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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)

Editorial

In 2016, the Pallas's Cat International Conservation Alliance PICA was established to improve awareness and knowledge about the Pallas's cat, and to enhance global conservation efforts for the species. Since global conservation efforts can be achieved only through a range-wide cooperation, PICA joined force with the IUCN SSC Cat Specialist Group Cat SG, the Pallas's Cat Working Group PCWG and manul specialists with the aim to develop a Conservation Strategy for the Pallas's cat. From 12–15 November 2018, the first Pallas's cat Global Action Planning Meeting took place in Nordens Ark, south-western Sweden, where the PCWG, PICA and the Cat SG met to (1) review and assess the global status of the species, (2) update its current and historic distribution range and (3) develop the first range-wide Conservation Strategy for the Pallas's cat.

The Global Action Planning Meeting was organised by PICA and supported by Nordens Ark, the Fondation Segré, the Royal Zoological Society of Scotland and Cincinnati Zoo. The meeting has been attended by 28 participants, including species experts from 8 of the 16 range countries (Appendix I; Fig. 1).

At the beginning of the action planning meeting, an overview on the Pallas's cat work of PICA, PCWG and the Cat SG was presented. Then, the available knowledge and information on the Pallas's cat was summarised. Species experts from each of the three defined regions (South-west Asia, Central Asia and adjacent areas, and the Himalayas and China) presented the available information on the Pallas's cat, specifically on its distribution and status, in the respective region (Chapters 3–5). These presentations (and status reports; Chapters 3–5) provided an overall view on the knowledge available on the Pallas's cat across its range and up-to-date information on its global distribution and status. This allowed reviewing and revising the global distribution map of the species, reflecting more accurately its current and historic distribution (Chapters 1, 3–5). This information was essential for identifying conservation priorities and the following strategic planning process with the aim to develop an effective global Conservation Strategy for the Pallas's cat.

The range-wide Conservation Strategy presented in the following is the result of a collaborative strategic planning process between PICA, PCWG, the Cat SG and Pallas's cat experts (Appendix I).

A prerequisite for good conservation is continuous monitoring and robust assessment of the population. This Special Issue will also set the baseline for future work and assessments of the Pallas's cat, and it marks the beginning of a range-wide cooperation of Pallas's cat experts. It is the first part of a process leading to a comprehensive and range-wide approach to Pallas's cat conservation based on the IUCN standards for strategic planning for species conservation. Strategic planning for species conservation according to IUCN SSC should be participatory, transparent and informed by the best available science. A transparent and participatory planning process helps to build partnerships, secure buy-in from stakeholders and local people, prevents loss of time and inefficient use of funding. The first step in the Strategic Planning Cycle (Fig. 2) is "preparing the ground": defining the conservation unit, building the partnerships, identifying

Fig. 1. Participants of the Pallas's cat Global Action Planning Meeting, Nordens Ark November 2018.

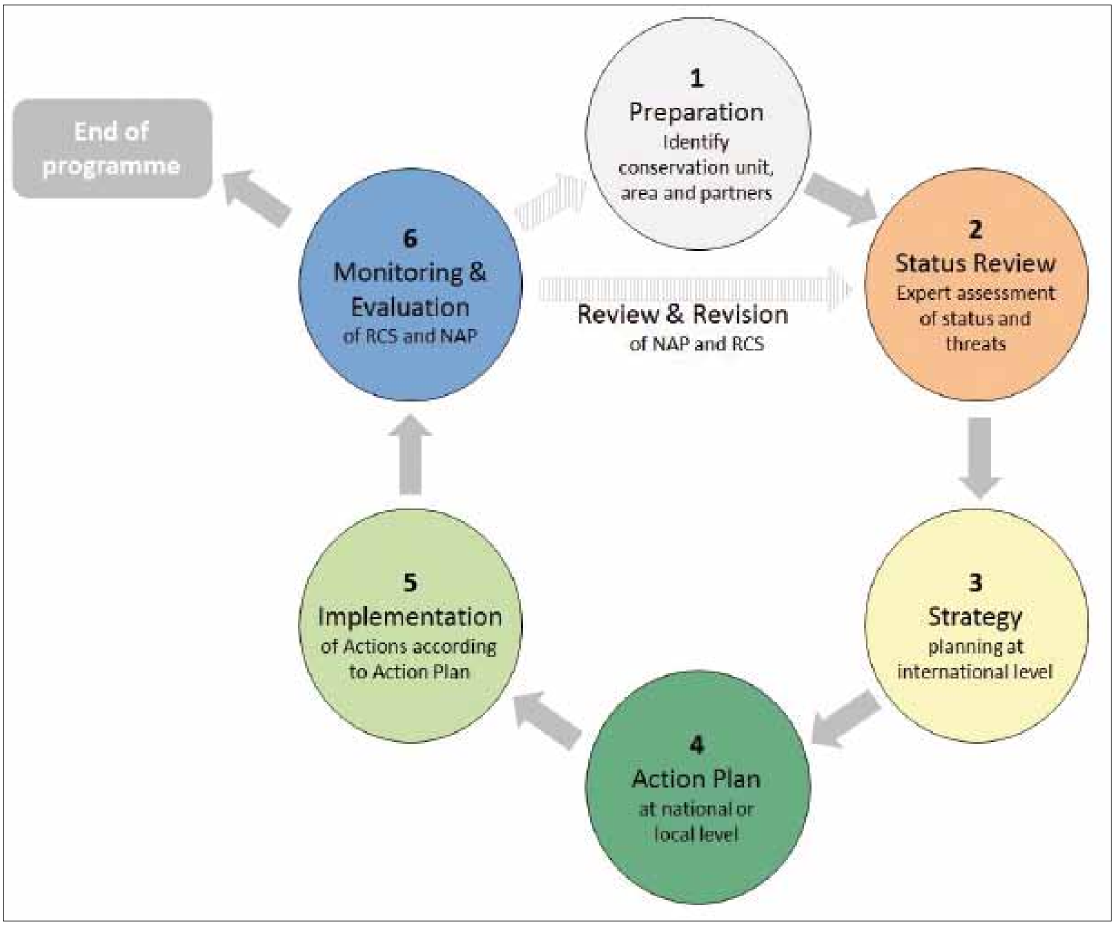

Fig. 2. Strategic Planning Cycle for species conservation projects. Step 1 and 2 are important for sensible planning and providing the baseline for the strategic planning. The actual planning process is covered by step 3 and 4. The ultimate goal of the procedure is the implementation of sensible conservation actions (step 5), but these will only be successful if properly planned and subsequently monitored and evaluated (step 6). The circle implies that conservation is an adaptive process (Breitenmoser et al. 2015).

stakeholders, securing political support and agreeing on the process and procedures. In the second step, the available important information, which has been collected with the help of a questionnaire (Supporting Online Material SOM), is compiled in a Status Review (Chapters 1–9). The Status Review serves as an input document for the development, for example, of a regional or range-wide Conservation Strategy (Chapter 10). This Special Issue covers the first three steps in the planning cycle (Fig. 2).

For the practical implementation of the Conservation Strategy, regional or National Action Plans should be developed to concretise the conservation measures according to national needs and prerequisites. Subsequently, the Conservation Strategy and the Action Plans will be implemented. Rigorous planning takes some time and effort, but it will allow saving time and funding during the implementation. As we generally do not have all the information needed for sensible planning at the beginning of such a process, conservation programmes need to be organised as adaptive processes, allowing adjustments to new developments and insights as they come up. Consequently, the implementation of conservation activities needs to be monitored and progress regularly evaluated. According to the findings of the evaluation, the plans may have to be revised.

The goal of this Special Issue on the Pallas's cat is to (1) compile and critically review all available information relevant for the conservation of the Pallas's cat, (2) identify gaps of knowledge, prioritise important research questions, and urgent conservation needs, and (3) present a Conservation Strategy at global level to inform future cooperation. It addresses scientists and conservationists working on the Pallas's cat, but it also aims to raise awareness for this awesome felid among national conservation authorities within range countries and the global conservation and donor community.

Urs Breitenmoser, Christine Breitenmoser-Würsten and Tabea Lanz

Supporting Online Material SOM is available at www.catsg.org.

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Prologue: Why care about *Otocolobus manul*?

The Pallas's cat or manul *Otocolobus manul* is a small felid of the leopard cat lineage inhabiting the Asian steppes from the Himalayas to the southern rim of the boreal forest. In spite of its vast distribution range, the Pallas's cat has received little attention from the scientific and conservation community, and hence information is scarce and often only available for small fractions of its range. The Pallas's cat is listed as Near Threatened in the IUCN Red List of Threatened Species, but robust information on the status and trend of the population are lacking from most of its distribution range. The gaps in knowledge of the species restrict the development of effective conservation actions and the establishment of targeted conservation plans. Thus, the Pallas's Cat International Conservation Alliance PICA and the IUCN SSC Cat Specialist Group Cat SG have joined up with the Pallas's cat Working Group PCWG and experts from all Pallas's cat range countries to produce this comprehensive Status Review summarising available information on *Otocolobus manul*, but also identifying important gaps of knowledge, priority research topics, and conservation priorities, and consequently the first Conservation Strategy. This Status Review and the developed Conservation Strategy will assist a more rigorous planning for the species' conservation according to IUCN standards.

The Pallas's cat, also known as the manul, is endemic to the Asian montane grassland and shrub steppe, and is found from north-eastern China across Central Asia to the Iranian Caucasus, from the Himalayas to the southern rim of the boreal forest (Ross et al. 2016; Fig. 1, 2). The Pallas's cat is believed to have lived in this area and habitat for around 5.9 million years since the Pliocene when it diverged from a leopard cat ancestor (O'Brien & Johnson 2007, Li et al. 2016). The Pallas's cat has a large distribution area ranging 5,800 km W–E and 2,700 km N–S, but it occurs at very low densities (2–6 individuals/100 km^2; Ross et al. 2016). Its estimated area of occupancy is 2,269,000 km^2 but includes many regions where the presence of the species was never confirmed (Ross et al. 2016; Fig. 2). In spite of its extensive distribution range, the Pallas's cat is a habitat (Ross et al. 2010a, 2016, Ross 2009) and prey specialist (Heptner & Sludskii 1992, Ross et al 2010b; Chapter 2). The species is vulnerable to both predation from and competition with other carnivores (Ross et al. 2012, 2016). As a hunter of rodents and lagomorphs (Guggisberg 1975, Heptner & Sludskii 1992, Sunquist & Sunquist 2002, Ross 2009, Ross et al. 2010b), the Pallas's cat rely on species with fluctuating populations, which are in turn vulnerable to changes in land use and likely also to climate change.

Perhaps due to the species low density, despite its vast range across 16 range countries, the Pallas's cat is almost unknown to people living outside of range countries and is rarely seen within range countries. The species has also received little attention from the scientific and conservation community. Range-wide data on the Pallas's cat is lacking, and information on its ecology, behaviour, distribution and population status is scarce (Brown & Munkhtsog no date, Murdoch et al. 2006, Aghili et al. 2008, Jutzeler et al. 2010, Barashkova & Smelanski 2011, Farhadinia et al. 2016, Ross et al. 2010b, 2016). Studying the Pallas's cat is particularly challenging due to the remoteness of its habitat and there is thus very limited information on the species (e.g. Munkhtsog et al. 2004, Murdoch et al. 2006, Ross 2009, Ross et al. 2010a, b, 2012, Barashkova & Smelanski 2011, Pavlova et al. 2015, Farhadinia et al. 2016, Barashkova et al. 2017). Consequently ecological data is only available from some parts of its large geographical range. Most information on the distribution was, and still is, based on opportunistic records (e.g. Fox & Dorji 2007, Aghili et al. 2008, Chanchani 2008, Thinley 2013, Hameed et al. 2014, Joolaee et al. 2014, Shrestha et al. 2014, Webb et al. 2016, Mahar et al. 2017, Otaghvar et al. 2017).

According to Sunquist & Sunquist (2002), "*much of the information on the status of the manul comes from records of the animal's pelt in the fur trade*" (Chapter 6). In the past, the Pallas's cat was heavily harvested due to its valuable pelt (Nowell & Jackson 1996). In the 1970s, harvest figures started to decline, which has been attributed to a decline in the global population (Nowell & Jackson 1996). However, the Pallas's cat was also listed under CITES Appendix II in 1977 and was granted legal protection in an increasing number of range countries and the known offtake thus diminished. Hunting of Pallas's cats is still permitted in Mongolia (Murdoch et al. 2006) and where Pallas's cats are still traded on local markets (Wingard & Zahler 2006). The fat, oil, meat and organs of the species are or have been used for medicinal purposes in Mongolia and Russia (Murdoch et al. 2006, Wingard & Zahler 2006, Ross et al. 2016; Chapter 6 & 8). Pallas's cats are also poached and their furs illegally exported to China (Murdoch et al. 2006). In 2005, it was estimated that 2,000 Pallas's cats were

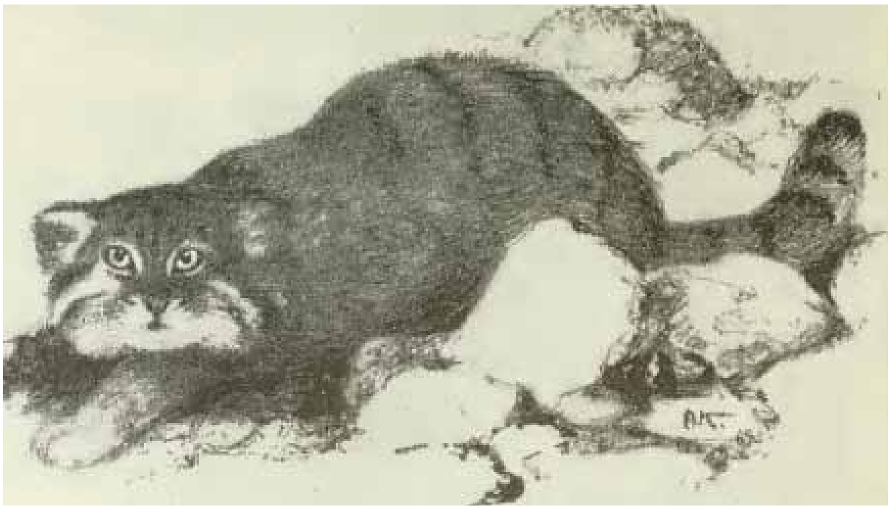

Fig. 1. *Felis* (*Otocolobus*) *manul*. Sketch by A. N. Komarov, from Heptner & Sludskii (1992).

killed per year in Mongolia (Wingard & Zahler 2006). Compared to the remarkable hunting pressure half a century ago (Chapter 6), the current offtake is small. However, there is no data available demonstrating neither a positive effect of the harvest reduction on the population development, nor is it known how much of the formerly legal and recorded hunting has been replaced by illegal hunting and hence is not reported.

History of the IUCN Red List assessment of the Pallas's cat

In 1994, the Pallas's cat was regarded as "*Insufficiently known*" (nowadays Data Deficient) in the IUCN Red List of Threatened Species (Groombridge 1994, Nowell & Jackson 1996). The species was considered vulnerable to rare. It was reported to be uncommon in most parts of its range, to have disappeared from most of the Caspian region and to have been eradicated from eastern China due to hunting (Groombridge 1994). The Pallas's cat was believed to be most abundant in the cold grasslands of Mongolia and Inner Mongolia (Nowell & Jackson 1996).

In 1996, the Pallas's cat was assessed as "*Lower Risk*" (now Least Concern) in the IUCN Red List based on its estimated wide range of 5,000,000 km^2 across Central Asia. However, still very little information about the species existed (Baillie & Groombridge 1996).

In 2002, 2008 and 2016, the Pallas's cat was assessed as Near Threatened in the IUCN Red List and its population trend as decreasing due to habitat and prey base degradation (Cat Specialist Group 2002, Ross et al. 2008, 2016). In 2002, the total effective population size of the Pallas's cat was estimated at less than 50,000 mature individuals. The Pallas's cat was considered to occur throughout the Tibetan plateau and to be widely distributed throughout the grassland steppes of Mongolia, but to be less abundant and threatened in the southwest of its range such as the Caspian region and Baluchistan province, Pakistan (Cat Specialist Group 2002). The Pallas's cat was described to mainly inhabit the Central Asian steppe regions of Mongolia, China and the Tibetan Plateau (Ross et al. 2008). Mongolia was thought to be the stronghold of the species, based on an estimated density of 7.5 ± 2 individuals/100 km^2 in the steppe grasslands of central Mongolia (Ross et al. 2008). Populations in the southwest of its range were, as in 1994 and 2002, described as declining and sparse, and populations in Armenia, Azerbaijan, Russia's Krasnoyarsk region and Turkmenistan were assessed to be threatened (Ross et al. 2008).

In 2016, the classification as Near Threatened was justified by population fragmentations and a suspected population decline of 10–15% over the last three generations (11 years), based on habitat loss and reduced habitat quality, growing threats, low detection rates and the Pallas's cat's susceptibility to disturbance (Ross et al. 2016). The Pallas's cat was considered to have a wide but fragmented distribution across the grasslands and montane steppes of Central Asia and to occur at low densities of 2–6 animals/100 km^2 (Ross et al. 2016). The low density was assumed to be the result of predation and the fact that Pallas's cats are habitat specialists requiring habitats with good cover from predators and sufficient prey availability (Ross et al. 2016). Due to its special habitat requirements, the Pallas's cat is vulnerable to several threats and vast areas are needed to conserve viable populations (Ross et al. 2016). In the 2016 Red List assessment, the main threats (as in previous assessments) were identified to be habitat loss and fragmentation due to increasing human and livestock populations, agriculture, infrastructure development and mining, prey base depletion due to poisoning and overhunting (rodent control programmes mainly in China and Mongolia), and killing by herding dogs (Cat Specialist Group 2002, Ross et al. 2016, 2008; Chapter 8). Illegal hunting and accidental killing in snares and traps were a further continuous threat to the Pallas's cat (Ross et al. 2016).

In the 2002, 2008 and 2016 Red List assessments, the authors discussed whether the Pallas's cat might even qualify for Vulnerable in the near future if negative trends persisted and if better information on its status and distribution range were available (Cat Specialist Group 2002, Ross et al. 2008, 2016). Ross et al. (2016) stated that the Pallas's cat may qualify as Vulnerable under criterion C1 (small population size) if the global population that was then estimated at 15,315 mature individuals would decline below 10,000. However, range-wide data was lacking and thus no reliable information was available to estimate the global population size and status of the species (Ross et al. 2016). Therefore it could be that the Pallas's cat may also qualify for Least Concern if better information on its population size and trend becomes available, as the assumed population size of 15,000 mature individuals is indeed the threshold between Least Concern and Near Threaten-ed. Considering the uncertainty in the Red List assessment, we agree with Ross et al. (2016) that understanding occurrence and abundance of the Pallas's cat is fundamental for the conservation of the species and that there is thus an urgent need for more surveys to understand abundance, distribution, population dynamics, and habitat needs of the Pallas's cat (Chapter 9).

