a significantly greater probability of species occurrence. Besides that, the species' distribution showed a positive trend with terrain ruggedness in the national park.

- The annual activity pattern of the Pallas's cat was most prominent in winter and summer, with peak activity recorded in January. The species' daily activity increased at dusk (around 20:00–21:00), consistent with its crepuscular behavior.

8. SUMMARY

Among mammals, felids are the most admired, paradoxically, the most endangered family, with populations generally declining and some species at risk of extinction. Conservation and research efforts have predominantly focused on larger cats, leaving many smaller felids with much less attention. As a result, many smaller, highly threatened, and elusive wild felids are often overlooked in comparison to their larger counterparts. The European wildcat (*Felis silvestris*) and Pallas's cat (*Otocolobus manul*) are examples of species severely hindered by a lack of detailed ecological knowledge, with critical information regarding their presence, mortality, and threats lacking, thus limiting effective conservation efforts. Studying felids in their natural habitat is notoriously difficult due to their low population density, large spatial requirements, nocturnal behavior, and shyness, particularly for small felids, whose small size renders them exceptionally challenging to detect. This research is driven by the urgent need to address the declining populations of small wild cats, the significant threats they face, and the lack of critical ecological knowledge regarding these endangered species. Our research examines the threat patterns and current distribution of the wildcat and Pallas's cat across different regions using the same methodology. To achieve this, we conducted our research using an integrated approach, which include 1) a broad literature survey to assess regional-level threats to both cats, and 2) a technical, field-based study to meet the primary objectives.

Firstly, in the broad literature survey, we aimed to: 1) reveal the geographical distribution of published scientific articles that address 2) the potential threats to wildcats in Europe and Pallas's cat in Asia, and 3) quantify the most significant threats to both species across their ranges using IUCN threat classification system, ranking these threats based on 88 scientific articles for wildcats and 23 publications for Pallas's cats. Our results showed that the geographic focus of research on both species, with the majority of publications on wildcats originated from Germany (19%) and Scotland (16%), whereas Mongolia (33%) and Iran (29%) lead the publications on Pallas's cats. For the Pallas's cat, the most serious threats are predation by herding dogs and overgrazing by livestock, while road kills and capture by snares or traps are deemed less critical. The wildcat faced significant threats from hybridization with domestic cat and disease, whereas primary poisoning and human disturbance are considered relatively minor. In conclusion, understanding the distinct geographical distributions and threat profiles of wildcats in Europe and Pallas's cats in Asia is crucial. To mitigate the threats posed by domestic cats and herding dogs to both species, it is essential to monitor and manage companion animals using effective methods such as Trap-Neuter-

Return, promote indoor cat keeping, raise public awareness, and encourage herders to use trained guardian dogs.

Secondly, our field-based research focused on the present distribution of wildcats in Hungary and Pallas's cats in Mongolia. We investigated the nationwide distribution of wildcats using online questionnaire data collected from game management units (GMUs). 1|) We evaluated the distribution of wildcats in Hungary at a broad scale and analyzed changes between 2004 and 2022. To achieve this, we collected species sightings as detections and evaluated them using the Universal Transverse Mercator (UTM) coordinate system, with 10 × 10 km grid cells representing the species' home range. We used a 6.25 km^2 coverage threshold for each grid cell, considering wildcat presence confirmed if at least 6.25% of the UTM cell provided detection data. We created detection histories for each grid cell and period, assigning a 1 for wildcat presence and 0 for absence. Multiple detections of wildcats in the same grid cell were merged into one detection for that grid cell and time period. 2) We examined the impact of land cover types on wildcat occurrence nationwide. To fulfill this objective, we used the CORINE Land Cover (CLC) database to assess which habitat types influenced the wildcat presence.
From GMUs, 551 respondents participated in 2004 and 354 in 2014, with a notable decline in responsiveness in 2022 (n = 200). For the analysis, we used only these 200 respondents from same GMUs in all survey years. The increase in wildcat detections was also reflected in the UTM grid scale. The detection area increased from 1207 thousand ha in 2004 to 1.304 thousand ha in 2014, reaching 1.688 thousand ha in 2022. Overall, nearly half of the studied UTM cells (51.1%) were classified as 'occupied' by wildcats based on relevant detections from the corresponding GMUs, indicating stable presence. Our results further revealed a significant increasing trend in wildcat detections over the extended period from 2004 to 2022. We found that among the various land cover types, broad-leaved forest cover was found to be positively associated with wildcat occurrence in Hungary. In each survey year, the area of broad-leaved forest was significantly greater ($p < 0.001$) in UTM cells with wildcat presence, with the following averages: 2004: 2.215 ± 2.073 ha, 2014: 2.384 ± 1.967 ha, and 2022: 2.149 ± 1.888 ha. A robust understanding of how the species' distribution changes over time and the variables that influence these changes provides essential data for identifying priority areas for the long-term persistence and effective conservation of this elusive species.

