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Pallas's cat Status Review & Conservation Strategy

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Cover Photo: Camera trap picture of manul in the Kotbas Hills, Kazakhstan, 20. July 2016 (Photo A. Barashkova, I Smelansky, Sibecocenter)

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Past, present and future threats and conservation needs of Pallas's cats

Habitat degradation and fragmentation, largely caused by increasing livestock numbers, conversion of steppe to arable land, infrastructure development, and resource extraction, are generally considered the main threats to Pallas's cats *Otocolobus manul* across its range. In addition, predation by domestic dogs, accidental capture when hunting/trapping other animals, decreasing prey numbers and poisoning can seriously impact local populations. We expect the impact of climate change and disease to increase in the near future, but the potential extent and severity of these threats are currently poorly understood and vary considerably between countries and regions. Even though our understanding of the basic ecology and distribution of Pallas's cat has increased during the last decade, a clearer scientific understanding is required to support the species conservation. Additional ecological research is critical, but our inability to efficiently monitor the species across its vast range and reliably detect population trends and distributional changes is arguably the most important gap in our understanding.

The Pallas's cat is listed as Near Threatened on the IUCN Red List (Ross et al. 2016). The species occurs over a very large area, with an area of occupancy of c. 2,269,000 km^2, although the estimate is associated with considerable uncertainty. Based on increasing threats, the global population is estimated to be decreasing, but there are very few reliable estimates of population size and trend (Ross et al. 2016). Although such a wide-ranging species is unlikely to face range-wide extinction in the short term, low density and sensitivity to anthropogenic disturbances (Ross 2009), renders the species vulnerable to local extinctions. This chapter discusses current and future threats faced by Pallas's cat (Table 1) from a theoretical and evidence-based stand point.

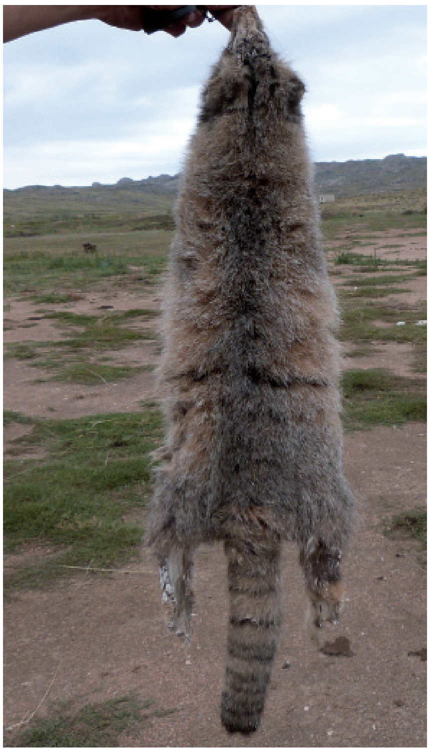

Fig. 1. Skin of a manul killed by herder dogs in Dogalan Hills, East Kazakhstan Uplands, Eastern Kazakhstan, July 2013. Killing by herder dogs is a major threat to manul across its range (Photo M. Gritsyna).

Habitat fragmentation and degradation

The most serious threat to Pallas's cats across its range is habitat degradation and fragmentation, that are largely consequences of increasing livestock numbers, conversion of steppe grasslands into arable land, infrastructure development and resource extraction. Mineral exploitation (especially mining and petrochemical extraction) and infrastructural developments have also increased substantially across the range with increased fragmentation as a result (Awehali 2011, Paltsyn et al. 2012, Selles 2013). Due to degradation and loss of habitat Pallas's cat populations are becoming increasingly fragmented, and isolated subpopulations are very likely disappearing without our knowledge (Ross et al. 2016). In Mongolia, for example, livestock numbers have increased from 26 million in 1991 to 66 million in 2018 (FAO 1998, National Statistical Office of Mongolia 2018). Increasing livestock numbers result in heavy grazing and habitat degradation, but also in displacement of Pallas's cats and increasing number of herding dogs which are known to kill Pallas's cats (Fig. 1, 3; Chapter 4; Ross 2009, Barashkova & Smelansky 2011, Ross et al. 2012, Joolaee et al. 2014, Farhadinia et al. 2016, Ruta 2018). Predation by herding dogs, feral dogs, accidental capture when trapping or snaring other animals, and illegal and legal hunting are the main recorded causes of direct anthropogenic mortality of Pallas's cats (Fig. 2, 4; Ross 2009, Barashkova & Smelansky 2011, Farhadinia et al. 2016, Ross et al. 2016, Ruta 2018; Chapters 3–5). New emerging threats are also of concern. Climate change for example is predicted to have large impacts on the grasslands and mountain ecosystems of Central Asia and the Himalayas (Angerer et al. 2008, Ross et al. 2016; Chapter 10).