Challenges to Pallas's cat conservation

One big challenge to the conservation of the Pallas's cat is the lack of consistent information across its range, which restricts the development of effective conservation actions and the establishment of targeted conservation plans (Murdoch et al. 2006, Ross et al. 2016; Chapter 8). Indeed, records of the species' presence after 1996 are available only from about 30% of the assumed distribution range, and the distribution of the point data and the distribution range do not really match (Fig. 2). The species' distribution, the degree of range fragmentation (the segregation into isolated populations), abundance and population trends are not known for most regions and the factors affecting variation in these parameters are not understood. Thus, the population size decline in the IUCN Red List assessment from 2016 is based on crude estimations and extrapolations (Ross et al. 2016). Although a majority of local experts assume a decrease in distribution and abundance (Chapters 3–5), there is no long-term robust population study that can confirm this, and no field study that would explain the ecological processes behind the assumed decline. In addition, the few field-studies conducted are likely not representative for the entire range and all habitat types; there is an urgent need for more field studies (Chapter 8). Even the historic distribution of the Pallas's cat is uncertain (Fig. 2a). The historic distribution (<1996) range of the Pallas's cat presented in Nowell & Jackson (1996) and the distribution records collected in the Global Mammal Assessment Database GMA of the Cat SG until 1996 show discrepancies in regard to the historical distribution of the species. There are also divergences between the extant and possibly extant distribution range of the species defined in the IUCN Red List of 2016 and more recently collected presence records (Fig. 2 and following Chapters). Thus, there is a need to clarify the current and his-toric distribution of the Pallas's cat in order to understand changes in the range and to help identify conservation priority areas. Given the large distribution of the Pallas's cat, we can assume that the population dynamics of the species may differ between regions. Also some threats are certainly effective throughout the species' range, it is unlikely that local populations all face the same challenges (Chapter 8). Consequently, understanding the ecology and population dynamics of and threats to the Pallas's cat will require field studies in different parts of its distribution range and consistent surveys in reference areas representing all major habitat types of the

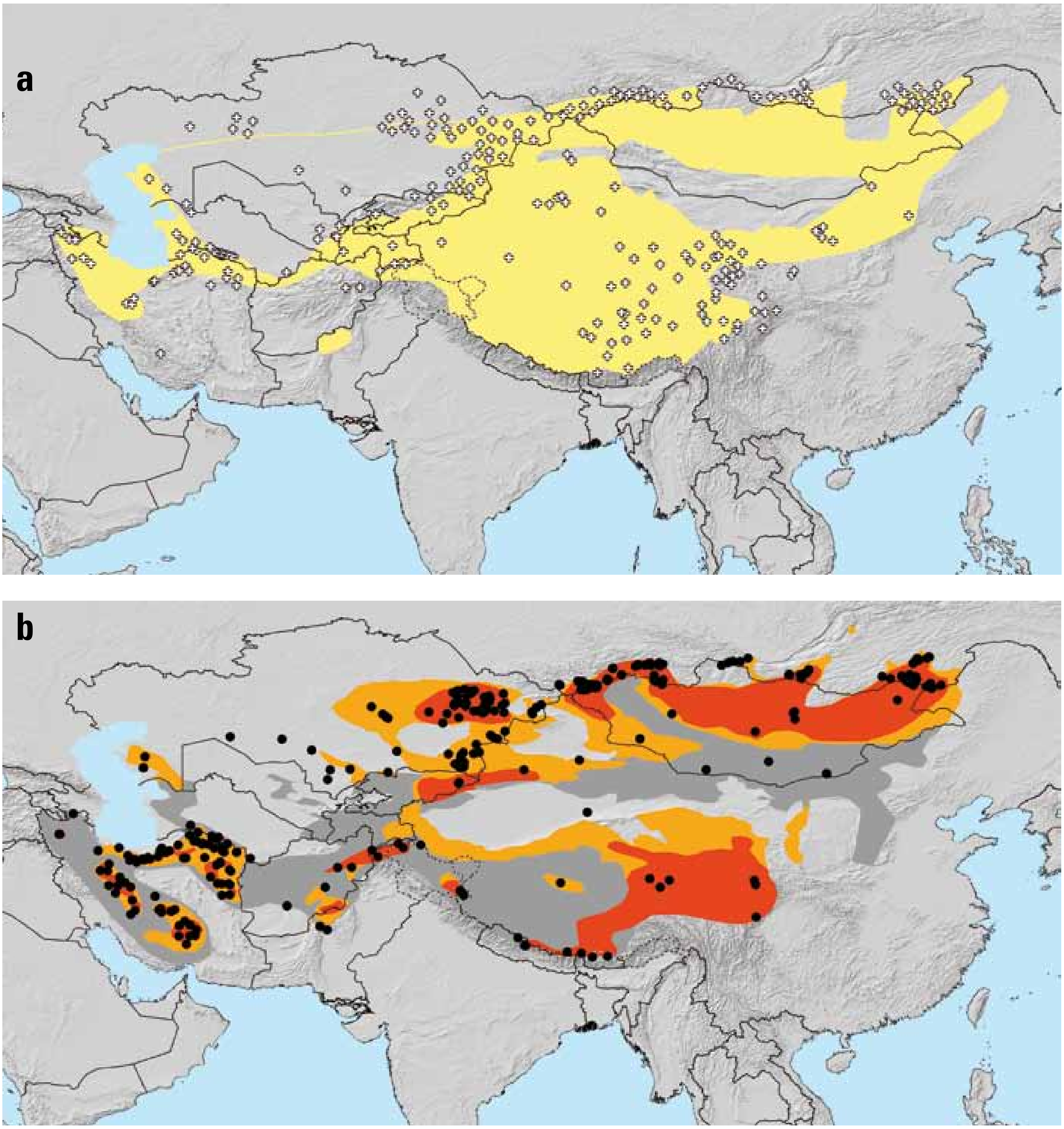

Fig. 2. Historic (a) and recent (b) Pallas's cat distribution. The differences between the assumed range and the point distribution references taken from the literature indicate the need for further surveys. Map a: Yellow = historic Pallas's cat distribution according to Nowell & Jackson (1996). White crosses = Pallas's cat records before 1996 compiled for the Global Mammal Assessment (IUCN SSC Cat Specialist Group). Map b: IUCN Red List distribution range: Red = extant, orange = possibly extant, grey = presence uncertain, black points = Pallas's cat records from the GMA after 1996.

species (Chapter 8).

The Conservation Strategy (Chapter 10) provides guidance for additional surveys and improved monitoring, and for further research, but also for conservation measures to mitigate threats as they were identified. Long-term successful conservation of the Pallas's cat will depend on range-wide co-operation and exchange of information. The contributors to this Special Issue and participants at the strategic planning meeting (Appendix I) have joined up in the intention to do so. The Status Review and the Conservation Strategy will also be used to reach out to the national wildlife conservation authorities of the Pallas's cat range countries. The Pallas's cat is an indicator species for the cold mountainous steppe habitats, and monitoring its populations across the range would allow tracking the conservation not only of *Otocolobus manul*, but also of its characteristic living space in Asia.

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The behaviour and ecology of the manul

Though widely distributed across the cold arid steppe and semi-desert ecosystems of Central and Western Asia, the manul is uncommon and rarely seen. The habitat in which it lives is demanding and highly seasonal; the manul exhibits morphological, physiological and behavioural adaptations that meet the challenges of temperature extremes, variable food resources and the risk of predation from other carnivores. This chapter describes the ecology of the manul, drawing from field studies and what we have learned from the captive zoo population. We end the chapter by asking how can the manuls ecology aid our understanding of its conservation biology?

Head and Body length: ♀ 49 cm, ♂ 55 cm; Tail length: ♀ and ♂ 25 cm; Weight: ♀ average 4 kg seasonally up to 5.0 kg, ♂ average 4.1 kg seasonally up to 5.3 kg.

The manul is approximately the size of a domestic cat but with shorter legs and thick fur, which accentuates its stocky appearance. On average, they weigh 4 kg, but individuals can weigh up to 5.3 kg at the end of summer when prey are more common and easier to catch. There is little sexual dimorphism, with males only slightly larger than females (100–300 g; Ross 2009, Naidenko et al. 2014).

The manul has a distinctive appearance. The head is broad and flattened with the ears set on the sides rather than the top of the head, a trait thought to be an adaptation to aid concealment when hunting in open habitats. The forehead is marked with distinctive black spots, and horizontal black and white stripes run from the eyes to the cheeks on either side of the face. Uncommon among the cats, the manul's pupils are round; in felids this characteristic is associated with diurnal hunters and/or those found in open habitats (Malmström & Kröger 2006).

The manul's coat colour varies seasonally and geographically. The species can be found with a silvery grey, rufous grey and dark grey coat, and a single individual may adopt all of these coat colours over the space of one year (Ross 2009; Fig. 1). The manul has the densest fur cover of all cat species inhabiting temporary climatic zone (Heptner & Sludskii 1992). The coat is often marked by faint black striping. In winter the pelage is longer, denser and lighter in colour than the summer coat, with a pale, frosted appearance, providing warmth and improving camouflage while there is snow cover. The manul moults in the spring, which often produces an intermediate rufous coat before the thinner and darker summer coat comes in (Ross 2009). In Iran sightings of the manul with a rufous coat colour have occurred year-round, suggesting the red morph is specific to the region (Farhadinia et al. 2016). The manul's tail is distinctly banded, with narrow stripes ending in a dark tip. Coat colouration is supremely camouflaged on a rocky steppe background. When motionless the manul resembles a small stone, or blends onto the stone it is crouching upon. Its background matching characteristics allow it to vanish in rocky habitats (Ross 2009, Ross et al. 2012; Fig. 2). In addition, the manul's white belly and under parts improve camouflage by balancing the effects of sunlight on the top darker fur and self-shadowing on the white underside, making it particularly difficult for aerial predators to spot while it is on the move (Ruxton et al. 2004).

Origin

Although once included within the genus *Felis*, the manul is now classified as the sole species in the genus *Otocolobus*. Its classification is based on its unique morphology and its distant genetic relationship to both the *Felis* (wildcat) and *Prionailurus* (leopard cat) lineages. Evidence suggests that *Otocolobus manul* diverged from a common leopard cat ancestor during the late Miocene approximately 5.9 million years ago. The manul is grouped within the leopard cat lineage alongside the leopard cat *Prionailurus bengalensis*, fishing cat *P. viverrinus*, flat-headed cat *P. planiceps* and rusty-spotted cat *P. rubiginosus* (O'Brien et al. 2008). Three subspecies of the manul have been described, but only two of these are said to be feasible based on geographic distribution (Kitchener et al. 2017). Although not verified by molecular analysis and not formally recognised, the subspecies are known as *Otocolobus manul manul* and *O. m. nigripectus* (Kitchener et al. 2017).

Distribution and Habitat

The manul has a wide but patchy distribution across Eurasia's high altitude montane grasslands and steppe, from western Iran to eastern Mongolia. The largest populations can be found in Mongolia, southern Siberia and China, with the distribution becoming progressively discontinuous further west. It has been recorded in mountain steppe and semi desert foothills in Kazakhstan and eastern Kyrgyzstan. Populations in the southwest of its range (the Caspian Sea region, Afghanistan, Pakistan and northern India) are diminishing, isolated and sparse. Recent records from Bhutan, Nepal and Pakistan suggest its occurrence across the Himalaya and Karakorum mountains, but despite large snow leopard survey efforts they are rarely found in this region (Chapters 3–5).

The manul's range within the continental climatic zone is characterised by aridity and large variations in annual temperature. Temperature range can reach over 100°C, as recorded in Zabaikalskii krai, Russian Dauria

Fig. 1. A female manul in montane grassland/steppe habitat of Mongolia (Photo S. Ross).

(+48°C in summer to -53°C in winter; S. Naidenko, pers. comm.). The manul's habitat preferences influence the species' distribution within its range. Typical habitat consists of montane grassland and shrub steppe (Fig. 1), with a preference for areas with rocky outcrops, ravines or other disruptive cover (Ross 2009), and within an altitude range of 450 to 5,593 m (Werhahn et al. 2018). The manul is rarely found in very open habitats such as short grassland and lowland sandy desert basins, but when prey availability is very high in open habitats it uses these habitats on a temporary basis (V. Kirilyuk, pers. comm.). It is also not found in areas where prolonged snow cover exceeds 15–20 cm, for example the manul's north-eastern range is limited by maximum snow depths of 16–17 cm in Transbaikal (Kirilyuk & Puzanski 1999). Due to their selective use of habitats they remain patchily distributed across their range (Heptner & Sludski 1992, Ross 2009).

At the smaller scale, a major influence on the manuls habitat usage is the constant risk of predation by sympatric aerial and terrestrial carnivores (Ross 2009). Predators of the manul include large raptors, red foxes *Vulpes vulpes*, the grey wolf *Canis lupus* and domestic dogs, they are also hunted by humans (Barashkova & Smelansky 2011, Ross et al. 2012). The manul is not a fast runner and when threatened by other predators its best line of defence is hiding out of sight, relying on their excellent camouflage and taking cover in burrows (of marmots or sympatric carnivores) or in rock crevices (Fig. 2 & 3). In general, open areas without suitable cover are avoided and habitats with disruptive cover such as ravines, rocky areas, shrub-steppe and hill-slopes are highly selected (Ross 2009, Ross et al. 2010a). As a result, the manul uses only a small fraction of habitats available within the steppe ecosystem. Their habitat selection and specialisation is the most likely explanation for their extremely low densities.

Manuls have a dependency on refuges or dens. Dens are used on a daily basis to provide important cover from predators, for feeding, mating, giving birth, raising young, and for thermoregulation during the extremely cold winters (Fig. 4). Den availability is thought to be essential for manul survival, and a critical habitat requirement for their conservation (Ross 2009, Ross et al. 2010a). In Mongolia they mostly use marmot burrows in winter and rock crevices in the summer (Ross et al. 2010a), in Southern Siberia and Kazakhstan the den sites of sympatric carnivores are more commonly used (A. Barashkova, pers. comm.), and in Iran the manul has been observed using aged *Juniperus excelsa* tree cavities as breeding dens (Dibadj et al. 2018). Despite the range of habitats used by the manul, the presence of suitable cavities appears to be a standard niche requirement.

Feeding Ecology

The manul's diet is mainly composed of small lagomorphs and rodents. Pikas are the most important prey across its range, typically comprising over 50% of the diet and highly selected over other prey species (Heptner & Sludskii 1992, Ross et al. 2010b). As pika are 2–4 times larger than other common small mammal prey, the manul's preference for them optimises hunting efficiency and energy intake. They also consume gerbils, voles, hamsters and ground squirrels; less frequently consumed prey includes small birds, young marmots, hares, hedgehogs, reptiles and invertebrates (Kirilyuk 1999, Ross et al. 2010b). Manuls have also been recorded eating berries (Kirilyuk 1999), scavenging from carcases (Ross et al. 2010b), and predating on a newborn argali sheep *Ovis ammon* (Reading et al. 2005).

Hunting and their activity in general mostly takes place at dawn and dusk in order to maximise the temporal overlap with prey while minimising overlap with predators, such as diurnal raptors or other competitors. Though they may switch to a more diurnal rhythm when temperatures are at their lowest (S. Naidenko, pers. comm.). As a further measure to avoid predators, the manul mainly hunts along the edges of rocky habitats and in ravines which penetrate into open grasslands and have high densities of pika, gerbils and other small mammals. Long grass and thick shrub are also used for cover when hunting and moving through flat open grasslands in the summer (Ross 2009).

Manuls hunt by three distinct techniques: 'stalking' by creeping very slowly and stealthily around cover to locate and move close to pounce on prey; 'moving and flushing', used mainly in spring and summer by walking quickly through long grass and undergrowth to flush rodents, small birds, and grasshoppers which are then pounced upon; and 'waiting in ambush' where a manul waits outside an active small mammal burrow for the prey to emerge (Fig. 5), a technique used mostly in winter to ambush pika (Ross 2009). Following a successful kill, prey is routinely taken into dens and burrows to consume in safety in Mongolia (Ross 2009), but observations of eating prey at the capture site are also common in Russia (S. Naidenko & V. Kirilyuk, pers. comm.).

Movement, density and dispersal

Similar to most other cats, the manul is solitary. Males do not help raise kittens and, as a rule, they meet females only during the mating season (Ross 2009). Males' home ranges encompass 1 to 4 female territories in the typical polygynic system of solitary felids. Research in Mongolia has shown that males have highly overlapping ranges throughout the year indicating little territoriality. However, aggressive encounters between males do occur during the breeding season indicated by fighting injuries during this time (Ross et al. 2012) and suggesting that male territoriality is associated with the breeding season and maiting rights. In contrast to male home ranges, spatial overlap between females was

Fig. 2. A male manul showing its supreme ability to blend into a rocky background in rocky habitat in Mongolia (cat in the centre; Photo S. Ross).

rare in Mongolia, but appears to be related to their relatively small home ranges, low density and the spacing of their preferred mountainous/rocky outcrop habitat (Ross et al. 2012).

Several cues regulate the manul's spatial behaviour, they have been observed spraying and cheek-rubbing (Mellen 1993), which provide temporal information for conspecifics. The manul also effectively communicates through vocalisations, making a strange call sounding like a honking goose. The long-distance calls and scent marking are likely used by the manul for mate attraction and to maintain spacing (Peters & Peters 2010).

Home range size is large in comparison to other species of their size. In Mongolia, females use areas between 7.4–125.2 km^2, averaging 23.1 km^2, compared to male home ranges of 21–207 km^2, averaging 98.8 km^2 (Ross et al. 2012). Research has shown that the availability and distribution of preferred rocky habitats is one of the main stimuli affecting home range size in Mongolia (Ross et al. 2012). Home ranges appear markedly smaller in Russian Dauria with male and female home ranges averaging 27.4 km^2 and 10.0 km^2, respectively (KIrilyuk & Barashkova 2011).