Using interview-based survey with local community, we estimated 1) the current distribution of Pallas's cats in Hustai National Park (HNP), Central Mongolia. To achieve this, we divided the study area into sampling units of 8 x 8 km square, each approximating the average home range of the species. We gathered the observation data of Pallas's cats, which were recorded using binary values to indicate absence and presence. A 5 km circular radius was created for each respondent, as herders reported rarely venturing more than 5 km from their households. To generalize Pallas's cat occurrence, we clipped the buffers with the 8 x 8 km grid cells, forming circular segments for each cell, which were then used as observations for statistical modeling. 2|) We investigated topographical and land cover variables influencing the Pallas's cat' distribution in the national park. We calculated the average elevation and Terrain Ruggedness Index (TRI) for the segments, along with the spatial extent of available land cover types. The most relevant land cover data from 2020 was obtained using publicly available datasets.

We conducted 107 interviews in HNP during the summer of 2023, with 86 male respondents and 21 female respondents. The majority of respondents were herders (85%) and rangers (12%). The mean age of the interviewees was between 36 and 45 years, with ages ranging from 24 to 65 years. A significant majority of respondents (74%) had lived in the area for over 20 years. We found that steppe cover showed a significant positive association with Pallas's cat occurrence, meaning that a higher percentage of steppe cover was linked to a significantly greater likelihood of detecting one or more individuals of the species. TRI, while near significance, may also play an important positive role in the species' occurrence in the national park. These findings underscore the need for monitoring and gathering information on the ecology of the species to inform conservation and management strategies in the region.

Using camera trapping, we detected 567 captures of Pallas's cat from four locations over 317 trap days in Mongolia. The species was active both day and night, exhibiting the highest activity peaks at dusk and being most active during winter, peaking in January. These activity patterns highlight the importance of timing in monitoring efforts to improve detection and guide effective conservation actions for this elusive cat. Winter, particularly January, may be the best time for camera-trapping surveys to investigate its temporal activity patterns of Pallas's cats, as they exhibit peak activity during this season. For better camera-trapping results, we recommend collaborating with local people or rangers to prevent camera loss or theft.

9. ÖSSZEFOGLALÁS

Az emlősök közül a macskafélék a leginkább csodált, mégis a legveszélyeztetettebb család, amelynek populációi a Föld különböző élőhelyein általában csökkennek, sőt egyes fajokat a kihalás veszélye fenyeget. A természetvédelmi erőfeszítések és a kutatások túlnyomórészt a nagyobb macskafélékre összpontosítottak, így sok kisebb macskafélének sokkal kevesebb figyelmet szenteltek. Ennek eredményeképpen sok kistermetű, erősen veszélyeztetett és rejtett életmódot folytató macskafélét gyakran figyelmen kívül hagynak nagyobb társaikhoz képest. Az európai vadmacska (*Felis silvestris*) és a Pallas macska (*Otocolobus manul*) olyan fajok példái, amelyek védelmét hátráltathatja a részletes ökológiai ismeretek hiánya, mivel az elterjedésükre, halálozási okaikra és az egyedek túlélését veszélyeztető tényezőkre vonatkozó kritikus információk nem feltétlenül állnak rendelkezésre mindenhol. A macskafélék természetes élőhelyükön történő tanulmányozása közismerten nehézkes alacsony populáció sűrűségük, nagy mozgáskörzet igényük, éjszakai viselkedésük és félénkségük miatt, különösen a kismacskafélék esetében, amelyeket kis méretük miatt rendkívül nehéz vizsgálni. Ezt a kutatást a vadon élő kistermetű macskák csökkenő populációinak, az őket fenyegető jelentős veszélyeknek és az e veszélyeztetett fajokra vonatkozó kritikus ökológiai ismeretek hiányának kezelése indokolja. Kutatásunk az európai vadmacska és a Pallas macska potenciális veszélyeztetettségét és jelenlegi elterjedését vizsgálja különböző régiókban, azonos módszertan alkalmazásával. Ennek érdekében kutatásunkat integrált megközelítéssel végeztük, amely magában foglalja 1) egy széleskörű szakirodalmi felmérést a regionális szintű veszélyeztetettség felmérésére mindkét faj esetében és 2) egy technikai, terepi vizsgálatot az elterjedési terület és élőhelyi viszonyok kapcsolatának becslésére.