Ecological susceptibility: the relationship between Pallas's cat ecology and conservation

From an ecological perspective, the Pallas's cat has several traits that make it vulnerable to local extinction. These include habitat specialisation, feeding specialisation and low density, but this may be somewhat countered by other traits which are associated with resilience, such as large litter size, ability for long range dispersal and physiological tolerance (Ross et al. 2010a, b, 2012, 2016).

A study of the spatial ecology and resource selection of Pallas's cats in Mongolia found that Pallas's cats were highly selective of resources (Ross 2009). Specialist and highly selective species, in turn, have been found to be more vulnerable to extinction (Purvis et al. 2000), as they generally have lower resilience to change (Begon et al. 1996). The population in Mongolia selected habitats that had more disruptive cover, such as rocky areas and ravine habitats, and avoided open areas without cover (Ross 2009). Pallas's cats were also very selective with regard to their prey (Ross et al. 2010a). Although the species ate almost all available food resources, they were highly selective of pikas *Ochotona* spp., eating a higher proportion of pikas than predicted based on their availability. In all regions where the feeding ecology of Pallas's cats has been investigated, pikas have formed more than 50% of their diet (e.g. Heptner & Sludski 1972, Ross et al. 2010a; Chapter 3). As pikas are 2–4 times larger than other common small mammal prey, the Pallas's cat's preference for pikas may reflect optimised hunting efficiency, energy intake, and the year-round availability of pika (Ross et al. 2010a). Maintaining energy stores may be very important considering the unpredictable nature of prey availability over the winter period.

Another example of their specialist behaviour and dependency on critical resources is their need of denning and resting sites to provide cover from predators, thermoregulation, and raising of young (Ross et al. 2010b). As Pallas's cats are unable to dig burrows themselves, they are dependent on existing cavities (Ross et al. 2010b). Such cavities primarily consist of rock crevices, marmot burrows, and burrows of sympatric predators (Ross et al. 2010b; Chapter 2 & 3). Most marmot species are in decline, and Siberian marmots *Marmota sibirica*, which are sympatric with Pallas's cats, have decreased considerably due to overharvesting and are now listed as Endangered (Zahler et al. 2004, Clayton 2016). The decline of marmots could have dramatic effects on Pallas's cats ability to find critical shelter habitats (Ross et al. 2010b, Zielinski 2015). Although observations indicate that Pallas's cats may fulfill this niche requirement by using any available cavity, such as abandoned human structures (Ross 2009; Chapter 3) and hollow tree stumps (Dibadj et al. 2018), cavities are generally a limited resource within the steppe ecosystem.

In most regions of its range, the specialist requirements of the Pallas's cat result in its distribution being naturally fragmented, due to resources and habitat patches being separated by large areas of poor habitat with insufficient prey or cover from predation (Ross et al. 2016). For example, the distribution of resource patches, with cover from predators, was found to be the main determinant of home-range size for Pallas's cats in Mongolia, where larger home ranges were associated with more dispersed and fragmented resources (Ross et al. 2012). The natural patchiness of their resources may also explain the apparent low density of Pallas's cat populations. The study by Ross et al. (2012) also suggests that Pallas's cats may be particularly susceptible to habitat loss and fragmentation, as it may further restrict their ability to gain resources through home-range expansion (Ross 2009).

Disease

There is very limited information on diseases of Pallas's cats in the wild and the influence of diseases at the population level is unknown (Chapter 9). Although captive studies of the species are relatively common, the epidemiological conditions in captive settings may have little relationship to those in the wild, though susceptibility of wild and captive Pallas's cats should be the same.