Density: There are no rigorous density estimates for the manul, mainly due to their low densities and cryptic behaviour resulting in difficulty in observing and surveying the species. Ross (2009) estimated density using 3-years of radio-telemetry data, surveys and observational data in what is considered prime habitat in Mongolia. At 4–8 manuls/100 km^2, the cats occurred at extremely low density in comparison to other carnivores found in the area. Much higher density estimates have been found in Dauria, Russia, for example Naidenko et al. (2014) captured a total of 16 manuls in an area of 16 km^2, equating to a density of 100/100 km^2. Snow tracking in Russia has also indicated that the manul can occur at very high densities (Kirilyuk & Barashkova 2011, Barashkova et al. 2017). More research is needed to understand regional differences and temporal changes in manul density, but presumably prey density and availability, and predation pressure are the most influential factors. Nevertheless, based the majority of surveys and the scarcity of sightings across the species range, evidence suggests that low density/rarity is the more common state of manul populations.

A number of factors may contribute towards the manuls' low density, including habitat specialisation, competition and prey availability. The habitats selected by the manul only cover 10–30% of mountain steppe typically occupied by the species, restricting the amount of available habitat reduces potential density of the species. Predation by other carnivores and competition for scarce prey resources may further constrain population density. For example, in the Mongolian study area carnivore density was measured using Distance Sampling. Corsac fox *Vulpes corsac* density was approximately 40–60 foxes/100 km^2, red fox density was 15–25 foxes/100 km^2 and grey wolf density was 3–20/100 km^2. The area also contained a high density of large raptors. These predators constrain manul density, directly through predation, and indirectly by influencing the species habitat selection (Ross 2009). Prey density may also be influential, as higher small mammal prey density should provide better nutrition and improve kitten recruitment and survival. High prey density may also reduce predation pressure, as predators focus on the more available and easily captured small mammal prey (e.g. Korpimäki & Krebs 1996). These theories need to be tested in a high density manul population, such as those found in Dauria.

Dispersal: As is normal with all solitary animals, manuls disperse from their natal home range after maturing. Data from Mongolia indicate that this happens when the kittens are approximately 4–5 months of age. Following emigration from their natal range, sub-adults make exploratory movements before settling and establishing their own home range area about 5 to 12 km from their natal home (Ross 2009).

Unusually large dispersal movements are also commonly seen in adult manuls of both sexes (Ross 2009). The sudden abandonment of the home range and subsequent relocation to a new area mostly occurs between August and October. Individuals have been recorded migrating a straight-line distance of 18 to 52 km, and journeys often entail crossing habitats that are not normally used. For example, one adult male was observed making an exploratory, looping excursion of 170 km over 2 months, requiring swimming across a large river twice, before settling in a new area. The high incidence of home range abandonment (50% of adults, of 29 study cats) suggests that it is an integral part of their ecology (Ross 2009). Observations of large movements have also been observed in Daurskii Reserve, Russia (S. Naidenko, pers. comm.). The motives for such moves are unclear, but most likely include a process of disturbance or prey depletion, where their home area becomes unviable, followed by emigration and subsequent colonisation of a new 'better' area. Potential home-range disturbances may include competition with other carnivores resulting in displacement, or localised prey depletion (Ross 2009).

Reproduction and demography

The manul lives in areas of the world subject to temperature extremes, thus it is unsurprising that reproduction in the wild is highly seasonal. In Mongolia, mating occurs between December and March; this is the only time of the year that females exhibit ovarian activity (Brown et al. 2002). Male sperm production also peaks during this time and dramatically drops off at other times of the year (Swanson et al. 1996). Experiments

Fig. 3. Pallas's cat showing its typical behaviour when threatened. It remains perfectly still relying on its camouflage for protection (Photo S. Ross).

in captivity using different treatments of daylight have found that the reproductive cycles of manuls are entirely controlled by day length (Brown et al. 2002).

During the mating period males pursue females to such an extent that it appears to take precedence over hunting and feeding. Extreme records have included males losing a total of 1,050 g (22%) over the course of only 14 days during the mating period, and a second male losing 800 g (19%) over 24 days (Ross 2009). Weight loss over the course of winter is also common in females, but most likely due to the scarcity of prey (Ross 2009, Naidenko et al. 2014). When females enter oestrus, males 'shadow' females for 2–3 days, protecting her from advances by other males. Mating appears to occur within marmot burrows or other crevices, presumably to protect the couple from predators (Ross 2009).

Gestation is 66–75 days and litter size averages 3–4 kittens in captivity (Swanson 1999), but females may give birth up to 8 kittens. Kitten mortality in the wild is high with approximately 68% of kittens dying before dispersal. Surviving kittens reach independence and disperse at 4–5 months. A radiotracking study in Mongolia showed that sub-adult females may mate and reproduce at 10 months of age (Ross 2009). Their reproductive lifespan in captivity is approximately 9 years, but there is a decrease in fecundity after 6 years and very few females give birth after 8 years of age (Barclay 2013).

The lifespan of the manul in the wild may be up to 6 years, though they can survive up to 12 years in captivity. Predation is the main cause of mortality in the wild. Most predation occurs in winter, from January to April, when vegetation cover and prey density is low, increasing their exposure to predators (Ross 2009). In Mongolia large raptors accounted for 38% of known deaths, while predation by domestic dogs and hunting by people accounted for an additional 53% of known mortalities, wolves are also a known predator, and smaller carnivores such as badger *Meles meles* and red fox occasionally kill manuls most likely on a competitive basis (Ross 2009, V. Kirilyuk, pers. comm). Mortality due to predation by domestic dogs has also been recorded in Iran, Russia and China, and appears to be a major threat to the wild population (Ross 2009, Barashkova & Smelansky 2011, Farhadinia et al. 2016). In Mongolia survival data showed that on reaching maturity at 1 year of age, adults have approximately 50% chance of surviving until 3 years (Ross 2009).

Fig. 4. A rock crevice den-site with manul kittens (top) and a marmot burrow den (bottom). Dens are used on a daily basis by the manul and are essential for raising young (Photo S. Ross).

Disease

Captive manuls, particularly kittens, have a unique and marked susceptibility to infectious agents, especially *Toxoplasma gondii*. The manul is suspected to be naïve and susceptible to the agent due to lower occurrence of toxoplasma in the wild. Though 2 cases of *T. gondii* antibodies were found in manul populations in the Chita region of Russia and central Mongolia (Brown et al. 2005, Naidenko et al. 2014). Naidenko et al. (2014) also recorded antibodies to Mycoplasma, Influenza A virus and Feline leukaemia virus in a sample of 16 cats. The manul is also exposed to feline immunodeficiency virus FIV in the wild. This virus does not cause death but is related to immune depletion. Interestingly the manul harbours a unique strain of the virus most closely related to the African cheetah and leopard FIV strains (Brown et al. 2010).

The conservation biology of the manul

The manul has a very wide range across central and western Asia, and because of this the population is very unlikely to go extinct in the short term. However, of more concern is localised and regional extinction, as the manul's ecology naturally disposes them to threats (Chapter 8).

The manul is a naturally rare species, they are dependent on specific habitats and prey, and are easily killed on open ground. As the manul is a habitat specialist this is likely to result in increased vulnerability to the effects of habitat fragmentation and degradation. Its large home-ranges increase the probability that their ranges will overlap with human activities, disturbances and associated mortality, and be more difficult to cover by protected areas. For the manul, the availability of burrows, rock crevices and other cavities is necessary, as these are critical resources, used on a daily basis and essential for breeding.

This dependency on burrows means that the decline of burrowing species such as marmot and small carnivores poses a threat to the manul (Ross et al. 2016). Overall, land use changes across the manul's range are increasing due to habitat destruction and fragmentation, declines in their prey base, and a rise in mortality associated with increased contact with herders and their dogs (Chapter 8).

Fig. 5. Manul paw prints outside a pika burrow – signs showing the sit-and-wait ambush technique often used by the manul to capture pika (Photo S. Ross).

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Distribution and status of the manul in Central Asia and adjacent areas

A significant portion of the manul's *Otocolobus manul* global range is situated in the Central Asian countries Mongolia, Kazakhstan, Kyrgyzstan, Uzbekistan, and Tajikistan, and several adjacent provinces of Russia. We estimated the manul current Extent of Occurrence EOO in the region at 1,225,313 km², which is about 84% of the predicted area of suitability calculated from the MaxEnt distribution model. Based on a conservative assessment of manul population density (4–8 cats/100 km²), we roughly estimated the regional population size at 49,000–98,000 manuls. Mongolia holds almost 60% of the estimated potential area of suitability in the region and over 50% of the estimated regional population. Kazakhstan and Russia both have relatively abundant manul populations while in Uzbekistan and Tajikistan the manul presence remains questionable. Killing by herding dogs, wildfires, and rodents poisoning are at present the main threats to the manul in this region. Manul is listed in the Red Data Books of Russia, Kazakhstan and Kyrgyzstan. Hunting ban or regulation, respectively, and protected areas are currently the main conservation instruments for the species. Protected areas cover approximately 15% of the manul habitats in Mongolia, 12% in Russia, 7% in Kazakhstan, and 6% in Kyrgyzstan. We recognise a lack of knowledge regarding manul ecology and biology in the region, its geographical distribution, and a lack of correct assessment of its population size. These gaps should be filled to raise conservation efficiency. Conservation efforts should include securing manul and its habitats in key areas, minimising dog attacks and poaching, and establishing a broad, long-term monitoring.

A significant portion of the manul's presumed global range is in the five Central Asian countries: Mongolia, Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan, and in adjacent Russian provinces (Ross et al. 2016). The entire region shared a common political system until 1990, with similar patterns of land use and wildlife management. Steppe ecosystems throughout the entire region, including manul habitats, faced a common set of threats as a result of extensive agricultural development, state-induced relocation of people, and large-scale mining, coal extraction, and hydropower projects. After the breakup of the USSR in early 1990s manul populations were affected by economic transition (Fernandez-Gimenez 2006, Smelansky & Tishkov 2012, Kamp et al. 2016) which had a significant impact on some large carnivores (Bragina et al. 2015), resulting in general rise of poaching and wildfires, large-scale changes in human use of the species habitats, leading to extensive grassland rehabilitation in Russia and Kazakhstan, but degradation in Mongolia.

During the 20th century, several detailed regional reviews of the species' distribution and ecology were published: Ognev (1935), Fetisov (1937), Heptner & Sludskii (1972), Sludskii (1982). Current information on manul distribution and biology can be found in national and provincial Red Data Books in each range country (e.g. Dronova 2001, Clark et al. 2006, Toropova 2006, Kirilyuk 2012, Sokolov 2012, Borisova & Medvedev 2013, Barashkova 2017, Kuksin 2018) and in publications and reports from recent studies (see Supporting Online Material SOM). Moreover, the only comprehensive ecological studies of manul have been conducted in this region (Kirilyuk 1999, Kirilyuk & Puzansky 2000, Ross et al. 2010a, b, 2012).

However, the information remains insufficient and is partly outdated. There is a need for re-evaluating the status of the manul in the region. In this chapter we summarise actual data on the geographical distribution, abundance, habitats, prey, threats, and protection. We reveal the main gaps and ambiguities for further investigation and conservation.

Table 1. Number of historical (< year 2000) and contemporary (≥ 2000), C1 ("confirmed"), C2 ("probable") and C3 ("possible") manul records compiled in this study.

Country	Historical*			Contemporary			Total
	C1	C2	C3	C1	C2	C3	
Kazakhstan	0	5	48	44	16	74	187
Kyrgyzstan	0	1	2	43	9	11	66
Mongolia	0	2	1	128	0	1	132
Russia	2	13	62	145	204	306	732
Tajikistan	0	0	4	0	0	0	4
Uzbekistan	0	0	12	0	0	2	14
Total	**2**	**21**	**129**	**360**	**229**	**394**	**1,135**

**Due to time constraints, the analysis of historical data was carried out carefully only for Kyrgyzstan, Tajikistan, and Uzbekistan from which contemporary records are rare or absent. For the rest of the countries only the data available in the authors' databases are shown.*

Methods

We used multiple data sources to consolidate information on the manul in the region. Every co-author completed a standardised questionnaire developed by the IUCN SSC Cat Specialist Group, and provided data on the manul from their countries. We supplemented this information with occurrence data from the Small Wild Cats of Eurasia Database (http://wildcats.wildlifemonitoring.ru), created in 2004 and maintained by Sibecocenter and the Pallas's Cat Working Group PCWG. The database contains over 500 contemporary (2004–2018) distribution records of the manul (Barashkova 2016, Barashkova et al. 2018). In addition, we obtained by-catch records of manul from routine camera trapping surveys of snow leopards *Panthera uncia* (see Acknowledgements). To characterise manul habitats, feeding habits, threats, and national conservation statuses we reviewed about 70 contemporary and old publications in Russian and English. We analysed 15 unpublished reports of research and conservation projects completed be-tween 2006 and 2018 in Russia, Kazakhstan, Uzbekistan and Kyrgyzstan.

Manul records were categorised as C1 ("hard fact" or "confirmed"), C2 ("probable"), or C3 ("possible") according to Molinari-Jobin et al. (2012). We further allocated all records to two time periods: "historical" (< year 2000) and "contemporary" (≥ 2000). We estimated the manul's Predicted Area of Suitability PAS and the Extent of Occurrence. First, we built a species distribution model using the MaxEnt software package (MaxEnt 3.3.3k; Phillips et al. 2006, Phillips & Dudik 2008) to outline suitable habitats for the manul across the study region, i.e. areas where landscape and climatic characteristics are favourable for the manul (see SOM for details). The PAS was then calculated using a binary output of the MaxEnt model. Based on expert opinion, areas on the northern edge where the average long-term maximal snow depth exceeds 20 cm and areas where main prey species are supposed to be absent were excluded (Kirilyuk & Puzansky 2000, Kirilyuk & Barashkova 2016a). The EOO was calculated as minimum convex polygons of precisely located contemporary C1 and C2 records with precise geographical coordinates (n = 570) in each country and for the whole region with following modifications: We excluded unsuitable areas from the conventional estimates of EOO according to our prediction of suitable habitats (see SOM). All the cartographic data processing was performed with ArcInfo GIS 9.3 and QGIS 2.12.

We applied EOO figures to estimate population size speculating on the following. Manul density in Mongolia was estimated at 4–8 cats/100 km^2 and was considered to be quite low (Chapter 2). Higher figures were obtained in Dauria and other regions of Russia – up to 100 cats/100 km^2. We assume that the average manul density in Kazakhstan and Kyrgyzstan is significantly lower than in Russia (our data). Thus, we have used the low-density estimation (4–8 cats/100 km^2) and national (or sub-national) EOOs for the conservative estimate of the regional population size.

Table 2. Predicted Area of Suitability PAS and Extent of Occurrence EOO per country based on contemporary (≥ 2000) C1 and C2 manul records compiled in this study.

Country	PAS, km^2 (% of the regional PAS)	PAS % of the national territory	EOO, km^2
Mongolia	853,147 (58.6)	54.5	661,910
Russia	175,284 (12.0)	1.0	118,107
Altai-Sayan	64,751	–	52,079
Eastern Sayan	8,486	–	262
Western Trans-Baikal	25,434	–	6,821
Eastern Trans-Baikal (Dauria)	76,613	–	58,945
Kazakhstan	337,304 (23.2)	12.4	264,801
Kyrgyzstan	77,216 (5.3)	38.6	31,575
Tajikistan	9,845 (0.7)	6.9	NA
Uzbekistan	1,907 (0.1)	0.4	NA
Total	**1,454,703**	**6.6**	**1,225,313**

Distribution

We gathered a total of 1,135 observations with the highest number of records collected in Russia (n = 732, 64.5%; Table 1).

Mongolia holds more than half of the regional PAS and estimated regional EOO, followed by Kazakhstan and Russia (Table 2).

The PAS is 6.6% of the total area of the re-gion but the countries are dramatically different in regard to their suitability for the manul (Table 2). PAS occupies just over half of the national territory in Mongolia and more than one third in Kyrgyzstan while only 6.9% in Tajikistan, 1% in Russia and less than 1% in Uzbekistan. The PAS in Russia and Kazakhstan are divided into several fairly large fragments (Fig. 1; SOM).

Kazakhstan

Heptner & Sludskii (1972) and Sludskii (1973, 1982) reviewed the distribution of manul in Kazakhstan in 1940–50s .These reviews were mainly based on fur trade data. Historically, the species was considered to be widely distributed from the Caspian Sea in the west to the Lake Markakol in the east and north from the Kazakh highlands towards the southern borders with Turkmenistan, Uzbekistan and Kyrgyzstan. It is supposed that the species' range declined in the late 20th century in

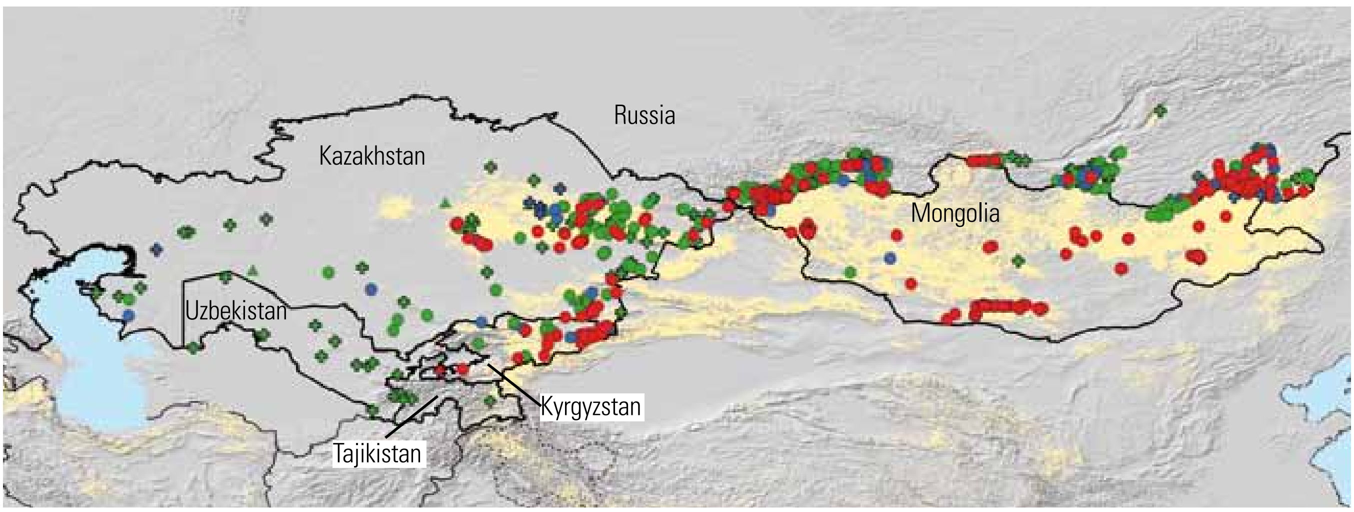

Fig. 1. Geographic distribution of the Pallas's cat in the study region, mapped according to historical (< year 2000; crosses) and contemporary (≥ 2000; circles) occurrence records collated in this study. Triangles = records where the timespan is unknown. Red = confirmed (C1); Blue = probable (C2); Green = possible (C3). Yellow polygons represent the Predicted Area of Suitability (see also SOM).