Először is, a széles körű szakirodalmi felmérés során a következő célokat tűztük ki: 1) feltárni a megjelent tudományos cikkek földrajzi eloszlását, 2) a vadmacskát Európában és a Pallas macskát Ázsiában fenyegető potenciális veszélyeket, és 3) számszerűsíteni a két fajra leselkedő legjelentősebb veszélyforrásokat a fajok elterjedési területén belül az IUCN veszélyességi osztályozási rendszerének segítségével, rangsorolva ezeket a veszélyeket a vadmacskára vonatkozó 88 tudományos cikk és a Pallas macskára vonatkozó 21 publikáció alapján. Eredményeink azt mutatták, hogy a két fajra vonatkozó kutatások földrajzi súlypontja, a vadmacskáról szóló publikációk többsége Németországból (19%) és Skóciából (16%) származik, míg a Pallas macskáról szóló publikációkat Mongólia (33%) és Irán (29%) vezeti. A Pallas macska esetében a legsúlyosabb veszélyt az „inváziós és egyéb problémás fajok” (például a pásztorkutyák általi ragadozás) és a „biológiai erőforrások használata” (ideértve a legeltető állattartás és az illegális vadászat hatásait) jelentette, míg az élőhely elvesztését és a hurkokkal vagy csapdákkal való befogást kevésbé tartják kritikusnak. Az európai vadmacskát jelentős veszély fenyegeti a hibridizáció és a betegségek miatt, amelyek az „inváziós és egyéb problémás fajok” kategóriába tartoznak, és amelyek mindegyike „súlyos” veszélynek minősül, míg a populáció csökkenése és a hurkokkal vagy csapdákkal való befogás viszonylag kisebb jelentőségűnek tekinthető. Összefoglalva, az európai vadmacska és az ázsiai Pallas macska eltérő földrajzi elterjedésének és fenyegető tényezőinek megértése alapvető fontosságú. A házi macskák és a pásztorkutyák által mindkét fajra jelentett veszélyek enyhítése érdekében elengedhetetlen a háziállatok hatékony módszerekkel történő nyomon követése és kezelése. Ebbe beletartozik a „csapdába ejtés-ivartalanítás-visszaszállítás” (TNR) módszer és a macskák beltéri tartásának ösztönzése, a közvélemény figyelmének felkeltése, valamint az, hogy rávegyük a pásztorokat arra, hogy kiképzett őrkutyákat használjanak.Másodszor, terepi kutatásaink a vadmacska jelenlegi magyarországi és a Pallas macska mongóliai elterjedésére összpontosítottak. A vadmacska országos elterjedését a vadgazdálkodási egységekben (VGE) gyűjtött online kérdőíves adatok segítségével vizsgáltuk. 1|) Felmértük a vadmacska jelenlegi magyarországi elterjedését, és elemeztük a vadmacska elterjedésének változását 2004 és 2022 között. Ennek érdekében a faj észleléseit gyűjtöttük össze és értékeltük az Univerzális Transzverzális Mercator (UTM) koordinátarendszer segítségével, 10 × 10 km-es rácshálós cellákkal, amelyek a faj elterjedési területét becsülik. Az egyes rácscellák esetében 6,25 km²-es lefedettségi küszöbértéket alkalmaztunk, és a vadmacska jelenlétét akkor tekintettük megerősítettnek, ha az UTM-cella legalább 6,25%-a szolgáltatott észlelési adatokat. Minden egyes rácsmezőre és időszakra vonatkozóan észlelési történetet készítettünk, a vadmacska jelenlétére 1, hiányára 0 értéket adva. A vadmacskák többszörös észlelését ugyanabban a rácsmezőben egyetlen észleléssé egyesítettük az adott rácsmezőre és időszakra vonatkozóan. 2) Megvizsgáltuk a felszínborítási típusok hatását a vadmacska előfordulására országszerte. E cél teljesítéséhez a CORINE Land Cover adatbázist használtuk annak felmérésére, hogy mely élőhelytípusok befolyásolták a vadmacska jelenlétét.