Fig. 2. Locals showing a skin of a poached manul, Eastern Kazakhstan, March 2012, while conservationists explain the species is rare and protected by law (Photo R. Nefedov).

In captivity, Pallas's cat kittens are known to be very sensitive to toxoplasmosis with up to 50% kitten mortality in zoo settings (Swanson 1999). Other infectious agents are also known to cause mortality in captive settings. For example, 76% of the mortalities of 37 Pallas's cats at the Moscow Zoo was caused by disease (T. S. Demina, pers. comm.; Chapter 9) with 43% of the mortalities attributed to feline panleukopenia virus FPV, 8% to coinfection of toxoplasmosis and FPV, 14% to toxoplasmosis, and 5% to respiratory infections (rhinotracheitis and calicivirus). As a comparison, Ross (2009) documented the mortality of 17 of 29 radio-collared Pallas's cats in Mongolia, 6 were caused by large raptors, 5 by domestic dogs, 3 were killed by humans, 1 by a red fox, and one cause of death was unknown. Using necropsies none of the deaths were attributed to disease, though this could not be ruled out as a contributing factor. Studies of disease seroprevalence in wild Pallas's cats also suggest very low exposure to diseases. For example, Pavlova et al. (2015) sampled 24 Pallas's cats and 61 domestic cats in Daursky Nature Reserve in Russia and found antibodies to feline immunodeficiency virus FIV and feline leukemia virus FeLV in 5% of the Pallas's cats but no cats with antibodies to feline calicivirus FCV or FPV. In contrast, 76% of the domestic cats had FCV, 55% had FPV, and 16% had FIV and FeLV. The patterns of seroprevalence were interpreted to show a low rate of interspecific contacts between domestic cats and Pallas's cats (Pavlova et al. 2015). Similarly, Brown et al. (2005) and Naidenko et al. (2014) found low prevalence of *Toxoplasma gondii* (the organisms causing toxoplasmosis) in wild Pallas's cats, their prey species, and sympatric domestic cats in central Mongolia and in Daursky, Russia. These two studies suggested that the low prevalence of *T. gondii* and other diseases in Pallas's cats was the result of limited exposure, low host density and extreme environmental conditions. However, a recent study of disease ecology in southern Mongolia found that *T. gondii* was common in both domestic and wild species (including pikas) in an area where Pallas's cats occurred but were not sampled (C. Esson, pers. comm.).

Our understanding of the consequences of disease on Pallas's cats in the wild is limited by the lack of data on causes of mortality. Nevertheless, there is currently no evidence to suggest that diseases are a large threat to Pallas's cat conservation in the wild. Studies of wild Pallas's cats so far have suggested that their low density and limited contacts between individuals results in low rates of disease transmission and that the extreme climate may also reduce the virulence of diseases. Nevertheless, globalisation and environmental change are undoubtedly affecting the emergence of infectious diseases (Daszak et al. 2001). For example, Pallas's cats have recently been found infected with *Spirocerca lupi*, a virulent parasitic nematode associated with introduced domestic cats and dogs (Hosseini et al. 2018). Thus, diseases pose a potential threat to Pallas's cats and need to be monitored.

Climate change

The potential impacts of climate change on Pallas's cats are unknown but evidence suggests recent changes of the grassland and mountain ecosystems of Central Asia and Himalayas are at least in part related to climate change (Xu et al. 2009, Angerer et al.

Table 1. The main threats and gaps to Pallas's cats, evidence and current trends in threats.