Kazakhstan (Belousova 1993, Nowell & Jackson 1996; see details of historical distribution in SOM and Fig. 1).

Between 2009 and 2018, studies confirmed the presence of manul in central and eastern Kazakhstan: in the South Altai, East Kazakhstan highlands (including Shynghystau), Tarbagatai Range, northern Balkhash, and central Kazakhstan highlands along the periphery of Betpakdala Desert (Chelyshev 2015, Barashkova & Smelansky 2017, Barashkova et al. 2018). Manuls were occasionally recorded in high mountain areas of Terskei Alatau, Ile Alatau and Jongar Alatau, and at low elevation in the eastern spur of Ile Alatau ridge (Barashkova et al. 2018). No contemporary data is available for the Ulytau, Karatau, and Chu-Ili Mountains. The status of the manul in western Kazakhstan remains unclear as contemporary evidence of the species is missing. Recent camera trap surveys on the Ustyurt Plateau failed to detect the species (Smelansky et al. 2017, Pestov et al. 2017, Pestov et al. in prep.).

The PAS includes the central Kazakh highlands (west to Ulytau low mountains), northern Balkhash, ranges of Kalba, Southern Altai, Tarbagatai, and Saur and its foothills, mountainous areas of the south-eastern and south Kazakhstan, in particular foothills and middle elevations of the Jongar Alatau, Kyrgyz Alatau, and Ile Alatau Ranges, the Chu-Ili and Karatau Mountains. Our model does not predict suitable habitat for manul in western Kazakhstan (Fig. 1; SOM).

Kyrgyzstan

Historically it was believed that the manul inhabits a large part of Kyrgyzstan, predominantly occupying the steppe vegetation belt, but also areas at higher altitude (Heptner & Sludskii 1972). The species was considered to occur in high-altitudinal belts of the Kemin Valley, Issyk Kul Depression, and the Central and Inner Tien Shan Mountains. There was speculation that the species could also occur on the Alai and Turkestan Mountain ridges, as well as the upper reaches of Kara-Kulja and Tar Rivers, but sources for the latter areas are not reliable (Sludskii 1973, Toropova 2006, Vorobeev & van der Ven 2003).

The majority of the contemporary manul data in Kyrgyzstan are camera trap records obtained during extensive studies on the snow leopard particularly in Sarychat Ertash State Reserve and its surroundings (Table 1; Fig. 1). These records are associated with high altitudes, while lower elevations remain unexplored. The other records are from illegally hunted or trapped animals (K. Zhumabai uulu, pers. comm.). Most of the collected data is from the eastern, central and northern parts of Kyrgyzstan. A recent study has shown that manuls also live in the south-western part of the country, although records are few (Barashkova & Gritsina 2018). Interview data suggest presence of manul in the area along the border between Talas and Jalalabad Provinces in the west of the country and in Atbashi District in the south (Gritsina et al. unpubl.). A camera trap picture of a manul in the foothills of the Alai Range in 2018 confirmed its presence in Osh Province (this location is only 10 km from the border with Uzbekistan; Fig. 1).

The predicted PAS includes most ranges of the Tien Shan (without high altitude zones) located in the central and eastern parts of the country, only the mid-mountain parts of the Talas and Ugam Ranges in the west and partially ridges bordering the Fergana Basin from the east and south-east (including Alai and Fergana Ranges; Fig.1).

Fig. 2. Manul stalking a Brandt's vole in the true grassy steppe in Har Am place, Khalzan soum, Sukhbaatar Province, the east of Mongolia, 20 July 2017 (Photo B. Otgonbayar).

Mongolia

Historically the manul was considered to occur throughout the country, except in coniferous forests of the Khentei Range and Khovsgol Lake region, alpine zones of Khangai and Mongolian Altai, and extra-arid desert areas in the south (Bannikov 1954, Clark et al. 2006). After 2000, studies on the manul in Mongolia focused on small-scale intensive ecological research in two or three sites (Munkhtsog et al. 2004, Murdoch et al. 2006, Reading et al. 2010, Ross et al. 2010a, b, 2012). The nationwide distribution of the manul has not been studied. Our prediction of suitable areas includes vast territories from eastern Mongolia to the ranges and foothills of the Mongolian and Gobi Altai in the west (excluding forest areas and plains of the Eastern Gobi Desert; Figs. 1–3).

Russia

Manul's distribution in Russia is probably the best studied and described in detail among the range countries (Heptner & Sludskii 1972, Kirilyuk & Puzansky 2000, Barashkova 2005, 2012, Barashkova et al. 2008, 2010, Barashkova & Kirilyuk 2011, Barashkova & Smelansky 2011, 2016, Istomov et al. 2016, Kirilyuk & Barashkova 2011, 2016a, b, Kuksin et al. 2016, Naidenko et al. 2007). Recently, Barashkova et al. (2017) reviewed status, distribution and habitat use of the manul and its presence in Russian protected areas.

Contemporary records confirm the species' historic distribution as described by Heptner & Sludskii (1972). Manul's range in Russia consists of several separate areas in the mountain belt of South Siberia adjacent to the continuous range mainly located in Mongolia: (1) the Altai-Sayan area including southeastern part of Russian Altai and Western Sayan Mountains, (2) Eastern Sayan Mountains (Tunka Mountains, or Tunkinskie Goltsy), and (3) Western and Eastern Trans-Baikal (Fig. 1).

Our PAS model predicted some places that have not yet been sufficiently studied, in particular the Argut River Valley, Ukok Plateau, and Shapshalsky Ridge in Altai, central Tyva (Eastern Tannu-Ola, Eastern Sayan), western Buryatia (Vitim Plateau), and south-eastern Dauria (Fig. 1). Recent records of the manul in the Shapshalsky Range and Eastern Sayan supports our prediction (Barashkova et al. 2018).

Uzbekistan

Historically the manul was reported to occur in the outcrop massifs of the Central Kyzylkum Desert and in the south-east along the borders with Turkmenistan, Afghanistan, Tajikistan, and Kazakhstan (Heptner 1956, Ishunin 1961, Sapozhenkov 1961, Heptner & Sludskii 1972, Lesnyak et al. 1984; SOM). Since the start of the manul survey in 2013, its presence in the country has not been confirmed. The species has not been recorded by 72 camera traps (> 7,000 trap days) deployed in Western Ghissar Alai, Western Tien Shan, Kyzylkum Desert, and Ustyurt Plateau (Gritsina et al. 2015, 2016, 2017). Camera trap surveys of snow leopards in the Western Ghissar Alai and Western Tien Shan implemented since 2013 did also not reveal manul presence (Esipov et al. 2016, Bykova et al. 2018). Regular inspections of markets with the purpose of finding manuls' skins have not yielded any results since 2006. The most recent, but unconfirmed (i.e. C3), data on manul were sighting claims of the cat by local people in Akbulak River watershed in the Chatkal Range near the border with Kyrgyzstan in 2005 and in the Ghissar Range in 2014 (Gritsina et al. 2017). Indeed, a recent camera trap record of manul in Kyrgyzstan, less than 10 km from the border with Uzbekistan (Barashkova & Gritsina 2018), gives hope that the species has not disappeared from the country. PAS for the manul in Uzbekistan includes the above mentioned outcrop massifs in Central Kyzylkum, Zeravshan and Turkestan Ranges, and the south-western spurs of the Ghissar Range, particularly Baisuntau Mountains (Fig. 1).

Tajikistan

In 1949, manul was caught in the mountains of Rangon, just south of Dushanbe (Heptner & Sludskii 1972). In the east, only one record of the cat was reported in the Central Pamir near the eastern shore of Sarez Lake and the mouth of the Murghab River (R. L. Potapov cited in Sludskii 1973; Fig. 1). Sokov (1973) declared the manul to be extinct or near extinct in Tajikistan.

Tajikistan is the only country in the region where no focused research on the manul has occurred to date. Contemporary data on the species do not exist. The manul has not been recorded by camera traps deployed since 2000 to monitor snow leopard and other wildlife (S. Michel, T. Rosen, R. Muratov, pers. comm.). PAS includes only the valleys and plateaus of Eastern Pamir in the eastern part of the country (including Sarez Lake and Murghab River; Fig. 1).

Fig. 3. Female manul with two kittens, as a part of the larger litter, near their den under rocks in Hustai National Park, Central Province of Mongolia, 30 June 2018 (Photo E. Mashkova).

Population number

No evidence-based assessment of manul population size has been made for the study region. A few attempts to estimate population numbers for several Russian provinces were based on snow tracking data in combination with expert opinions (see SOM). We estimated the potential population size in the region as approximately 49,000–98,000 manuls (Table 3). This estimation is highly speculative and the value is rough, but reveals the magnitude of the possible population until better estimations are available.

Habitat

The manul's range in Central Asia and adjacent territories covers a vast area with high climatic and landscape diversity. The manul's regional EOO covers mainly mountains and highlands (Fig. 1). All known contemporary C1 and C2 records (n = 589) are located between 440 and 3,730 m. The species occupies different habitats in different parts of its range. All habitat types have three common features: (1) continental cold, semi-arid climate with cold but low snow precipitation in winter and a hot dry summer; (2) presence of appropriate rocky shelter, both natural or constructed by other mammals or human-made; and (3) presence of colony-forming non-hibernating rodents or pikas.

Based on our observations and published data (Heptner & Sludskii 1972, Sludskii 1982, Kirilyuk & Puzansky 2000, Medvedev 2010, Munkhtsog et al. 2004, Ross et al. 2010a, b, 2012, Istomov et al. 2016) we identified two main habitat types: (1) Low erosion hills with rock outcrops and scree on slopes and crests, frequently granite, covered with petrophytic dry steppe or semi-desert vegetation. This habitat type is found throughout the range in Russia and Central Asia, on hilly plains, foothills, elevated plateaus and intermountain valleys in many mountain systems (Heptner & Sludskii 1972, Sludskii 1982, Kirilyuk & Barashkova 2011, 2016 b); (2) Ravines, rocks, and scree, covered with petrophytic dry steppe or semi-desert vegetation along slopes and pediments of mountainous ridges at higher altitudes of Inner Asia, Southern Siberia, and the Tien Shan Range (Kirilyuk & Puzansky 2000, Toropova 2006, Barashkova & Smelansky 2011, Kirilyuk & Barashkova 2011, Istomov et al. 2016). Accordingly to our observations (240 C1 and C2 locations) the vegetation cover in both types is typically semi-arid petrophytic grassland – dry steppe, desert steppe, or semi-desert (northern desert) dominated with low xerophytic and petrophytic grasses and low shrubs, particularly species of the genera *Stipa*, *Artemisia*, *Salsola*, *Nanophython*, and *Ephedra*. Steppe shrubs (e.g. *Caragana*, *Spiraea*, *Cotoneaster*, *Lonicera*) are also common in these habitats, forming distinctive shrub patches or scattered through the grasslands.

Five other habitat types can be recognised in the region (see SOM). They are marginal and situated only in the eastern part of the regional range, east of the Altai.

Table 3. Manul population size estimation based on the EOO and an assumed lower (4 cats/100 km²) and higher (8 cats/100 km²) density, respectively*.

Country	Lower bound (4/100 km²)	Upper bound (8/100 km²)
Mongolia	26,476	52,953
Russia	4,724	9,449*
Altai-Sayan	2,083	4,166
Eastern Sayan	10	21
Western Trans-Baikal	273	546
Eastern Trans-Baikal (Dauria)	2,358	4,716
Kazakhstan	10,592	21,184
Kyrgyzstan	1,263	2,526
Tajikistan	NA	NA
Uzbekistan	NA	NA
Total	**49,013**	**98,025**

**This estimate does not take into account the significant changes in the number of manul (up to 5-10 times) for several years, shown for example, for Russian Dauria (V. Kirilyuk, pers. comm.; see also SOM).*

Prey

The principal prey base of the manul in the region consists of small and medium-sized, non-hibernating colony-forming rodents and pikas (Heptner & Sludskii 1972, Sludskii 1982, Kirilyuk & Puzansky 2000, Jutzeler et al. 2010, Barashkova et al. 2017). In central Kazakhstan, Sludskii (1982) considered Kazakh pika *O. opaca* (referring as Mongolian pika *O. pallasii*) as the main prey and steppe pika *O. pusilla*, flat-headed mountain vole *Alticola strelzowi*, common vole *Microtus arvalis*, and birds such as common partridge *Perdix perdix* and larks (especially *Melanocorypha* spp.) as secondary prey for manul (Fig. 4; SOM). In the Tian-Shan highlands, Sludskii (1982) presumed the main prey to be Turkestan red pika *O. rutila*, large-eared pika *O. macrotis*, silvery mountain vole *A. argentata*, and narrow-headed vole *M. gregalis*. Daurian pika, Mongolian pika, and mountain voles (mainly flat-headed mountain vole) are considered key prey for manul in Russian Altai (Barashkova 2017). Other prey species here include long-tailed suslik *Spermophilus undulatus*, young marmots of various species, and tolai hare *Lepus tolai* (Sludskii 1982). Large-eared mountain vole *Alticola macrotis* and silvery mountain vole are referred as the most important prey on the northern edge of the manul's range, in the East Sayan Mountains, where the cats also consume alpine pika *O. alpina*, young snow hare *L. timidus*, rock ptarmigan *Lagopus mutus*, and other birds (Medvedev 2010). In years when the Daurian partridge population peaks, it is an important prey for manul in Dauria (V. Kirilyuk, pers. comm.). Daurian partridge is also considered key prey for manul in areas on the northern edge of the range, in the Western Sayan (Istomov et al. 2016).

Fig. 4. Kazakh pika (Photo A. Lissovsky).

Using 249 identified prey remains in 146 scats collected from radio-collared manuls in Hustai National Park in Central Mongolia, Ross et al. (2010) revealed that 85.5% of prey items were small mammals. Daurian pika *Ochotona dauurica*, Mongolian gerbil *Meriones unguiculatus*, and Mongolian silver vole *Alticola semicanus* were the most frequently consumed ones (frequency of occurrence was 60.9%, 35.6%, and 28.1% respectively). Prey selection analysis indicated a preference for Daurian pika irrespective of its density.

Another quantitative investigation in Russian and Mongolian Dauria analysed 490 manul scats and prey remains collected from radio-collared and snow-tracked manuls as well as close to dens (Kirilyuk 1999). Mammal remains occurred in 66.5% of the sample and Daurian pika was the most frequently consumed prey species (55.5%). No other mammal species exceeded 1.2%. Mongolian hamster *Allocricetulus curtatus*, Brandt's vole *Lasiopodomys brandti*, voles *Microtus* spp., and tarbagan marmot *Marmota sibirica* oc-curred each in 1.0–3.7% of manul scats. Other mammals (including Mongolian five-toed jerboa *Alactaga sibirica*, Siberian dwarf hamster *Phodopus sungorus*, and weasel *Mustella nivalis*) were recorded only once. Pacific swift *Apus pacificus* was present in 8.2% of the scats. Insects were consumed even more frequently than birds (22% in total), mainly large beetles Scarabaeidae and orthopterans. Daurian pika was especially important prey in winter (occurrence reached 95%). The prevalence of insects and birds in the summer diet and a large proportion of berries in the winter diet were possibly the consequences of unfavourable conditions regarding primary food sources such as Daurian pika and other small mammals (Kirilyuk 1999).

Threats

During the Soviet time in the mid-20th century, main threats to the manul in the region were habitat loss and habitat degradation (including overgrazing, soil erosion, habitat fragmentation, etc.) due to large-scale conversion of steppe grasslands into arable farmland. Over 452,000 km² of dry steppe grasslands were converted into permanent arable land during the Soviet "Virgin Land Campaign" from 1954–1963, mainly in Kazakhstan and Russia (Bragina et al. 2018, Reinecke et al. 2018). Similar campaigns in Mongolia affected over 10,000 km² in 1959–1980 (Davaajav 2017). After the USSR collapsed in 1991, these threats dropped sharply in Russia and Kazakhstan as vast areas were abandoned (Smelansky & Tishkov 2012, Wesche et al. 2016, Kamp et al. 2016, Bragina et al. 2018, Reinecke et al. 2018). However, overgrazing and its secondary effects such as decreased habitat protection and increased disturbance by humans and herding dogs, is a persistent issue and has even worsened in Mongolia (Pfeiffer et al. 2018) and to a lesser extent in Uzbekistan (Yang et al. 2016). Over the last 15 years, arable land and livestock numbers partly recovered in the rest of the region (Priess et al. 2011, Kraemer et al. 2015, Meyfroidt et al. 2016, Wesche et al. 2016, Bragina et al. 2018, Reinecke et al. 2018).

Killing by herding dogs is one of the most important causes of human-related death of manuls (Ross 2009, Sokolov 2012, Barashkova 2012, 2017). In Russia about 25% of respondents interviewed in Altai Republic in 2006 and 2009 (n = 52) and 20% of respondents interviewed in Tyva Republic (n = 145) reported manul being killed by their herding dogs (Barashkova & Smelansky 2011, Barashkova 2012). In Dauria in 1990s killing by dogs caused manul's death in 8 of 33 known cases (Kirilyuk & Puzansky 2000). Nonetheless, manuls are capable to reoccupy human-disturbed habitats as soon as pastoralists abandon the rangeland, if there is a strong prey base and limited snow precipitation (V. Kirilyuk, pers. obs.).

Approximately a century ago, manuls were extensively hunted for their skins, specifically in Mongolia (Shnitnikov 1934, Bannikov 1953, 1954, Wingard & Zahler 2006; Table 4).

To the 1950s the manul's pelt export from Mongolia seems to have practically ceased despite ongoing hunting and continuing domestic trade (Wingard & Zahler 2006).

Mongolia' hunting records in 1958–1960 revealed that 5,500 individuals were killed annually (Clark et al. 2006). According to records from the National Archive Center in Ulaanbaatar, 5,537 manuls were hunted (and traded) in Mongolia in 1962, while the target figure was 7,500 (N. Battogtokh, unpubl. data). In the period 1965–1985, over 5,400 manul skins were traded in the country annually (Wingard & Zahler 2006). No contemporary data on trades of manul skins in Mongolia is available but legal hunting in the 2000s was estimated at 2,000–4,000 annually (approximately 1,000 manul hunters with a mean harvest of 2–4 cats per hunter; Wingard & Zahler 2006; Chapter 6).