A VGE-k közül 2004-ben 551, 2014-ben 354 válaszadó vett részt a felmérésben, míg 2022-ben jelentősen csökkent a válaszadási hajlandóság (n = 200). Csak ezen 200 válaszadó adatait elemeztük ugyanazon vadgazdálkodási egységekből minden évben. A vadmacska észlelések számának növekedését az UTM háló jól érzékeltette. Az észlelési terület a 2004-es 1 207 000 hektárról 2014-ben 1 304 000 hektárra nőtt, és 2022-ben eléri az 1 688 000 hektárt. Összességében a vizsgált UTM-cellák közel felét (51,1%) a megfelelő VGE-k vonatkozó észlelései alapján a vadmacskák által „elfoglaltnak” minősítették, ami stabil jelenlétet jelez. Eredményeink azt is kimutatták, hogy a vadmacska észlelések jelentős növekedési tendenciát mutatnak a 2004 és 2022 közötti hosszabb időszakban. Megállapítottuk, hogy a különböző felszínborítási típusok közül a lombhullató erdők jelenléte pozitívan kapcsolódik a vadmacska előfordulási gyakoriságához Magyarországon. Minden egyes felmérési évben a lombhullató erdők területe szignifikánsan nagyobb volt ($p < 0,001$) a vadmacska jelenlétét mutató UTM-cellákban, a következő átlagokkal: 2004: 2.215 ± 2.073 ha, 2014: 2.384 ± 1.967 ha és 2022: 2.149 ± 1.888 ha. A faj elterjedésének időbeli változásáról és az ezeket a változásokat befolyásoló tényezőkről kapott megbízható adatok jó alapot szolgáltatnak e rejtőzködő életmódot folytató faj hosszú távú fennmaradása és hatékony védelme szempontjából kiemelt fontosságú területek meghatározásához.

A helyi közösség tagjaival készített interjúkon alapuló felmérés segítségével megbecsültük 1) a Pallas macska jelenlegi elterjedését a Hustai Nemzeti Parkban, Közép-Mongóliában. Ennek érdekében a vizsgálati területet 8 x 8 km-es mintavételi egységekre osztottuk, amelyek közelítőleg megfelelnek a faj egyedei átlagos mozgáskörzet méretének. Összegyűjtöttük a Pallas macska megfigyelési adatait, amelyeket bináris értékek segítségével rögzítettünk a hiány és a jelenlét jelölésére. Minden egyes válaszadó számára egy 5 km-es körsugarat hoztunk létre, mivel a pásztorok arról számoltak be, hogy ritkán merészkednek 5 km-nél messzebbre a háztartásuktól. A Pallas macska előfordulásának általánosítása érdekében a puffereket a 8 x 8 km-es rácscellákkal metszettük el, kör alakú szegmenseket képezve minden egyes cellához, amelyeket aztán megfigyelésként használtunk a statisztikai modellezéshez. 2) Megvizsgáltuk a Pallas macska nemzeti parkban való elterjedését befolyásoló topográfiai és felszínborítási változókat. A szegmensekre kiszámítottuk az átlagos tengerszint feletti magasságot és a domborzati tagoltsági indexet (TRI), valamint a rendelkezésre álló élőhely típusok térbeli kiterjedését. A 2020-ra vonatkozó legrelevánsabb földfelszín borítási adatokat nyilvánosan elérhető adatállományokból szereztük be.