Threat/gap	Evidence of threat
Habitat loss, degradation and fragmentation caused by habitat conversion to arable lands, increasing livestock numbers, resource extraction (e.g. mining) and resource use (e.g. cordyceps).	Documented evidence and trends. Research required to understand effects of threats
Depletion of prey base and secondary poisoning through small mammal poisoning and control programmes	Documented evidence based on unofficial accounts and research conducted in China. Research is needed
Hunting (legal hunting in Mongolia only)	No information on impact of legal hunting. Research is needed
Illegal hunting and illegal trade	Documented evidence. Research is needed
Predation by domestic dogs	Documented evidence across the majority of range countries
Accidental capture when snaring other animals (e.g. marmots and foxes)	Documented evidence with reports of accidental capture consistent across its range
Disease	Disease has been quantified in the wild by 3 studies
Climate change	Currently no quantified evidence for the species specifically but considerable evidence of changes to grassland and mountain ecosystems. Research is needed
Lack of information and funding to monitor population trends	The threat is based on the lack monitoring data on Pallas's cat populations which means that populations may become heavily reduced and even locally extinct without being detected
Lack of awareness	Based on community surveys, many people living in Pallas's cat habitat are unaware of its presence. Raising awareness is required to gain support for the species conservation

2010). Climate change is also predicted to have large impacts on steppe and mountain ecosystems in the future with a cascade of changes to the ecosystem likely to follow (IPCC 2007). For example, climate change is likely to result in the redistribution of species with more competitive species and new diseases expanding their ranges (Daszak et al. 2001, Parmesan 2006). Human distribution is also likely to be affected by climate change as livestock husbandry or agriculture adapts to the new climatic conditions. However, as the impacts of climatic change are expected to differ between regions, it is difficult to predict the potential consequences to the Pallas's cat population given the large distribution and the diversity of conditions experienced. For example, the impacts of climate change will likely not be the same in the Himalayan Mountains and the Eurasian steppes, both of which are occupied by Pallas's cats (Ross et al. 2016).

Despite the environmental variability between Pallas's cat populations, there are some general challenges that all Pallas's cats are likely to face due to climate change. For example, changes in distribution of competing carnivores that predate on Pallas's cats will likely have an impact throughout their range. Similarly, vegetation cover and phenology, and climate-caused changes in the assemblages and fluctuations of small mammal populations (Qu et al. 2016) could have serious impacts on Pallas's cats, given their reliance on small mammal prey (Ross et al. 2010a).

Based on the species biology, changes in seasonality will likely have a distinct impact, due to Pallas's cat being a strict seasonal breeder. Female ovulation and male sperm production are both regulated by day length and peak during the late winter breeding season (Brown et al. 2002; Chapter 2). Considering that the breeding season is dictated by day length, as opposed to climate, Pallas's cats may be unable to respond to seasonal changes in ecological parameters that result from climate change. As seasons change, gestation, births and raising of kittens may take place under different climatic and ecological conditions. As Pallas's cats have not evolved to deal with these 'new' conditions, their ability to survive will depend on the species plasticity, and the nature of the changes they face.

A related aspect of Pallas's cat's reproductive biology that may make them vulnerable to climate change is that they appear to be capital breeders (Ross 2009, Naidenko et al. 2014). "Capital breeders" rely largely on stored energy reserves for reproduction, using energy stores accumulated at an earlier time, as opposed to "income breeders" that rely largely on energy gained concurrently to reproduction (Houston et al. 2006). As indicated by large gains in body mass, Pallas's cats build-up energy reserves during the summer when prey is abundant (Ross 2009, Naidenko et al. 2014), and invest these reserves in reproduction during the late winter when prey availability is low (Ross 2010a). As climate change alters seasonal patterns, and with it prey availability, this is likely to affect Pallas's cats ability to balance energy reserves. Weight gains and losses could be influenced either in a positive or negative way depending on how prey species respond to changes in seasonality. As the direction of Pallas's cats' response to climate change is unknown, understanding the above aspects of Pallas's cat life history and how they relate to changes in seasonality and climate are an important gap in our understanding that need research attention in the future.

Small mammal poisoning campaign's

The poisoning of small mammals, such as pikas and Brandt's vole, aims to reduce disease transmission from small mammals to humans and livestock, and to improve rangeland quality for livestock (Smith et al. 2008). Although information is scarce, poisoning continues in China where pika populations can be reduced by 95% (Lai & Smith 2003, Badingqiuying et al. 2016). In the Qinghai-Tibetan Plateau, for example, between 2006 and 2013 approximately $25.5 million was spent to eradicate the plateau pika (*O. curzoniae*) from over 78,500 km^2 in Sanjiangyuan National Nature Reserve alone (Wilson & Smith 2015). Research has also shown carnivore populations suffer declines as a consequence of poisoning campaigns (Badingqiuying et al. 2016; Chapter 5). In Mongolia, campaigns to control small mammal numbers have occurred in all provinces (Clark et al. 2006, Winters 2006, Ross et al. 2016) but there is no information on its current prevalence. In Russia and Kazakhstan poisoning occurs at a local scale to control local disease outbreaks (Chapter 3). Although the occurrence of poisoning has very likely decreased over the last decade, where the practice continues there is little doubt that aerial and terrestrial carnivores will suffer multiple consequences, such as secondary poisoning and prey depletion.