Poaching takes place occasionally in every country – for pelts, to suppress predators, or just for entertainment (Fig. 5). Quantitative data do not exist, but poaching is considered to be the primary threat in Russian Dauria (Kirilyuk 2012). In the 1990s Kirilyuk & Puzansky (2000) reviewed 33 cases of human-related deaths of manuls in Dauria; 23 were victims of poaching. Unintentional killing of manuls during trapping for other mammals occurs almost everywhere in the study region (Toropova 2006, Sokolov 2012, Kirilyuk 2012, Borisova & Medvedev 2013, Kuksin et al. 2016, Barashkova 2012, 2017, our data).

We collected data on 50 contemporary (≥ year 2000) incidents of manul mortalities in Russia and Kazakhstan. Approximately half of them (22 of 50) were inflicted by herding dogs. In five cases (10%), manuls were accidentally trapped. There was a single confirmed intentional trapping for fur and six kills for unknown reasons. Other ascertained causes were starvation or disease (n = 3), vehicle accident (n = 2), and killing by eagle (n = 1).

Poisoning is recognised as a potentially important threat to manuls in the region (Barashkova 2017). Using poisoned bait as a predator control method has been banned or severely restricted for several decades. Yet, poisonings of the manul's primary prey (rodents and pikas) for pest (Brandt's vole in Mongolia; Tseveenmyadag & Nyambayar 2002) or disease control (several species of pikas and rodents are controlled as vectors of plague in the region) is an ongoing practice (A. V. Denisov, pers. comm., Popova et al. 2018). In 2001–2003 poisoning campaigns to control Brandt's vole in Eastern Mongolia using bromadialone had a devastating effect on both raptors and predatory mammals (Tseveenmyadag & Nyambayar 2002). This activity in Mongolia is currently being phased out as the effect on non-target species is better understood (N. Batsaikhan, pers. comm.). More recently bromadialone was in use in Russia as a part of a system of measures to prevent plague in the Kosh-Agach district of Altai Republic (A. V. Denisov, pers. comm., Popova et al. 2018). Similar incidents involving other pesticide or other countries are a continuous risk.

Mining is recognised as a potential significant threat to critical manul habitats in Russia, Kazakhstan, and Mongolia (Reading et al. 2010, Smelansky & Tishkov 2012, Kamp et al. 2016, Wesche et al. 2016). Steppe fires also appeared to be a limiting factor for the manul in several areas such as Buryatia (Borisova & Medvedev 2013), Trans-Baikal Territory of Russia, and North-Eastern Mongolia (V. Kirilyuk, pers. comm.).

Climate change is an emerging potential threat. Manul is strongly affected by harsh winter conditions, especially deep snow and ground surface icing (Sludskii 1973, 1982, Kirilyuk 2012, Kirilyuk & Barashkova 2016a, b, Barashkova 2017, Kuksin 2018). Deep snow with severe prey depression lead to a strong reduction in the number of manuls (Kirilyuk & Barashkova 2016a, b). Different climate change scenarios for the period 2020–2080 predict that climate in Southern Siberia and Inner Asia will generally become warmer, partly more humid and with higher winter precipitation (Tchebakova et al. 2009, Shvidenko et al. 2013, Lioubimtseva & Henebry 2009, Poulter et al. 2013). It could result in more snow, afforestation of steppes, and increased wildfires – all negative changes for the manul in the region.

Manul may come into contact with at least four different pathogens possibly transmitted by other wild mammals and domestic cats *Felis catus* (Naidenko et al. 2014, Pavlova et al. 2015). *Toxoplasma gondii* results in high mortality in young manuls in captivity (Dubey et al. 1988, Basso et al. 2005) and may threaten the survival of local populations in the wild, as 9% of manuls and 15% of sympatric feral/domestic cats are serum positive to this pathogen in Dauria (Pavlova et al. 2016). Toxoplasma antibodies were also found in wild rodents and pikas in the manul range (Pavlova et al. 2016). Feline panleukopenia virus and feline calicivirus are other potentially dangerous pathogens. In the vicinity of the Daursky Reserve 45–60% of tested domes-

Table 4. Export of manul pelts from Mongolia.

Period	Pelts per year on average	Reference
1900–1910	50,000	based on trade data in Urga, presented by V. Flanden 1912
1927–1929	6,400	Bannikov 1954
1931–1932	1,600	Bannikov 1954
1940s	600–650	Bannikov 1954

tic cats were serum positive to the viruses while no manuls were. This could be interpreted as extreme susceptibility of manuls to these viruses with a high degree of lethality (Naidenko et al. 2014, Pavlova et al. 2015; Chapter 9).

Conservation

Although formally strictly protected in most countries of the region (see Chapter 6) manul is not focus of special conservation efforts. In Russia, there have been attempts to incorporate manul research into official research plans in relevant protected areas. Nonetheless, only Daursky Biosphere Reserve is engaged in ongoing study and active protection of the manul. Other protected areas in Russia collect manul data opportunistically in the course of camera trap studies, routine winter snow-tracking censuses, and other field-based activities (Belov 2015, Istomov et al. 2016, Kuksin et al. 2016). In-situ conservation of the species occurs mainly through prohibition or regulation of hunting and trade, and habitat conservation within protected areas. Ka-zakhstan, Kyrgyzstan, and Russia prohibit hunting and trade in manul, Uzbekistan restricts it, and Mongolia restricts hunting and regulates trade; the situation in Tajikistan is unclear (see Chapter 6 for details).

At least 12% (approximately 180,000 km^2) of the regional PAS is situated in at least 170 protected areas of Russia, Mongolia, Kazakhstan and Kyrgyzstan; the species is documented in 36 of them. The percentage of the protected PAS per country varies from 5.6 to 14.7% (Table 5; see also SOM). The largest share of national suitable habitats is situated in the protected areas of Mongolia (almost 15%) that is almost 72% of the estimated PAS within the protected areas of the region.

Concluding remarks

Despite the long history of studying manul in the region there is lack of knowledge in many aspects of its ecology and biology. Thus, we still know little about home range, dispersal, competition with other predators, and population dynamics. Moreover, several significant gaps remain with regard to the species distribution. First, spatial pattern of the species range in Mongolia, presence status in Uzbekistan, Tajikistan, and western part of Kazakhstan should be revealed.

Correct assessment of population number and dynamics is another important future task. Increased knowledge will lead to more effective conservation measures including creation of targeted protected areas to secure manul and its habitats in key territories, mitigating dog collisions and poaching, and establishing a broad network to monitor manul populations and threats.

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Fig. 5. Fur-cap made of manul fur offering for sale in a souvenir shop in Ulaanbaatar, Mongolia, April 2007 (Photo A. Barashkova)

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Table 5. National Predicted Area of Suitability PAS and confirmed manul presence in protected areas.

Country*	Total (km²) and relative (%) share of national PAS within protected areas	Number of protected areas within PAS (Number of protected areas with contemporary C1 data)
Kazakhstan**	24,397 (7.2%)	31 (5)
Kyrgyzstan***	4,347 (5.6%)	20 (3)
Mongolia	125,126 (14.7%)	76 (13)
Russia**	16,329 (9.3%); 21,119 (12.0%) including buffer zones	43 (15)

** Except Tajikistan and Uzbekistan from where the data on protected areas were not processed in this study*

*** See SOM for details*

**** The strict protected areas and national parks only (without wildlife refuges)*

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Distribution and status of the Pallas's cat in the south-west part of its range

The present report covers Afghanistan, Armenia, Azerbaijan, Iran, Pakistan and Turkmenistan, forming the south-west part of the Pallas's cat *Otocolobus manul* distribution range. The Pallas's cat has been rarely studied in these countries, and the current knowledge of the species in this region is limited. Our review estimates that the Pallas's cat's current Extent of Occurrence EOO in the region is 1,371,783 km² (or 723,296 km² when expressed as the sum of country-based convex polygons). While climatically suitable areas seem to exist for the Pallas's cat at many sites (1,155,654 km² in total, or 42.8% of the regional Extent of Occurrence), confirmed contemporary (≥ year 2000) records (n = 98) are limited to few areas and geographically biased towards Iran (75.5%). Consequently, the current Area of Occupancy AOO for the species appears sparse (3,925 km²) and highly fragmented. In particular, we found no confirmed contemporary records of the Pallas's cat in Armenia, Azerbaijan and Turkmenistan, and from outside the Hindu Kush-Hindu Raj mountain ranges in Afghanistan and Pakistan. However, the apparent trends in geographic distribution may not be significant given the lack or increase of recent detection efforts compared to the past. Anecdotal evidence suggests that Afghan pika *Ochotona rufescens* is an important prey species for the Pallas's cat in this region, and availability of this prey species in climatically suitable areas could constitute a biological predictor of the Pallas's cat occurrence. Pallas's cat populations in the range countries are likely to be threatened to various extents by incidental killing by pastoralists and their dogs, habitat fragmentation and depletion of main prey species. We did not find any evidence of active harvest or specific persecution of Pallas's cats in the study region, and the possible effects of climate change on the species ecology remain unknown. Significantly more research is needed to evaluate and understand the impact of potential threats on Pallas's cat distribution, abundance and population trends in its south-western distributional limit.

In the present report, the south-west part of the Pallas's cat distribution range is the transcontinental Asian region extending from Pakistan in the east to Armenia in the west and including Afghanistan, Azerbaijan, Iran and Turkmenistan. To our knowledge there have been so far no confirmed records of Pallas's cats from the Arabian Peninsula or other countries in the Middle East including Iraq and Turkey (Ross et al. 2016). Recent information on the ecology and conservation status of the Pallas's cat in this region is scarce and outdated (but see Farhadinia et al. 2016). This is due in part to the region's remoteness, but also in several countries to a lack of recent detection efforts because of decades of political unrest or armed conflicts (e.g. Smallwood et al. 2011, Gaynor et al. 2016). It has been presumed without much evidence that the Pallas's cat occurs in small and isolated habitat patches and is declining in this region (Nowell & Jackson 1996, Ross et al. 2016). In the present chapter, we try to evaluate whether recent information on the Pallas's cat's geographic distribution, habitat typology, prey and threats support the hypothesis of a decline of the species in this part of Asia. Through this assessment, we hope to create a foundation for future research that will inform conservation planning for the species.

Methods

The assessment used a standardised questionnaire, developed by the IUCN SSC Cat Specialist Group, and completed by all co-authors based on original data pub-lished in peer-reviewed and grey literature and unpublished information collected from reliable sources (see Acknowledgments).

We categorised Pallas's cat data as either "historical" (< year 2000) or "contemporary/current" (≥ 2000). We assigned the occurrence records to three levels of reliability; either "confirmed" (C1), "probable" (C2), or "possible" (C3) following SCALP criteria proposed by Molinari-Jobin et al. (2012). We determined Pallas's cat's Extent of Occurrence and Area of Occupancy in each range country from C1 and C2 records only. Specifically, we excluded from the analyses all indirect signs of Pallas's cat presence that were not assessable (e.g. direct sightings; C3). We measured EOO by estimating the smallest area that contained all C1 and C2 occurrence locations from minimum convex polygons in each range country (i.e. country EOOs) and at regional scale (i.e. regional EOO). To calculate AOO, as a subset of EOO, we superimposed a 5 × 5 km grid layer over the regional EOO. We considered cells with at least one C1 or C2 occurrence records as "occupied" and summed them up to calculate AOOs. We selected 25 km² grids based on the approximate, average of annual home range size (100% minimum convex polygon estimates) of female Pallas's cats from Russia and Mongolia (≈37 km²; Barashkova & Kiriliuk 2011 cited in Ross et al. 2016, Ross et al. 2012).

To exclude unsuitable areas from our estimates of Pallas's cat's current EOO and AOO in each range country, we adopted a simple approach from Rondinini & Boitani (2006) with the following modifications. Using contemporary C1 and C2 occurrence localities collated in this study and a set of bioclimatic variables, we generated an ecological niche model (also termed as species distribution model) to depict potentially suitable areas for the Pallas's cat inside the conventional estimates of EOO and AOO (see Supporting Online Material SOM). The predicted suitable areas include the geographic regions with favourable climatic conditions for the Pallas's cat, in the absence of dispersal limitations, biotic interactions and anthropogenic disturbances (i.e. fundamental niche; Peterson et al. 2011).

Distribution

Overall, we gathered 195 occurrence localities (Table 1) with the highest number of records collected in Iran (n = 119, 61%). The westernmost and southernmost verified records of Pallas's cats in the study region came from Iran (Fig. 1). The last verified evidence (C1) of Pallas's cat occurrence in Armenia and Azerbaijan date back to the 1920's. In Afghanistan and Pakistan, confirmed contemporary occurrences are all from the Hindu Kush-Hindu Raj mountain ranges in east-central Afghanistan and northern Pakistan (Fig. 1). In

Turkmenistan, almost all historical occurrence records of the Pallas's cat are from the Kopet Dag Mountain Range along the international border with Iran (Fig. 1).

The current EOO of the Pallas's cat across the study region (i.e. regional EOO) was 1,371,783 km^2. The sum of country EOOs was estimated at 723,296 km^2 (Table 2), 98.4% of which occurred in Iran where the recent detection effort was the most intense and widespread (Table 2). The historical EOO seemed geographically less biased and covered Turkmenistan as well (Table 2). Number of contemporary occupied cells (AOO) varied widely amongst range countries (range: 3–146). Climatically suitable areas for the Pallas's cat extend over 1,155,654 km^2, which include 42.8% of the regional estimates of current EOO, or 75.2% of the sum of country EOOs, and 94.3% of AOO estimates (Fig. 1, Table 2 & SOM Figure F1).

Afghanistan

The distribution of the Pallas's cat in Afghanistan is imprecisely known. Habibi (2003), citing mostly Hassinger (1973) and adding information he collected prior to the Soviet invasion in 1979, reported that the species occurred in Salang Pass and Panjsher Valley of the central Hindu Kush Mountain Range (skins and captured live specimens) and in the Wakhan Corridor and Zebak Valley in north-east of Afghanistan (pers. comm. of local people). Based on communication with the staff of Kabul Zoo, Roberts (1977) reported that the species occurred in the 1970's in the vicinity of Kabul.

The Wildlife Conservation Society WCS has compiled the most recent information from the country (Table 1), with the caveat that large extents of potentially suitable areas could not be accessed because of lack of security. All contemporary C1 records (i.e. camera trap photographs and captures) were obtained from the central part of the Hindu Kush Mountain Range in the provinces of Bamyan, Day Kundi and northern Ghazni (Fig. 1, SOM Table T1), which are relatively more secure. WCS did not confirm the presence of the species, during the snow leopard *Panthera uncia* camera trap surveys it has carried out in the Hindu Kush and Pamir mountain ranges of Wakhan District, Badakhshan Province between 2011 and 2018 (SOM T1). A previous habitat suitability modelling exercise proposed that the potential habitat of the Pallas's cat in Afghanistan is fragmented (Kanderian et al. 2009), but no ground truthing was carried out to verify this hypothesis. Our predictions suggest that the most favourable climatic conditions for Pallas's cat in Afghanistan occur in the Central highlands and Wakhan District (Fig. 1).

Table 1. Number of historical (< year 2000) and contemporary (≥ 2000), C1 ("confirmed"), C2 ("probable") and C3 ("possible") occurrence records of the Pallas's cat compiled in this study.

Country	Historical			Contemporary		
	C1	C2	C3	C1	C2	C3
Afghanistan	0	0	6	21	0	1
Armenia	1	1	1	0	0	1
Azerbaijan	0	1	1	0	0	0
Iran	2	4	11	74	4	24
Pakistan	3	0	5	3	0	5
Turkmenistan	8	0	16	0	0	2
Total	**14**	**6**	**40**	**98**	**4**	**33**

Armenia

The presence of the Pallas's cat in Armenia is supported by only one verified record (skull and skin specimen) in the 1920s from an unknown location between Vedi (then Beyuk-Vedy) and Yeraskh (then Arazdaya), within Urts (= Urtsk) Ridge (then Sarai-Bulag(sk) = Saray-Bulak(h) Mountain Range) of Ararat Province (Ognev 1935, Dal 1954). Heptner & Sludskii (1972) mentioned, without confirmation, another undated specimen from Meghri District, Syunik Province (Fig. 1). The contemporary presence of the Pallas's cat in Armenia is unclear, and the Red Data Book of Armenia has categorised the species as "Regionally Extinct" (Khorozyan 2010). We found only one unverified record (C3) of Pallas's cat poaching by a local resident near Nrnadzor (then Nuvadi) village in southern parts of Armenia in the early 2000's (Khorozyan 2007). Between 2013 and 2015, surveys at 24 locations in the southern parts of Armenia failed to camera trap Pallas's cat including in its historical sites (Askerov et al. 2015; SOM T1). The predictions of suitable areas based on favourable climatic conditions suggest that almost entire Armenia would be suitable for the species (Table 2, Fig. 1 & SOM F1).

Azerbaijan

Adjacent to Armenia, Azerbaijan forms the western edge of the Pallas's cat range in the study region. There is only one undated occurrence record from Julfa, close to the Aras River in the borderland between Azerbaijan and Iran (Alekperov 1989). Some sources have reported another record from Sadarak in Nakhchivan (e.g. Aghili et al. 2008), which is in fact the specimen from Urts Ridge in the nearby Armenia (Fig. 1). Heptner & Sludskii (1972) speculated that historically the Pallas's cat inhabited also the Talysh area in southeast of Azerbaijan. Lastly, an undated skin specimen was observed in 1996 in Dashkesan village inside Karabakh, in the possession of a local hunter frequently moving between Armenia and Karabakh (V. Ananyan, pers. comm., Aghili et al. 2008).

The Pallas's cat is considered "Extinct" in the Red Data Book of Azerbaijan, as it has not been recorded with certitude for the last 25 years (Askerov & Talibov 2013). The species was not recorded in over 50 camera trap stations surveyed between 2012 and 2018 for detecting Persian leopards *P. pardus tulliana* (= *saxicolor* = *ciscaucasica*) in Nakhchivan, including known historical sites of the species (Askerov et al. 2015, WWF Azerbaijan unpubl. data; SOM T1). The prediction of climatically suitable areas for the Pallas's cat includes Nakhchivan, parts of Karabakh and, beyond large gaps, in southeast of the Greater Caucasus Mountain Range in northern parts of Azerbaijan (Fig. 1 & SOM F1).