A Hustai Nemzeti Parkban 2023 nyarán 107 interjút készítettünk, 86 férfi és 21 női válaszadóval. A válaszadók többsége pásztor (85%) és vadőr (12%) volt. A megkérdezettek átlag életkora 36 és 45 év között volt, a koruk 24 és 65 év között mozgott. A válaszadók jelentős többsége (74%) több mint 20 éve élt a területen. Megállapítottuk, hogy a sztyepp élőhelytípus borítási aránya szignifikáns pozitív összefüggést mutatott a Pallas macska előfordulási gyakoriságával, ami azt jelenti, hogy a sztyeppék nagyobb százalékos borítása a faj egy vagy több egyedének észlelésének szignifikánsan nagyobb valószínűségével járt együtt. A Pallas macska elterjedése a nemzeti parkban gyenge, majdnem szignifikáns összefüggést mutatott a terep egyenetlenségével. Ezek az eredmények hangsúlyozzák, hogy szükség van e ritka faj ökológiájának nyomon követésére és információgyűjtésre, hogy a régió természetvédelmi és kezelési stratégiáinak alapjául szolgálhasson.

Kamera csapdázás segítségével Közép-Mongóliában 317 csapdázási nap alatt négy helyszínről 567 Pallas macska észlelést gyűjtöttünk. A faj nappal és éjszaka is aktív volt, a legnagyobb aktivitási csúcsot napnyugtakor mutatta, és télen volt a legaktívabb, ami januárban tetőzött. Ezen a viselkedési mintázat ismerete azért fontos, hogy a faj monitorozását megfelelően időzítsék növelve e ritka macskafaj észlelésének valószínűségét és ezáltal segítve hatékonyabb védelmi intézkedések kidolgozását. A tél, különösen a január, lehet a legjobb időszak a kameracsapdákkal végzett felmérésekre, amelyekkel a Pallas macska időbeli viselkedési mintáit lehet vizsgálni, mivel ebben a szezonban mutatják a legnagyobb aktivitást. A kameracsapdákkal végzett felmérések eredményességének javítása érdekében javasoljuk a helyi lakosokkal vagy vadőrökkel való együttműködést, hogy megelőzzük a kamerák elvesztését vagy ellopását.

10. LIST OF PUBLICATIONS

- Publication (Journal Article: Q1 – IF = 1.9) – Peer reviewed

Otgontamir, C., Fehér, Á., Heltai, M., Lkhagvasuren. D., Batzaya, Ts., Biró, Z. (2025). A preliminary approximation to determine the distribution of Pallas's cats in Hustai National Park, Mongolia. *Mammalian Biology*. 10.1007/s42991-025-00496-w

- Publication (Journal Article: Q1 – IF = 2.7) – Peer reviewed

Otgontamir, C., Fehér, Á., Schally, G., Heltai, M., Szabó, L., Lehoczki, R., Lkhagvasuren, D., & Biró, Z. (2024). Assessing changes in the distribution patterns of the European wildcat in Hungary. *Animals*, *14*(5). 10.3390/ani14050785

- Publication (Journal Article: Q3 – IF = 1.1) – Peer reviewed

Otgontamir, C., Lkhagvasuren, D., Alexander, J. S., Barclay, D., Bayasgalan, N., Lkhagvajav, P., Nygren, E., Robinson, S. L., & Samelius, G. (2023). Delivery of educational material increased awareness of the elusive Pallas's cat in Southern Mongolia. *Applied Environmental Education & Communication*, *22*(1), 1–12. 10.1080/1533015X.2023.2169785

- Publication (Journal Article: Q1 – IF = 1.9) – Peer reviewed

Otgontamir, C., Alexander, J. S., Samelius, G., Lkhagvajav, P., Davaa, L., Bayasgalan, N., & Sharma, K. (2021). Examining the past and current distribution of Pallas's cat in Southern Mongolia. *Mammalian Biology*, *101*(6), 811–816. 10.1007/s42991-021-00132-3

- Oral presentation

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- Conference Abstract (published only abstract)

Otgontamir, C., Zsolt, B. (2024). Crossing the border of a small felid conservation: A case study to investigate the threats to the European wildcat in Hungary and Pallas's cat in Mongolia, *The 3rd International Electronic Conference on Diversity session Biodiversity Conservation*. 11th November 2024.