Hunting, illegal hunting and illegal trade

Pallas's cats have been hunted for their fur in relatively large numbers in Mongolia, Russia, Khazakstan and China (Heptner & Sludskii 1972, Nowell & Jackson 1996, Ross et al. 2016). However, the international trade in Pallas's cat pelts has largely ceased since the late 1980s, and Mongolia is the only range country where hunting of Pallas's cats is permitted today, although they can be hunted in China if a special license is obtained (Lu et al. 2010, Ross et al. 2016; Chapter 6). The permitting system in Mongolia is said to be ineffective and Pallas's cat furs were exported illegally to China (Murdoch et al. 2006). It has been estimated that there were about 1,000 Pallas's cat hunters in Mongolia with a mean harvest rate of 2 Pallas's cats per hunter per year (Wingard & Zahler 2006). Evidence of illegal trade in Pallas's cats is reported from Afghanistan and Pakistan (e.g. Kretser et al. 2012), but it seems to be only occasional and opportunistic (Chapter 4). Pallas's cats are also shot when being mistaken for marmots, which are commonly hunted in most of the Pallas's cats range (Ross et al. 2016). They are also trapped incidentally in leg-hold traps and snares set for other animals (Ross 2009). The fat and organs of Pallas's cats are used as medicine in Mongolia and Russia (Ross et al. 2008, A. Barashkova, pers. comm.). The extent of illegal hunting and illegal trade of Pallas's cats or their body parts is unknown.

Information gaps and conservation needs

Even though our understanding of the ecology of the Pallas's cat has increased substantially during the last 10 years, we still lack a clear understanding of much of its ecology and how populations may respond to threats.

For instance, data on the prevalence of small mammal poisoning campaigns is extremely difficult to come by, due to the control of information released on this controversial method. Considering the potential impacts from poisoning, an investigation of the existence and methods of poisoning campaigns is needed to understand the level of this threat. The efficiency of poisoning (financial investment compared to reaching the defined goal) should also be evaluated, to understand if the method is even justifiable. Only then can we understand the potential harm to biodiversity of poisoning and enable campaigns to reduce its occurrence.

One large challenge to Pallas's cat conservation is a lack of data on population trends. Many range countries have only recently detected Pallas's cats, including Bhutan (Thinley 2013) and Nepal (Shrestha et al. 2014). In other countries, such as Azerbaijan and Armenia (Chapter 5), and Uzbekistan and Tajikstan (Chapter 3), there are question marks of the species continued occurrence. Given the poor resolution of historic distributional data, and the challenges associated with monitoring the species, it is likely that Pallas's cats have disappeared from a portion of their former range. Without initiating surveys and subsequent monitoring, there is a risk that it may continue to become locally extinct without our knowledge. Population assessment and monitoring of the species has received little attention up till now but is arguably of prime importance for the species conservation.

Similar to other rare and cryptic species, occupancy modelling may be a useful technique for Pallas's cats monitoring (O'Connell et al. 2010, Ahumada et al. 2013). Monitoring occupancy is normally cheaper and less technically demanding than estimating population abundance or density at broad scales, making occupancy an important measure of extinction risk (Geyle et al. 2019). Camera traps can collect detection/non-detection data (Chapter 4) that are well suited to monitor trends using occupancy models, through quantification of changes in the proportion of area occupied (Steenweg et al. 2016), and for comparison of the relative occupancy in separate surveyed areas. Occupancy modelling can also be used to measure habitat suitability and preference, which can have direct application in prioritising areas and habitats for conservation. Obtaining adequate sample sizes required for occupancy modelling may be best achieved by combining survey efforts for other threatened species (e.g. Chapter 4). Such collaborative research is now being formed with conservation groups working in areas that overlap Pallas's cat populations (e.g. Ruta 2018; Fig. 5).