Iran

Recently, Farhadinia et al. (2016) provided a detailed status assessment of the Pallas's cat in Iran. We have supplemented this previous assessment with new data collected in 2017–2018 (Table 1). Iran has the widest geographic distribution (EOO and AOO) of the Pallas's cat in the study region (Table 2). Historical occurrence records were mainly from the northeast of the country (Fig. 1). However, increased detection efforts since 2000, have resulted in the discovery of Pallas's cats in several new areas (Aghili et al. 2008, Chalani et al. 2008, Ziaie 2011, Joolaee et al. 2014, Farhadinia et al. 2016, Karami et al. 2016, Talebi Otaghvar et al. 2017, Dibadj

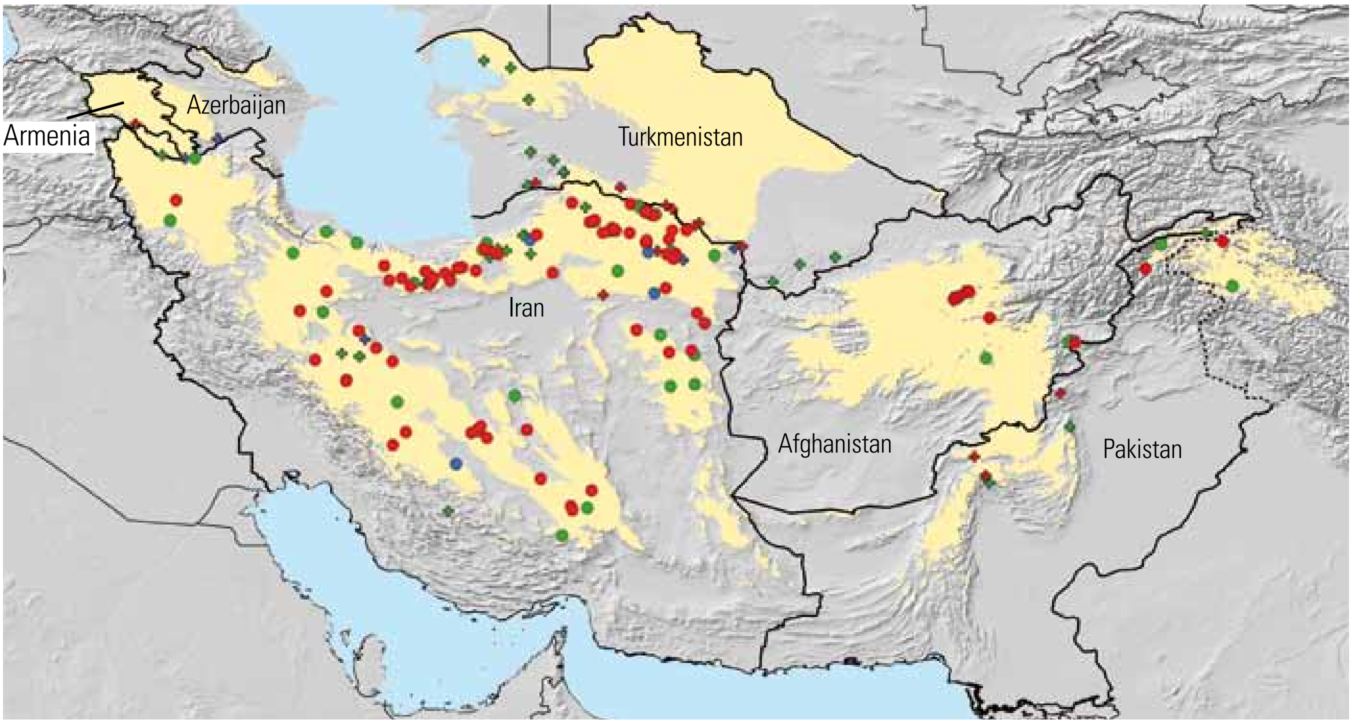

Fig. 1. Geographic distribution of the Pallas's cat in the study region, mapped according to historical (< year 2000; crosses) and contemporary (≥ 2000; circles) occurrence records collated in this study. Red = confirmed (C1); Blue = probable (C2); Green = possible (C3). Yellow polygons represent the predicted, climate-based suitable area (see SOM F1).

et al. 2018). The current EOO of the Pallas's cat in Iran covers almost the entire northeast, westwards through central and southern slopes of Alborz Mountain Range in the north and southward across the Zagros Mountain Range as far south as Kerman Province. We found no evidence of Pallas's cat occurrence in southeast parts of Iran, in Sistan-va-Baluchestan Province, along the border with Pakistan and Afghanistan (Fig. 1). The current AOO is more fragmented in the Zagros range. The niche model predicts highly suitable climatic conditions in the northeast (Razavi Khorasan and North Khorasan provinces) and the north (Semnan, Tehran and Alborz provinces in the centre and southern slopes of Alborz Range) of the country (SOM F1). In general, the suitability predictions of our climate-based model are aligned with those retrieved from the model developed by Farashi et al. (2017) from coarse-grain atlas data (25 × 25 km resolution; Karami et al. 2016) and a different set of environmental variables.

Pakistan

Most historical occurrences of Pallas's cat in Pakistan came from northern Baluchistan Province (Fig. 1). Roberts (1997) reported a skin specimen collected in 1910 from Toba Kakar, north of Hindu Bagh (now at the Natural History Museum in London) and two live specimens that were captured in Ziarat and South Waziristan Agency in 1977 and 1978, respectively. Additional anecdotal evidence exist from Zarghun Mountains and Kaliphat (= Khilafat) in Baluchistan Province, northwards into the Takht-i-Suleiman (= Takht-e-Sulaiman) in the Federally Administered Tribal Area and near Baroghal (= Broghil) in Chitral District (Roberts 1997).

Contemporary records confirmed the presence of the Pallas's cat in the Hindu Kush and Hindu Raj mountain ranges, in Chitral District and Parachinar Valley of Khyber Pakhtunkhwa Province and Ghizer and Diamer districts of Gilgit-Baltistan, in north and northwest of Pakistan (Sheikh & Molur 2004, Hameed et al. 2014, Hussain 2018; Fig. 1). The species may also occur in Gilgit District (Hameed et al. 2014). Accordingly, Pallas's cat's current AOO and EOO are restricted to north and northwest of Pakistan. However, Baluchistan Province as the historical stronghold of Pallas's cat in the country was not surveyed recently. The prediction of areas with optimal climatic conditions for the Pallas's cat in Pakistan includes Gilgit-Baltistan and the Central Brahui Range in Baluchistan Province (Fig. 1).

Turkmenistan

Based on our literature review, the species historically occurred in western and southern parts of Turkmenistan, in the Big (= Bolshoi = Uly) Balk(h)an and Kopet Dag (= Kopetdagh = Koppeh Dagh) mountain ranges, respectively (Fig. 1). Opportunistic field surveys carried out in the 1990's did not bring new confirmed records (Lukarevsky 2001). Rustamov & Hojamyradov (2011) reported at least two contemporary occurrence records from Central Kopet Dag. However, we could not recover the exact locations and assess the reliability of these records (Fig. 1). As a result, we found no verified contemporary records of Pallas's cat from Turkmenistan (Table 1). The available information suggests that the species' probable AOO in Turkmenistan is fragmented, and that the remaining populations are likely small and isolated (Rustamov & Sopyev 1994, Rustamov & Hojamyradov 2011). Our predictions of areas with favourable climatic conditions for the Pallas's cat include Central Kopet Dag and Karakum Desert in the north (Fig. 1).

Habitat

A continental climate with cold, dry winters and warm summers with moderate to low precipitation characterises the habitat of Pallas's cat in the study region (SOM T2). The niche model selected higher-elevation areas as most suitable, but excluded long-lasting ice- and snow-covered areas (SOM F1). We overlaid the contemporary C1 and C2 occurrence localities used to build the niche model on a digital elevation map at 2.5 arc minutes (≈ 5 km) resolutions produced by the USGS/NASA Shuttle Radar Topographic Mission (http://srtm.csi.cgiar.org). The median elevation of these records for the species was 2,372 m (range: 894–3,665 m), which in the study region corresponds to a mid-mountain elevation. These preliminary results are in agreement with the hypothesis that high altitude areas with permanent deep snow may act as barriers to Pallas's cat's dispersal (Heptner & Sludskii 1972).

In the Southern Caucasus, historical occurrence records are from flat or hilly semi-desert areas with rocky outcrops. Arid grasslands and semi-deserts with rocks and cliffs in the southern parts of Armenia are potentially suitable sites for the Pallas's cat (Khorozyan 2010). The only contemporary C1 record from the entire Caucasus is a Pallas's cat captured in East Azarbayjan Province in northwest of Iran, in a semi-rural landscape characterised by open steppes and shrublands, dominated by *Astragalus* spp. with scattered trees (Aghili et al. 2008; Fig. 1). In Iran, the Pallas's cat occurs across a wide continuum of habitat types, from arid grassland steppes and dry mountains to temperate open shrublands (Chalani et al. 2008, Joolaee et al. 2014, Farhadinia et al. 2016, Talebi Otaghvar et al. 2017, Dibadj et al. 2018; Fig. 2).

In Afghanistan, the Pallas's cat inhabits a wide range of arid plateaus with flat and rolling mountains interspersed by rocky and deep valleys. These findings are aligned with early reports that the species occurs in Afghanistan in stony alpine deserts, grasslands and montane steppes, especially in areas with little rainfall and low levels of humidity (Hassinger 1973, Habibi 2003). In Pakistan, the species seems to prefer alpine and subalpine scrub zones, dominated by rugged and broken terrain with high cliffs, ridges and ravines. A Pallas's cat was photo-captured on a ridgeline in a forested area in Gilgit-Baltistan dominated by juniper trees *Juniperus* spp. (Hameed et al. 2014).

Historical occurrence localities of the Pallas's cat in Turkmenistan are predominantly associated with mountains and foothills (Heptner & Sludskii 1972, Rustamov & Sopyev 1994, Lukarevsky 2001). Desert foothills, ribs with fragmented rocks with alluvial and sparse xerophyte vegetation, shallow canyons with grass and shrub cover and inundated tangles in mountain brooks are thought to be suitable microhabitats (Rustamov & Hojamyradov 2011).

Prey

Pallas's cat's current EOO in Western and Southern Asia overlaps broadly with the distribution range of the Afghan pika (= collared pika; Habibi 2003, Khaki Sahneh et al. 2014, Karami et al. 2016, Smith & Johnston 2016). Together with the predictions of climatically suitable areas (SOM F1) and sporadic historical accounts (e.g. Heptner & Sludskii 1972), this provides anecdotal evidence that the Afghan pika could be an important prey species across most of the Pallas's cat's range in the region covered in this assessment (Moqanaki 2015).

The contemporary presence of Afghan pikas in the Caucasus Ecoregion is uncertain (Čermák et al. 2006, Smith & Johnston 2016), and the forest dormouse *Dryomys nitedula* has been suggested as an alternative prey species (Aghili et al. 2008), as well as reptiles and small birds. Similarly, in northeast Afghanistan and northwest Pakistan the large-eared pika *O. macrotis*, which is an important prey species for many small carnivores (S. Ostrowski, pers. obs.) could be an alternative prey species for the Pallas's cat. Stomach and intestine contents of five Pallas's cats killed in Razavi Khorasan Province (n = 3) and the southern slopes of Alborz Mountain Range in Semnan Province (n = 2) in Iran included remains of chukar partridge *Alectoris chukar* (frequency of occurrence per food item = 33.3%), see-see partridge *Ammoperdix griseogularis* (16.7%), Afghan pika (16.7%), Persian jird *Meriones persicus* (16.7%) and one snake (possibly *Macrovipera lebetina*; Adibi et al. 2018, M. A. Adibi, unpubl. data). Caspian snowcock *Tetraogallus caspius*, hares *Lepus* spp., great gerbil *Rhombomys opimus* and Libyan jird *M. libycus* are possibly other important prey species in Iran (Harrington & Dareshuri 1976, Karami et al. 2016, M. A. Adibi, pers. obs.). Hares, pikas, small rodents and birds such as the chukar partridge could also be part of Pallas's cat diet in Pakistan (Roberts 1997). In addition, there are historical, unverifiable reports of Pallas's cat predation on new-born bezoar goats *Capra aegagrus* in the Kopet Dag, Turkmenistan (Morits 1930 cited in Rustamov & Sopyev 1994).

Threats

We did not identify conspicuous threats that would significantly affect Pallas's cat on a

Table 2. Estimations of extent of occurrence EOO and area of occupancy AOO based on historical (< year 2000) versus contemporary (≥ 2000), C1 and C2 occurrence localities of the Pallas's cat in each range country. The EOO and AOO were estimated either as the conventional geographic range, or potentially suitable area calculated from a climate-based niche model developed in this study (FN: fundamental niche; SOM F1).

Country	Area (%)*	Geographic range (km²)				Suitable area (km²)		
		Historical		Contemporary		Contemporary		
		EOO (%)	AOO (%)	EOO (%)	AOO (%)	FN (%)	EOO (%)	AOO (%)
Afghanistan	642,181 (17.2)	NA	NA	2,161 (0.3)	200 (5.1)	200,219 (17.3)	1,953 (0.4)	75 (4.7)
Armenia	29,588 (0.8)	NA	50 (10.5)	NA	NA	28,638 (2.5)	NA	NA
Azerbaijan	86,250 (2.3)	NA	25 (5.3)	NA	NA	24,778 (2.1)	NA	NA
Iran	1,622,509 (43.7)	81,507 (85.2)	150 (31.6)	711,689 (98.4)	3,650 (93.0)	563,392 (48.8)	540,933 (99.4)	3,500 (94.6)
Pakistan	872,939 (23.4)	7,273 (7.6)	75 (15.8)	9,446 (1.3)	75 (1.9)	95,755 (8.3)	1,296 (0.2)	26 (0.7)
Turkmenistan	470,850 (12.6)	6,918 (7.2)	175 (36.8)	NA	NA	242,872 (21.0)	NA	NA
Total	**3,724,317**	**911,037 (95,698)****	**475**	**1,371,783 (723,296)****	**3,925**	**1,155,654**	**586,643 (544,182)****	**3,701**

NA = Not Applicable

** This information is produced based on data (km²) downloaded from www.naturalearthdata.com (accessed on 6 April 2018) for comparison purposes only, and it may not be regarded as authoritative in any respect*

*** The estimates of regional EOOs were based on a minimum convex polygon over the entire dataset of either historical or contemporary C1 and C2 records. The sum of country EOOs are presented in parentheses*

Fig. 2. A camera trap picture of a Pallas's cat in Shirkuh No-Hunting Area, Yazd Province in Iran, 19 May 2017 (Photo M. Zare Pandari/T. Ghadirian/Yazd DoE).

large scale in the study region. Incidental killing by pastoralists or their herding dogs, anthropogenic and climate change-induced habitat loss and habitat fragmentation and, possibly, depletion of preferred prey (i.e. pikas) could threaten to an unknown extent the Pallas's cat populations in the study region. Although there is no management or conservation plans specific to the Pallas's cat in this region, the species is officially protected in all range countries.

Traditional livestock herding that is widespread across the predicted suitable areas, when practiced unsustainably, may negatively affect the Pallas's cat and its main prey species and increase the risk of attacks by herding dogs. Because of ignorance and weak wildlife law enforcement (particularly outside protected areas) throughout the region, Pallas's cat individuals are at risk of being killed or captured when they encounter herders (Fig. 3). Farhadinia et al. (2016) reported 16 verified mortality records of the Pallas's cat in Iran caused by opportunistic killing by herding or feral dogs (n = 7), live capture attempts by local people or wildlife authorities (n = 7) and poaching (n = 2). In adition, Adibi et al. (2018) discovered a road-killed Pallas's cat in northern Semnan Province. Evidence of harvest of Pallas's cat for fur and pet trades was reported from Afghanistan and, to a lesser extent, from Pakistan (Roberts 1977, Rodenburg 1977, Johnson & Wingard 2010, Kretser et al. 2012). The scale of this activity did not seem to be massive and it was not targeting specifically Pallas's cats. Hunting and trapping of wild carnivores to sell their pelts in roadside shops for tourists and gas stations happens relatively often and with little law enforcement in several countries across the study region. The impact of this threat on a small sub-population of Pallas's cat could be significant.

Overgrazing, development of infrastructures, agriculture, mining and climate change might contribute to fragment and degrade the habitat of the Pallas's cat in the study region. These human-induced activities could have direct or indirect (e.g. through prey depletion; Smith et al. 1990) effects on Pallas's cat survival and productivity. For example, secondary exposure to rodenticides could occasionally pose a problem. However, it is not known where and how these anthropogenic activities and threats currently affect Pallas's cats, and how and to which extent the species adjusts to them.

Future research and conservation

Very limited research and conservation attentions have been devoted to the Pallas's cat in the study region and, as a result, current status and population trends are difficult to interpret. The apparent increase in number of Pallas's cat records in Afghanistan and Iran over the past 10 years (Table 1) could indicate a range expansion because of improved legal protection, or only reflect an increase in detection efforts. In the Caucasus, the apparent decrease in number of records, despite the recent use of camera traps, could point at a decline or, given the small number of historical records, a situation of rarity. Continuing monitoring of recently surveyed areas should in the future inform Pallas's cat occupancy trends in Iran and Afghanistan and clarify the situation of the species in the Caucasus. Species-specific surveys, using modern methodologies, are required in Turkmenistan and northern Baluchistan Province of Pakistan.

The suitability map we generated as an alternative estimate of the current EOO and AOO (SOM F1) only addresses climatic constraints to the Pallas's cat distribution in the study landscape (Marino et al. 2011), but it can guide future conservation efforts (Elith & Leathwick 2009). However, the predictions are preliminary and potentially biased because of the limited knowledge of the Pallas's cat-habitat relationships at various scales, the spatially biased occurrence data used, as well as not accounting for biotic interactions (e.g. predator-prey relationships). Although our estimates of EOO and AOO are conservative as they include only C1 and C2 occurrence localities, the low threshold we used to make the binary map (10% training omission rate = 0.194; SOM F1) may have led to over-prediction of suitable areas ("fundamental niche" in Table 2). Further, suitable areas outside the known EOOs of the Pallas's cat may indicate inaccessible areas that are beyond likely dispersal barriers (e.g. the Greater Caucasus Mountain Range and Karakum Desert in northern parts of Azerbaijan and Turkmenistan, respectively). Future studies must test these assumptions to improve our predictions of potential distribution of the Pallas's cat in this region, and help prioritise areas for further surveys and conservation (Moqanaki 2015).