- Poster (Conference Abstract)

Otgontamir, C., Zsolt, B., Lkhagvasuren, D., Alexander, J. S., Sharma, K., Samelius, G., Lkhagvajav, P., Bayasgalan, N. (2022). Examining the past and current distribution of Pallas's cat in Southern and Central Mongolia, *29th Poster Day.* Bratislava, Slovakia. 9th November 2022.

- Poster (Conference Abstract)

Otgontamir, C., Lkhagvasuren, D., Purevjav, L., Barclay, D. (2017). Understanding and developing community awareness of Pallas's cat in Mongolia, *Biodiversity Research of Mongolia*, Mongolia. 2017.

<u>Other publications</u>

- Conference Article

<u>Otgontamir. C</u>, Zsolt. B, Lkhagvasuren. D, Justine. S.A, Koustubh. S, Gustaf. S, Purevjav. Lk, Narangarav. B. (2022). Examining the past and current distribution of Pallas's cat in Southern and Central Mongolia. In: Vitková, J., Botyanszká, L. (eds.). Interdisciplinary Approach in Current Hydrological Research. IH SAS, E-Book, Bratislava, p. 242. ISBN: 978 80-89139-53-8.

11. ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to a range of individuals and organizations who have played a pivotal role in the completion of my Ph.D. thesis:

I am truly grateful to my supervisor, Dr. Zsolt Biró, Associate Professor from the Hungarian University of Agriculture and Life Sciences, Hungary for his unwavering source of support, valuable comments, and expert guidance throughout my academic journey.

I would like to extend my sincere thanks to my local supervisor Dr. Prof. Davaa Lkhagvasuren at the National University of Mongolia, for his unvaluable feedback, continuous guidance since my bachelor's studies and for managing and organizing fieldwork in Mongolia, particularly setting up camera traps and replacing batteries.

Thanks to my department, especially Prof. Dr. Miklós Heltai, Prof. Dr. Sándor Csányi for the permission to use the additional data for my research. Also, thanks go to Dr. Ádám Fehér and Dr. Gergely Schally for their valuable assistance and support in the publication of this work.

I would like to thank the Hungarian Game Management Units and local people of Hustai National Park for their participation in the surveys and for sharing their knowledge, as well as the national park for providing research permissions. Thank you to my friend, Ms. Tsogt Batzaya from HNP, for assisting with the fieldwork, collecting data during the summer, and bravely putting up with the herders' dogs, who barked endlessly and chased the motorbike. It was one of the hardest fieldwork experiences of my life.

I am profoundly thankful to the Tempus Public Foundation for granting me the Stipendium Hungaricum Scholarship and making my dream of studying in Europe come true.

Lastly, I would like to express my heartfelt thanks to my dear mother, Davaadagva Mijiddorj, for her strength in allowing me to be thousands of miles away from home and for taking care of my cat, Nogoonoo. I also extend my gratitude to my only brother, Chimed Zorigtbaatar, for looking after mom while I was abroad, and to my sisters for their continuous support and love. Your presence made this journey lighter - special thanks to Istvan Hejja (a drága barátom).

Last but certainly not least, I would like to thank myself for staying consistent with my goals and dreams and pushing through the rough days along the journey.

12. APPENDICES

Appendix A: Bibliography

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Appendix B: Interview questions used in Pallas's cat survey (Mongolian version)

Мануул (*Otocolobus manul*) санал асуулгын судалгаа

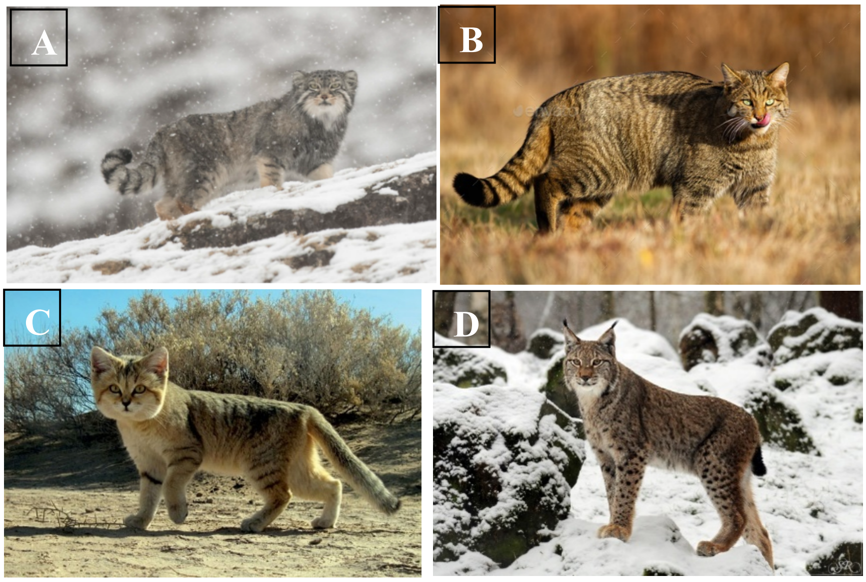
Овог нэр:_______________ Хүйс: _________________ Төрсөн он: _______________