Regarding the ecology of Pallas's cats, most published information is based on one study in

Fig. 3. A nomadic herder camp in Central Mongolia. Livestock herding has been practiced in the Eurasian steppes for 1000s of years, but increasing livestock numbers and changing lifestyles now threaten the steppe ecosystem (Photo S. Ross).

Fig. 4. A manul trapped by a poultry farmer in Razavi Khorasan Province, Iran, January 2016, after, allegedly, killing domestic fowl. The cat was delivered into a local office of Iran DoE and consecutively released (Photo neda-chenaran.ir/Iran DoE).

Mongolia (e.g. Ross 2009, Ross et al. 2010a, b, 2012) and current work in Russian Dauria (e.g. Kirilyuk 1999, Kirilyuk & Puzansky 2000, Naidenko et al. 2014, Barashkova et al. 2017). Considering the variety of environmental conditions across the Pallas's cat's range, it is therefore important that ecological studies extend into new study areas experiencing different environmental conditions. In addition, relating Pallas's cat ecology and distribution to measurable threats such as climate change, habitat fragmentation, human impacts, and prey dynamics are important topics on which there is little or no information but are important for the conservation of the species (Chapter 10).

Finally, engagement with governments, different interest groups, and local people on the threats and conservation needs of Pallas's cats is crucial for the development of sustainable conservation strategies and the implementation of actions (Fig. 2; Chapter 10). Much can be learned from the work done in Russia and Kazakhstan (Chapter 3). However, how to engage with governments and other interest groups may vary considerably between countries and regions.

Concluding remarks

The Pallas's cat continues to be a challenging species to understand at the population level. While we know its basic distribution and ecology, our understanding is incomplete, and we still have more questions than answers. There is a distinct need to intensify conservation efforts and apply scientific rigor into studies, so we may quantify and apply facts in support of the species conservation.

Although the wide distribution of the Pallas's cat may be interpreted as security against extinction, until we understand regional variability in occupancy and the species response to contemporary threats, we should not assume that the population will remain intact without intervention and development of conservation management plans (see Chapter 10).

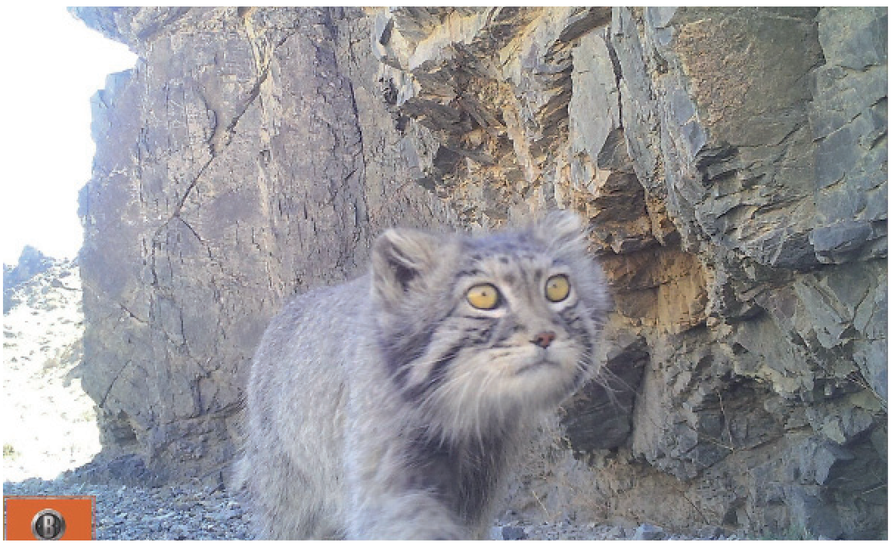

Fig. 5. Pallas's cat in South Gobi, southern Mongolia, encountered in 2018 during survey of snow leopards (Photo Snow Leopard Trust and Snow Leopard Conservation Foundation).

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