Limited scientific knowledge is a potential barrier to effective conservation of the Pallas's cat. In the study region, the Pallas's cat has never been the subject of a specific research (but see Raeesi Chahartaghi et al. 2018). All occurrence data (Table 1) are based on opportunistic sightings or by-catches of camera trap surveys focused on sympatric large carnivores, notably the Persian leopard and snow leopard (Fig. 4, SOM T1). Although these sporadic records can provide a basic understanding on species range, scientific researches using reliable techniques, such as GPS telemetry (Ross et al. 2012), remain needed to inform conservation activities specific to the Pallas's cat.

Conclusions

The Pallas's cat assessment for the study region confirmed the presence of the species in Afghanistan, Iran and Pakistan and did not identify confirmed contemporary records (≥ 2000) from Armenia, Azerbaijan and Turkmenistan. In Afghanistan and Iran, the number of confirmed contemporary records was substantially higher than the number of historical records (< 2000). This can be either because of more intense detection efforts such as the use of camera trap methodology and increased awareness of the species, or a range expansion following unknown natural and human-induced changes. In Pakistan, the number of contemporary records is similar to historical records although Baluchistan Province, known as a historical stronghold of the species in the country, was not recently surveyed. At the western edge of Pallas's cat distribution range, the lack of records from Armenia and Azerbaijan, despite recent camera trap surveys including in historical localities of occurrence, could signal a declining trend, a 'stable' situation of rarity, or a local extinction of the species. The contemporary status of the Pallas's cat in Turkmenistan is unknown due to a lack of science, monitoring and reporting. This assessment supports that killing by herders and their guard dogs could be a significant cause of mortality for Pallas's cats. Exploitation of the species for its fur is not reported to be a significant threat in the region, though this illegal activity could be underestimated. Although the Pallas's cat seems to occur in habitat patches, the extent to which anthropogenic activities impact the persistence and connectivity of these patches is unknown. The density, abundance and population trend of the Pallas's cat in this region are not known. Based on this regional evaluation, we suggest that the Pallas's cat should be classified as a research priority species in the range countries covered by this chapter, excluding Armenia and Azerbaijan where the presence of this species is uncertain.

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Fig. 3. Pallas's cat kept as an exotic pet from Parachinar Valley, Khyber Pakhtunkhwa Province, Pakistan, March 2017. Incidental killing and live trapping threaten Pallas's cats in the study region (Photo S. Hussain).

Fig. 4. A camera trap photograph of a Pallas's cat in Bamyan Plateau, Bamyan Province, Afghanistan, 20 December 2015. The camera trap was deployed for a Persian leopard detection survey (Photo WCS Afghanistan).

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Supporting Online Material SOM Table T1 & T2 and Figure F1 are available at www.catsg.org.

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Distribution and status of the manul in the Himalayas and China

In this article, we used published and grey literature and expert observations to review the distribution and conservation status of the Near Threatened Pallas's cat or manul *Otocolobus manul* in Bhutan, China, India, and Nepal. The species appears widespread in China; however, distribution in the Himalayas is patchy and not clearly understood. Recent sightings and camera trap records from north Sikkim in India and Bhutan extend the species range to the east of the Himalayas and suggest a wider distribution than previously thought. Nevertheless, the population size and trend in the region remain unknown. The Pallas's cat is likely to be threatened by habitat degradation and fragmentation from traditional pastoralism, unregulated tourism, infrastructural developments such as roads and petrochemical industry, and also by poaching (including their prey). Climate change is also an emerging threat to the species although the potential impacts remain uncertain. Moreover, the species remains one of the lesser known wild cats, and in-place research and monitoring are highly lacking. There is a strong need for active conservation actions and dedicated studies on their presence and distribution followed by a more detailed investigation of their ecology and the impact of ongoing anthropogenic activities.

Pallas's cat is known to occur widespread in China (Nowell & Jackson 1996, Jutzeler et al. 2010). However, their distribution in the Trans-Himalayan regions of India to Nepal and Bhutan in the eastern Himalayas is fragmented and also represent the southern limit of the species range. Records in this range are mostly recent and sparse, and information on Pallas's cats is currently restricted to ad-hoc presence records (mainly from snow leopard surveys) and incidental sightings (e.g. Thinley 2013, Shrestha et al. 2014). There are many studies on the ecology of its primary prey, pika *Ochotona* spp., as well as on high altitude rangeland ecology, especially in China (e.g. Smith et al. 1986, Smith et al. 1990, Smith & Wang 1991, Smith & Foggin 1999, Lai & Smith 2003, Hogan 2010, Guo et al. 2012) but very few on Pallas's cat. It is evident that the species is rare, occurs at low density and is highly vulnerable to disturbances from rangeland habitat degradation and destruction (Ross et al. 2016). Therefore, given the dearth of information on Pallas's cat, there is a strong need to take stock of what is known about the species. This will improve our understanding of Pallas's cat status in the region and help guide conservation interventions. In this article, we review the distribution and conservation status of Pallas's cat in Bhutan, China, India and Nepal.

Methods

Information for this assessment was accrued from published and grey literature, expert observations and through a standardised questionnaire survey developed by the IUCN SSC Cat Specialist Group which was completed by Pallas's cat experts from Bhutan, India, and Nepal. We reached out to researchers in China but unfortunately could not find anyone actively involved with the species. Therefore, the status of Pallas's cat from China was solely based on literature review and information acquired from traceable sources such as the IUCN Cat Specialist Group, Pallas's Cat Working Group (http://www.wild-cat.org/manul/pallas-cat/#), iNaturalist (https://www.inaturalist.org) and other information outlets including blogs and news. Some of the records had only locality references, so we had to obtain approximate GPS coordinates from Google Earth to map the species distribution and calculating the Area of Occupancy AOO. The distribution points were also categorised as historical (< 2000) and contemporary (≥ 2000) and wherever possible into "confirmed" (C1), "probable" (C2) and "possible" (C3) records according to the SCALP criteria (Molinari-Jobin et al. 2012). Only contemporary data inclusive of C1, C2 and C3 records was used to calculate AOO (Table 1). However, due to the low number of recent records, the estimated AOO was unrealistically small. Therefore, we have also included estimates of the extant and possibly extant range of the Pallas's cat in the region from the range-wide data of the most recent IUCN Red List Assessment (Ross et al. 2016; Fig. 1) which includes expert opinions. The AOO was estimated using Geospatial Conservation Assessment Tool, also known as GeoCAT (Bachman et al. 2011), an online open-source, browser-based tool used in IUCN Red List Assessments. To calculate the AOO, we applied a 5 x 5 km^2 grid based on the average home range size of female Pallas's cats in Mongolia, which is around 25 km^2 (Ross et al. 2016).

Distribution

We gathered a total of 358 locality records in the current assessment out of which we could confirm only 35 as C1, one as C2 and two as C3. The rest were too coarse to correctly categorise and so were grouped together as records of unknown category. Most of these are historical data prior to the year 2002. Nevertheless, China is un-doubtedly the stronghold of the species in the region with 334 location points. Bhutan has the least with only three records. Unlike China where the distribution is widespread, distribution in the Himalayas is discontinuous relatively restricted to one or two locations in each country, which appear highly isolated from each other. We were also able to accrue a decent amount of historical data from China, but we could find

Table 1. Number of historical (year < 2000) and contemporary (year ≥ 2000) records of Pallas's cats, Area of Occupancy, and extant and possibly extant areas in each country in the study region.

Country	Historic records	Contemporary records	AOO (km^2)	Extant (km^2)	Possibly extant (km^2)	Total (km^2)
Bhutan	NA	3	75	7,619	0	7,619
China	255	80	1,825	932,609	991,172	1,923,781
India	2	8	200	20,861	8,053	28,914
Nepal	1	10	125	8,965	1	8,966

very few from India and Nepal and none from Bhutan (Table 1). Pallas's cat continues to be reported in the region except for Bhutan where the species has not been recorded since 2012. The AOO estimates for each country in the region were produced from 100 contemporary records (> 2000) resulting in an unrealistically small estimated AOO of 2,225 km² for the region. However, the approximate extant and possibly extant areas of the species in the countries of the region sum up to 970,054 km² and 999,226 km² respectively.

Bhutan

Pallas's cat is the least known and the rarest of the wild cat species found in Bhutan. The Mammals of Bhutan guidebook published in 2004, predicted the distribution of the species at elevations between 2,800 to 4,000 m (Wangchuk et al. 2004). However, the first photographic evidence (i.e. C1) was obtained only in 2012 during a snow leopard *Panthera uncia* survey in central Bhutan when a Pallas's cat was camera trapped at two different sites in the north-western part of Wangchuck Centennial National Park (WWF 2012). A couple of months later in the same year, a similar snow leopard survey in western Bhutan photographed a Pallas's cat in Jigme Dorji National Park at 4,122 m (Thinley 2013). However, camera trapping surveys in the following years, including a nationwide high-elevation tiger *Panthera tigris* survey in 2014 and a nationwide snow leopard survey in 2015 failed to gather any additional Pallas's cat records.

China

China has approximately 50% of the presumed global distribution range of Pallas's cat (Jutzeler et al. 2010, Ross et al. 2016). They can be found in northern, western and central China, in the Altai Mountains (Ross et al. 2016), and on the Qinghai-Tibetan Plateau (Mallon 2002). There are also reports from Gansu, Hebei and western Sichuan provinces (Mallon 2002). The species is also reported to be present in at least 25 Chinese Nature Reserves (Jutzeler et al. 2010), including Xuelingyunshan, Tuomuerfeng, Luoshan, Baijitan, Qinghaihuniaodao, Wanglang, Wolong, Zhumulangmafeng, Kalamailishan, Qitaihuangmobanhuangmo, Aerjinshan, Ganjiahu (Xinjiang), and Luobupoyeluotuo protected areas (China Species Information Service 2008). The Pallas's cat was also previously reported from the east in Jilin Province and the areas around Manchouli (Banjie 1984). The species has also been sighted in the Arjin Mountains Nature Reserve in Xinjiang (Butler et al. 1987) and Gertse County in Ngari Prefecture of the Tibetan Autonomous Region (Fox & Dorji 2007).

Published records after 2010 have come from the Tibetan Plateau north of Rouergai in Sichuan Province. Sightings were made in 2011, 2012 (Webb et al. 2014) and then in 2015 and 2016 (Webb et al. 2016). Sightings by tourists and wildlife-watching tourism operators with photographic evidence have also been reported from other parts of the country: an adult with two kittens near the Qinghai Lake in Qinghai (Townshend 2016), an adult with four kittens in the Bayan Bulag Grassland, Xinjiang (New China TV, 2018), Bortala Mongol Autonomous Prefecture of the Xinjiang Uyghur Autonomous Region (People Daily China 2017), Sanjiangyuan in the Yushu Prefecture in Qinghai (Townshend 2017), Ngawa Tibetan and Qiang Autonomous Prefecture of northwestern Sichuan (Faucher 2018), and in the Hainan Tibetan Autonomous Prefecture of northeastern Qinghai Province in Western China (Hoit 2014).

India

The presence of Pallas's cat in Ladakh was mentioned in the Indian literature since the early 1970s (Prater & Barruel 1971). To date, the species has only been confirmed from the Trans-Himalayan landscapes of Ladakh and Sikkim, where its occurrence is nominal (Mallon 1991, Pfister 2004, Chanchani 2008, Mahar et al. 2017). In Ladakh, the species has been reported from Hanle, Staklung

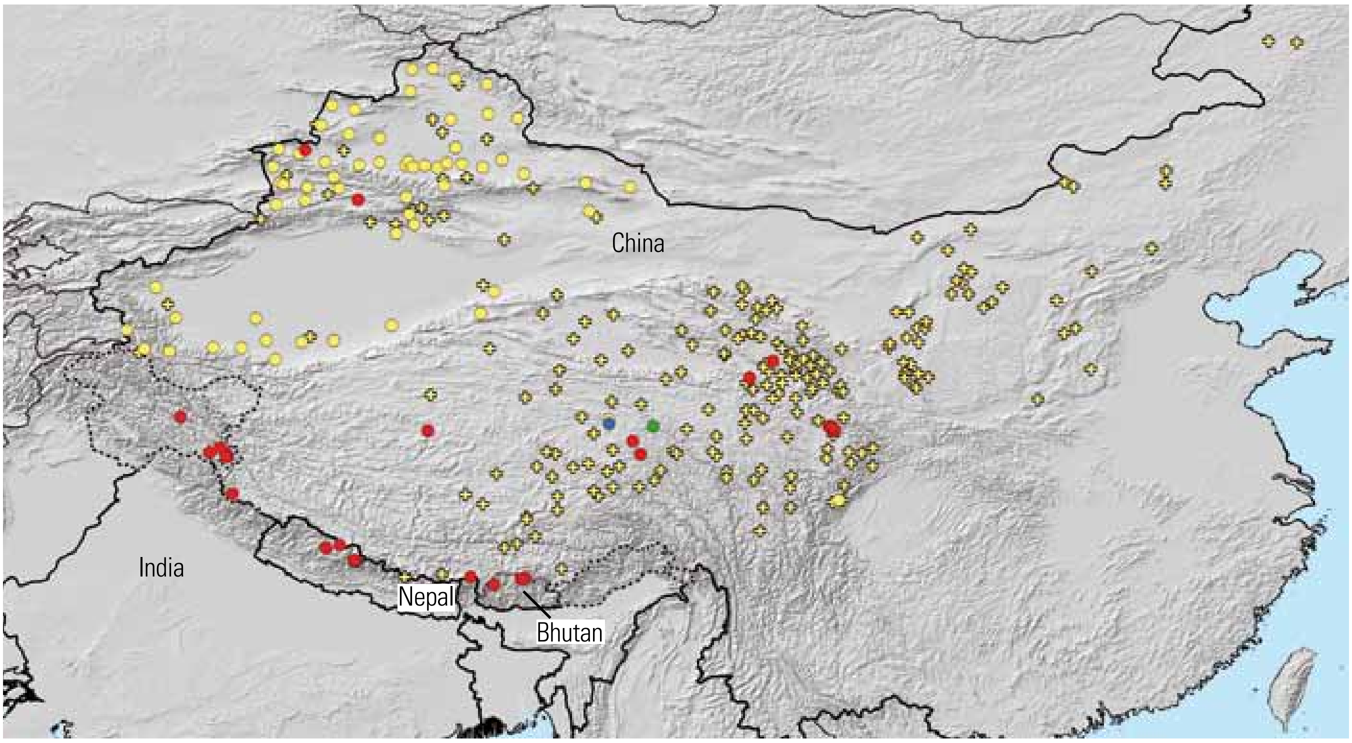

Fig. 1. Geographic distribution of the Pallas's cat in the study region, mapped according to historical (< year 2000; crosses) and contemporary (≥ 2000; circles) occurrence records. Red = confirmed (C1); Blue = probable (C2); Green = possible (C3); yellow = records where categorisation was not possible.

and Lal Pahari areas of Changthang Wildlife Sanctuary and, in Rupshu (Mallon 1991, Pfister 2004, Mahar et al. 2017), at altitudinal ranges between 3,000 and 4,800 m (Pfister 2004). In Sikkim, the first occurrence record consists of a single sighting at Tso Lhamo Plateau at an elevation of 5,073 m, the then highest altitudinal record of the Pallas's cat (Chanchani 2008). Photographs of the species taken by tourists and nature photographers from the area continue to appear in the social media. Negi (1998) described the species occurrence in Spiti area of Himachal Pradesh, but this has not yet been confirmed.

Nepal

The first evidence of Pallas's cat presence in Nepal occurred in 2012 during a snow leopard survey using camera traps in the Marsyangdi valley of Manang district, located within the Annapurna Conservation Area ACA (Shresthra et al. 2014) at Thorkya (4,200 m) and Aangumie Lapche (4,650 m). A camera trapping survey on Pallas's cat in 2014–2015 in the same area detected the species at six different locations at elevations ranging from 3,988 m to 5,073 m, confirming the importance of ACA for Pallas's cats (Regmi et al. 2016). A photograph of a Pallas's cat pelt from Nyesyang valley in 1987 likely confirms the species' historical presence in Manang district (Lama et al. 2016). Recently, a second record for Pallas's cat in Nepal was documented at 5,539 m in the north-eastern part of Tinkyu village of upper Dolpa, some 90 km northwest of Manang (Werhahn et al. 2018). This is the highest elevation record for Pallas's cat across its range. The evidence included a faecal sample verified through faecal DNA analysis. In 2017, a camera trap photo-captured the Pallas's cat in Phoksundo Village Development Committee of Dolpa district (G. Khanal, pers. comm.).

Habitat

A Pallas's cat habitat consists of rocky areas, grassland, shrubland, hills, low mountains, and cold montane deserts and is generally characterised by low rainfall and, low humidity and a substantial variation in temperature (Ross et al. 2016). The habitat of the species is very similar across the Himalayan and China's Tibet-Quinghai Plateau and fringes (Fig. 2 & 3). Bhutan is located within the warmer south-facing slopes of the Himalayas, and the cat's habitat is comprised of rolling hills dominated by glacial out-wash and alpine steppe vegetation (WWF 2012).

Fig. 2. Pallas's cat photographed near Staklung in Changtang Wildlife Sanctuary, Ladakh, India, 14 May 2015 (Photo N. Mahar).

In Nepal, the upper Manang valley has a dry and cold climate, falling in the rain-shadow of the Annapurna Mountain Range. It is a transition zone between the moist southern Himalayan slopes and the high alpine desert of Tibet. The upper watershed of Marsyangdi River, the largest river in Manang district (1,950 km^2), consists primarily of alpine grasslands (4,500 m to 5,000 m) and subalpine scrublands (4,000 m to 4,500 m; Shrestha et al. 2014). However, the Pallas's cat occurs in very broken and rocky areas consisting of mostly rolling hill slopes and very little cliffs. In Dolpo, the species was also recorded in very rocky hill slopes within montane grassland steppe.