Мэргэжил:____________________Газрынннэр:_____________________________________
Нутагтаа амьдарсан жил?________ Уртраг:____________________Өргөрөг: _____________________
Судалгаан өгсөн өдөр: _____________2022

Мануул

1. Аль нь мануул бэ? Нэг хариулт сонгоно уу.

   A ☐ B ☐ C ☐ D ☐ Мэдэхгүй ☐



2. Сүүлийн жилүүдэд мануулын популяцийн чиг хандлага өөрчлөгдөж байна уу? Нэг хариулт сонгоно уу.

   Ихэссэн ☐ Багассан ☐
   Өөрчлөгдөөгүй ☐ Мэдэхгүй ☐

3. Мануулд ямар аюул занал тулгарч байна гэж бодож байна? Олон хариулт сонгож болно.

   Ан ☐ Амьдрах орчны хомсдол ☐
   Идэш тэжээлийн хомсдол ☐ Газар тариалан ☐
   Уул уурхай ☐ Бусад махчдад бариулах. ☐
   Өвчин ☐ Аюул занал тулгараагүй ☐
   Хордуулах ☐ Other ☐

4. Сүүлийн жилүүдэд үхсэн мануултай таарсан уу? Нэг хариулт сонгоно уу.

   Тийм ☐ Үгүй ☐
   Мэдэхгүй ☐ Хэрэв тийм бол хаана харсан бэ?

   ……………………………………………………………………………….

5. Үхсэн шалтгааныг нь мэдэж байна уу?

   Тийм ☐

   Нохойд бариулсан ☐
   Өвчин ☐
   Бусад махчдад бариулсан ☐
   Хор ☐
   Ан (үс) ☐
   Бусад махчин амьтдын урхинд өртсөн ☐

Үгүй ☐

Бусад ☐

Хандлагын судалгаа

6. Мануул таны амьдарч буй нутгийн нэг чухал хэсэг гэдэгтэй санал нийлж байна уу эсвэл үгүй юу? Нэг хариулт сонгоно уу?

Санал нийлж байна ☐

Зарим талаар санал нийлж байна ☐

Аль ч талаар санал нийлэхгүй байна ☐

Зарим талаар санал нийлж байна ☐

Огт санал нийлэхгүй байна ☐

Тохиолдоцын судалгаа

1.0 Сүүлийн жилүүдэд хаана нутаглаж байгаа бэ? (Гарзын нэр________________________Байршил:____ _____)

1.1 Тухайн газраа мануул харж байсан уу?

Тийм ☐ Үгүй ☐

1.2 Тухайн газраа мануулын ул мөр харж байсан уу?

Тийм ☐ Үгүй ☐

1.3 Ямар төрлийн ул мөр харж байсан бэ?

Сарвууны мөр ☐ баас ☐ үхсэн ☐ үүр ☐

2.0 Танайх нохойтой юу, хэдэн нохойтой бэ?

Тийм Үгүй __________________

Утасны дугаар ....

Appendix C: Survey questionnaire used in wildcat study (Hungarian version)

Vadmacska előfordulás felmérő kérdőív
Tisztelt Vadgazdálkodó!
Kérem segítsék a doktorandusz hallgatóm kutatását azzal, hogy az európai vadmacska (Felis silvestris silvestris) előfordulásával kapcsolatos kérdésekre válaszolnak! A kérdések megválaszolása maximum 5-10 percet vesz igénybe.

A válaszokat név nélkül kezeljük, csak a VGE kódokhoz kötjük azokat. Ezért az első kérdés pontos megválaszolása alapvető fontosságú a vizsgálat szempontjából, mert csak így tudjuk az aktuális elterjedési térképet elkészíteni. Azonban a feldolgozás során nem a vadgazdálkodási egységek lesznek megjelenítve, hanem UTM térképet fogunk előállítani, így a közölt információk a vadgazdálkodási egység érdekeivel szemben nem használhatók fel.

Köszönettel
Dr. Biró Zsolt
egyetemi docens
MATE Vadgazdálkodási és Természetvédelmi Intézet Vadbiológiai és Vadgazdálkodási Tanszék

---

*Kötelező

Vadgazdálkodási egység kódja *13-572850-201

1. A kitöltő életkora *

Soronként csak egy oválist jelöljön be.

- 18-25 év
- 26-35 év
- 36-45 év
- 46-55 év
- 56-65 év
- 65 évnél idősebb

2. Melyik az európai vadmacska? Jelölje meg az egyik képet! *

Soronként csak egy oválist jelöljön be.

Opció 4

1. opció

Opció: 2

Opció: 3

Opció: 4

3. Előfordul a területükön az európai vadmacska? *

Soronként csak egy oválist jelöljön be.

- Igen
- Nem *Ugrás a(z) 9. kérdésre*
- **Talán, nem vagyok biztos a faj meghatározásában**

4. Ha előfordul, akkor az előfordulási gyakorisága: *

Soronként csak egy oválist jelöljön be.

- Néha
- Rendszeresen

5. Véleménye szerint hogyan változott az európai vadmacska populációja a * területükön az elmúlt 10 évben? Jelöljön egy választ!

Soronként csak egy oválist jelöljön be.

- Csökkent
- Növekedett
- Nem változott
- Nem tudom megítélni

6. Az előfordulásra miből következtet? Több választ is megadhat. *

Válassza ki az összeset, amely érvényes.

- nyomait láttam ürülékét láttam
- odút/kotorékot találtam
- elpusztult egyedet találtam élő
- példányt láttam Egyéb:
- ____
-

7. Ön szerint előfordul a területükön vadmacska-házi macska hibrid? *

Soronként csak egy oválist jelöljön be.

- Igen
- Nem
- Nem tudom megítélni

Veszélyeztető tényezők

8. Mit gondol melyek lehetnek az európai vadmacska populációt veszélyeztető tényezők? Többet jelölhet.

Válassza ki az összeset, amely érvényes.

- ☐ Vadászat
- ☐ Zsákmány hiány
- ☐ **Hibridizáció a házi macskával**
- ☐ Betegségek
- ☐ Mérgezés
- ☐ Élőhely hiány
- ☐ Mezőgazdaság
- ☐ Az erdők pusztulása
- ☐ Elütések
- ☐ Más vadfajok
- ☐ A vadmacskát nem veszélyezteti semmi Egyéb:
- ☐ ______________________
- ☐

10. Az elmúlt 10 évben látott/talált elpusztult európai vadmacskát a területükön? *

Soronként csak egy oválist jelöljön be.

- ◯ Igen
- ◯ Nem *Ugrás a(z) 14. kérdésre*
- ◯ **Nem vagyok biztos benne**

11. Az elpusztult egyedekből mennyi volt hím/nőstény illetve kölyök? *

12. Ha látott/talált elpusztult vadmacskát, hol találta, milyen élőhelyen? Ha tudja a koordinátákat, kérem adja meg!

____

13. Ha talált elpusztult vadmacskát/vadmacskákat, mi lehetett a halál oka? Több választ is jelölhet. *

Válassza ki az összeset, amely érvényes.

- ☐ Elütés
- ☐ Betegség
- ☐ Más állat ölhette meg
- ☐ Mérgezés
- ☐ Csapdában pusztult el
- ☐ Orvvadászat Egyéb:
- ☐ ______________________

A vadmacska jelentősége

14. Egyetért az alábbi állítással? 1-5-ig osztályozhat. A vadmacska fontos számomra, mert annak a tájnak a része, ahol élek.

Soronként csak egy oválist jelöljön be.

Egyáltalán nem értek egyet ezzel

1. ⬭
2. ⬭
3. ⬭
4. ⬭
5. ⬭