In the Trans-Himalayan region of India, the Pallas's cat lives in extreme conditions where the temperatures fall to -30° C in winter (Bagchi et al. 2012) and sites dominated by sparse vegetation and barren sloping land with <100 mm annual rainfall (Hartmann 1983). In central Ladakh, the mid-winter snow depths at 4,000 m elevation can be less than 10 cm (Fox et al. 1991). Usually, the species occupies empty burrows of marmots and foxes in proximity to prey species like pika *Ochotona* spp. and Himalayan marmot *Marmota himalayana* habitats. It prefers south-facing slopes, especially rocky terrain with crevices, open rock-strewn terrain and mountain steppe areas (Menon 2014). Vegetation of the Tso Lhamo plateau in Sikkim is dominated by grasses (*Stipa orientalis*, *Elymus nutans*) and forbs; at the edges of the range, this is replaced by Juniperus- and Rhododendron-dominated communities of the alpine zone of the Himalayas (Chanchani 2008). Typical habitat for Pallas's cat in China consists of flat and rolling steppes with open grassland. They can occur in deserts, semi-deserts and dry steppe areas (Bangjie 1984). *Kobresia pygmaea* and *Carex* spp. are the two most dominant forms of vegetation cover in the alpine meadows of the Tibetan Plateau (Badingqiuying 2008). The record from north-eastern Gertse County in the Tibetan region reported a desert steppe habitat at 5,050 m dominated by *Stipa* spp. and various forbs (Fox & Dorji 2007). Observations from Tibet however also come from heavily disturbed habitats such as old quarries, proximity to human habitation and vehicle traffic and heavily grazed areas at 3,500 m (Webb et al. 2016).

Prey

Pallas's cats are specialist feeders. Rangewide pikas are their most important prey (Ross et al. 2010). They were also reported to prey on a wide variety of small mammals, insects, birds, reptiles and carrion but in fewer proportions (Chapter 3). In Bhutan, potential prey species include Royle's pika *O. roylei*, large-eared pika *O. macrotis*, voles, Himalayan marmot and numerous high-altitude bird species like the blood pheasant *Ithaginis cruentus* and several species of partridges. In the region of Manang in Nepal, prey species can include Royle's pika and the Sikkim vole *Alticola sikkimensis* (Shrestra et al. 2014). A single, genetically-identified Pallas's scat collected in Dolpo (Nepal) revealed pika *Ochotona* sp. and woolly hare *Lepus oiostolus* hairs, and traces of vegetation and debris (Werhahn et al. 2018). Also, in China, Pallas's cats are known to feed predominantly on colonial pikas, small rodents such as voles, birds, hares, and marmots (Wozencraft 2008). In the Trans-Himalayan region of India, potential key prey species also include pikas, voles *Alticola* spp., Himalayan marmot and the woolly hare. Many bird species such as chukar *Alectoris chukar*, Tibetan snowcock *Tetraogallus tibetanus* and Tibetan partridge *Perdix hodgsoniae* that occur in this landscape use marmot burrows and could thus be possible diet items for this cat. The Pallas's cats in the Tibetan region of Rouergai area mostly survive on the vast colonies of the plateau pika (or black-lipped pika) *O. curzoniae*, as well as the Himalayan marmot (Webb et al. 2016).

Threats

Pallas's cats are dietary and habitat specialists, occupying larger home ranges than other small wild cat species (Ross et al. 2012). In open alpine grasslands, they appear to show significant dependence for shelters such as burrows made by marmots and other animals. They are also highly vulnerable to mortality and displacement resulting from pastoralist activities. These factors may even increase the vulnerability to natural predation by e.g. eagles and foxes (Ross 2009). However, a comprehensive understanding of threats across the region is lacking (Chapter 8). Habitat degradation and disturbance are widely reported to be ubiquitous throughout the distribution range of the Pallas's cat in this region: its habitat is mostly used for seasonal grazing by domestic animals such as yaks, horses, cattle, goats, and sheep, along with herding and feral dogs, with grazing intensities varying among sites and countries. The alpine meadows of the Himalayas and China are visited by hundreds of people during late spring or summer collecting the Chinese caterpillar *Cordyceps* spp. This is accompanied by littering of the environment, chopping off rhododendron shrubs for fuelwood and disturbing or trapping wildlife (Wangchuk et al. 2013).

In Nepal, there is evidence that around 20 years ago people from Manang used to sell the pelts of the Pallas's cat, leopard cat *Prionailurus bengalensis* and snow leopard along with red fox *Vulpes vulpes* and golden jackal *Canis aureus* (Lama et al. 2016). Local people also catch small mammals like pikas for consumption. Although hunting is prohibited, current trade and local use of wildlife species from these parts of Nepal are not clear. In Dolpa, stone trap and steel-jaw traps are or have been widely used by local people to kill large carnivores like snow leopards and wolves in retaliation for livestock depredation, which may adversely impact non-targeted animals like Pallas's cat (Lama et al. 2017). Recently, road construction reached remote settlements in Mustang and Manang Districts, accelerating habitat fragmentation and human disturbances within the Pallas's cat habitat.

The major threats to wildlife in the high altitudes of the Indian Himalaya include unregulated tourism, development activities, livestock grazing and disturbance (Fox et al. 1994, Bhatnagar et al. 2006, Geneletti & Dawa 2009, Humbert-Droz 2017), factors that are known or suspected to have a negative impact on the Pallas's cat (Chapter 8). Although wildlife hunting is prohibited, the presence of workers in Ladakh for development projects such as road construction might affect this cat negatively. There are several anecdotal records of outsiders hunting and consuming marmots and other herbivores. Pastoralism in Ladakh is an age-old practice; intensive livestock grazing and the presence of livestock guard dogs may have an impact on Pallas's cat, however, requires further investigation. For example, a Pallas's cat sighted in Hanle lacked its tail, presumably from having been attacked by dogs (P. Raina, pers. comm.).

Poaching and, before legal protection, hunting was thought to constitute main threat to Pallas's cat in China and law enforcement was considered to be weak (Sunquist & Sunquist 2002, Brown et al. 2003, Murdoch et al. 2006). The population was believed to have declined, and it was suggested that Pallas's cat was extirpated from the easternmost part of its range in China due to hunting (Nowell & Jackson 1996, Mallon 2002). Their main prey base, namely pika, were or still are routinely poisoned as vectors of bubonic plague (Nowell & Jackson 1996, Smith et al. 1990, Mallon 2002, Badingqiuying et al. 2016) and because they are also believed to cause damage to the grassland ecosystem and compete with livestock (Wilson & Smith 2015, Wu & Wang 2017). Recent studies in the southern Qinghai region show that the poisoning campaign is reducing carnivore abundance, possibly through prey depletion and secondary poisoning and could affect Pallas's cats (Badingqiuying et al. 2016).

Climate change is also expected to affect the species, but the consequences remain uncertain. Soon, climate change is predicted to affect the fragile mountain ecosystem of the Himalayas and the grasslands in the high steppes of China with adverse effects on biodiversity (Xu et al. 2009, Luo et al. 2015). This may alter the ecosystem functioning and adversely affect the availability of prey, and alter disease prevalence and the phenology of the species (Daszak et al. 2001, Ross 2009, Qu et al. 2016).

Fig. 3. A Pallas's cat camera trapped in Annapurna Conservation Area, Nepal (Photo Tashi R. Ghale / Global Primate Network Nepal).

Future Research and Conservation

Listed as Near Threatened on the IUCN Red List, Pallas's cats are experiencing a global decline in their population size (Ross et al. 2016). The species is included in Appendix II of CITES and is legally protected in the region. In India, it is a Schedule I species under the Indian Wildlife Protection Act, 1972 (Anon 1992) and Jammu and Kashmir Wildlife Protection Act, 1978. In China, it is a Class II species on the national list "Protected Animal of National Importance in China." In Nepal and Bhutan, although there is no special protection, it is illegal to hunt the Pallas's cat or sell its pelt. However, monitoring of illegal activities is relatively weak across most of the region.

There is a strong need for dedicated studies looking at the distribution, ecology, and threats of the Pallas's cat and to prescribe well-targeted conservation actions in all range countries. Conservation plan and systematic monitoring schemes are currently lacking, and direct or indirect effects of over-grazing through livestock, predation by dogs and human use of prey species need to be assessed. Education and information represent another priority. Compliance, law enforcement, and legislation need to be strengthened at the national level, and the scale of illegal trade of Pallas's cat pelts should be studied and assessed, best in a transboundary collaborative approach of the range countries.

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Legal status, utilisation, management and conservation of manul

Pallas's cats *Otocolobus manul* have an extensive range across Central Asia, covering 16 countries, from Iran in the west to China in the east. The global population is listed by the IUCN as Near Threatened. However, there is a wide variety with national conservation statuses, with some countries listing the species as Extinct (e.g. Armenia & Azerbaijan), others as Endangered (e.g. China and Turkmenistan) and some as Near Threatened (e.g. Pakistan, Mongolia, Kyrgyzstan). For regions (e.g. Mongolia & China) where historical data on the level of utilisation and trade is known, it was considered high (e.g. early 1900's in Mongolia offtake estimated at 50,000 skins) but for other regions the level is unknown (e.g. Bhutan, Nepal, India). Data indicates skins of Pallas's cats have been traded the most. Other used items derived from Pallas's cats include fats, oils, meat and organs. We lack data to estimate the extent of domestic versus international trade. 37 conservation and research projects were documented to date, but the species seems not to be included in any national action or management plan. From a conservation perspective the inclusion of Pallas's cat into such plans could be a key element in the long-term conservation of the species.

International trade in wildlife includes complex interactions with people and the environment, which are often poorly understood (Cooney et al. 2015). Elusive, cryptic behaviour of species can, when coupled with limited research studies, result in low detection rates making detailed knowledge on species occurrence, population size, status, threats and trends challenging. Such a situation is true for the Pallas's cat. Local communities living across Pallas's cat range countries have a poor understanding of what Pallas's cats are or even look like (Ruta 2018). Without reliable information, or basic understanding of the species, the ability to develop and implement effective conservation strategies or for its inclusion within local, national or international conservation management plans is likely compromised or even neglected. This chapter aims to provide an overview of Pallas's cat legal status, wildlife trade and utilisa-tion (domestic & international), management and conservation. Data was collected using a standardised questionnaire, distributed to in-country experts, as well as personal communication with Pallas's cat researchers, international trade through the CITES trade database, and trafficking information from publications. It must be noted however that, with the existing knowledge gaps of the species and the fact that the CITES trade database only reflects reported transboundary trade, some of the conclusions should be taken with caution.

Legal Status

The global IUCN Red List of Threatened Species lists the Pallas's cat as Near Threatened (Ross et al. 2016; Chapter 1). However, the species' listing in national Red Data Books varies depending on the country. Pallas's cats are considered extinct in Armenia and Azerbaijan (Askerov et al. 2013, Khorozyan 2010). Its status in Uzbekistan and Tajikistan is unclear and it is not listed in the Red Data Books of these countries based on the lack of presence records (Rahimi et al. 2017, Azimov et al. 2015; Supporting Online Material SOM). However, the species has previously been considered a resident or migrant species to all.

Three range countries (Bhutan, Iran, Afghanistan) do not have national Red Data Books of threatened species but the Pallas's cat is protected by law. In Nepal the species is listed as Data Deficient given the lack of species information (SOM).

Both China and Turkmenistan list the species as Endangered (Jutzeler et al. 2010, Rustamow et al. 2011) with populations in Kazakhstan and Russia considered "rare" (Dronova 2001, Grachev 2008). Pakistan, Mongolia and Kyrgyzstan currently list the species as Near Threatened (Sheikh et al. 2004, Clark et al. 2006, Davletkeldiev et al. 2006). No red list status for India could be found despite it being a protected species.

Pallas's cats are known to be protected by law in 12 of the 16 range countries, with the remaining four countries being Armenia and Azerbaijan where the species is extinct, Tajikistan where the status is unclear and Mongolia where the species is not protected. It is unclear, despite being regionally extinct, as to whether the species is still considered as "protected" in Armenia and Azerbaijan (SOM). In Mongolia 12% of the species range lies within important protected areas (Clark et al. 2006) but poaching of the species within these areas has been documented to be frequent (Murdoch et al. 2007). Despite it's Near Threatened status, Mongolia remains the only range country where (it is known) there is no legal protection for the species (Wingard & Zahler 2006) and where trophy hunters can purchase hunting licenses to export trophies, from which US$70 has been allocated to the government (Clark et al. 2006).

Although the species is fully protected by law in almost all other range countries with extant populations, Russia, Kazakhstan, Kyrgyzstan, Uzbekistan and China are known to have legal mechanisms for capture, hunting or even trade of Pallas's cats following strict regional permitting systems. However, such permits are often only issued for conservation purposes. In Russia these conditions are specifically documented in the legislation but in other countries such as Kazakhstan reasons for permit acquisition including ex-situ breeding, scientific investigation or development of traditional hunting (the last applies to specific bird species e.g. saker falcon *Falco cherrug*, golden eagle *Aquila chrysaetos* etc.) are less clear.

Trade and utilisation

Information on the level of Pallas's cat trade is available to some extent from animal trade databases and historical reports. Although there was little international trade, as of the mid-1990's, the manul had long been hunted for its fur in relatively large numbers. In the 1950's annual trade figures from Western China alone (excluding Inner Mongolia and Manchuria) were in the order of 10,000 (Tan1984, Nowell & Jackson 1996). Even greater annual off take occurred throughout Mongolia during the early 1900's which was reported as being as high as 50,000 skins (Heptner & Sludskii 1992, Wingard & Zahler 2006, Nowell & Jackson 1996) and in the mid-1970's harvests from Afghanistan were estimated at 7,000 (Rodenburg 1977, Nowell & Jackson 1996). Despite this historical harvest and trade of Pallas's cats for fur, with large numbers from Mongolia, Russia and China, the international trade in Pallas's cat pelts has largely ceased since the late 1980's (Fig. 1; Ross et al. 2016).

Trade and utilisation of the species was not restricted to skins as records indicate the fat, oil, meat and organs were also used for medicinal purposes in Mongolia and Russia (Ross et al. 2016; Chapter 8), however little data exists regarding scale or trends.

An important milestone for greater control and recording of international trade came on the 4 February 1977 when Pallas's cat (as *Felis manul*) was listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora CITES on Appendix II (CITES 2019). Currently all Pallas's cat range countries are member states of CITES except Turkmenistan (CITES 2019). Data from the CITES Trade Database, helps to provide a general overview of recorded trade in Pallas's cats since 1977. When a search is restricted to include only range countries as the "exporting countries" it shows that between 1977 and 2018 Russia (including former Soviet Union) had the highest number of records (69) for trade exports (i.e. number of times they were listed as exporting country). This was fol-lowed by Mongolia (32), China (31), Pakistan (1) and Afghanistan (1). During this period the items traded in the greatest volume were skins with a total reported quantity of 4,522, followed by specimens (i.e. any recognisable part of the species) with a total of 767 and live specimens with a total of 124 (CITES 2019).

It is important to note that prior to 1989 no "source" records (i.e. confirmation of the source location) are available highlighting the caution when using these figures.

When records are only used where the source location is known (1989 – 2018) and restricted to "taken from wild" (W), "confiscated or seized" (I) and "taken from wild as juvenile and reared" (R) the figures for reported quantity of the above items change with skins totalling 11, specimens totalling 441 and live specimens totalling 51 (CITES 2019).

When considering all trade exporter reported quantities from range countries recorded by CITES, the database does indicate a peak of recorded international trade between 1984 and 1992 with a decline thereafter (CITES 2019; Fig. 2).

Whilst there is some value in using this CITES database tool as a general guide such figures are unlikely to provide a realistic account of the full extent of trade during this timeframe given that domestic trade is not accounted for and that there is an issue of potential duplication of records for import/export of the same item's multiple times. It is also worth noting that there is a wide variety to "purpose" of Pallas's cat trade items, as used in the database. Listed purposes include breeding in captivity or artificial propagation, educational, hunting trophy, medical (including biomedical research), reintroduction or introduction into the wild, personal, scientific, commercial and zoo.

Despite some records indicating a diminished trade in Pallas's cat data from questionnaires, compiled during this report, highlighted that some level of trade, hunting and harvest continues. Six out of the eight range country questionnaires (Afghanistan, Iran, Pakistan, Bhutan, Nepal and India) stated that both Pallas's cat harvest/hunting/culling and trade in body parts continues, however the number and trends are largely unknown. The remaining questionnaires, from Armenia and Azerbaijan, reported no harvest, hunting, or culling however given that populations are considered extinct in both countries this should be expected. Given the documented decline in (international) trade of Pallas's cats in the last two to three decades (Fig. 1) it is likely that current hunting and trade activities are unlikely to be extensive, but for areas with a small and fragmented population, the impact could still be significant. Data from Iran suggests the species is occasionally killed by herders. Additional records reported 16 verified mortality records of the Pallas's cat in Iran caused by herding or feral dogs (n = 7), live capture attempts by local people or wildlife authorities (n = 7), and poaching (n = 2; Farhadinia et al. 2016; Chapter 4). In Afghanistan hunting/harvest as well as trade were reported to occur. Pallas's cats were stated to be captured for pets/domestication and killed for skins to make blankets. Again, the number and trend were unknown. In Pakistan the level of hunting/harvest is unknown however trade was identified as being present. Like in Afghanistan, Pallas's cats were captured for pet/domestication and killed for their skins. Although the number taken was unknown, it was recorded that the trend was increasing.

Mongolia continues to be the only range state which still permits hunting for "household purposes", although the permitting system is considered ineffective and Pallas's cat furs were exported to China as of 2005 (Murdoch et al. 2006). The continuing "trade" in Pallas's cats from Mongolia is highlighted by the number of CITES export permits for the species. Between 1996 and 2015 Pallas's cats export permits (28) were ranking fifth behind that of grey wolf *Canis lupus* (291), argali *Ovis ammon* (263), saker falcon (83) and golden eagle (30; Wingard et al. 2018). As Mongolia is considered the "stronghold" of the species (Ross et al. 2016) and as China is hosting 50% of the global manul distribution range (Jutzeler et al. 2010), developments in both countries have the potential to have a significant impact on global trends.

Trade and or hunting in Pallas's cats is only one of several factors that has the potential to influence wild populations and conservation status. Culling or hunting, possibly even trade, in Pallas's cat prey or sympatric species such as pika *Ochotona* spp. or marmots *Marmota* spp. could also be a key factor. Pallas's cats depend on marmot burrows and rock cavities particularly for raising young (Ross et al 2010a) and any significant change in marmot distribution and abundance could negatively impact the species. Pallas's cats are also shot as mistaken for marmots (Ross et al. 2016).

Data collected during the first cross-sectional study on wildlife trade in Mongolia, Silent Steppe (Wingard & Zahler 2006) and Silent Steppe II (Wingard et al. 2018), aimed to identify both, practices and trends over a ten-year period. The study undertook surveys within local communities and at markets conducting 5,100 surveys in 2005 and then 4,920 in 2016. Results from the second study (2016) indicat-

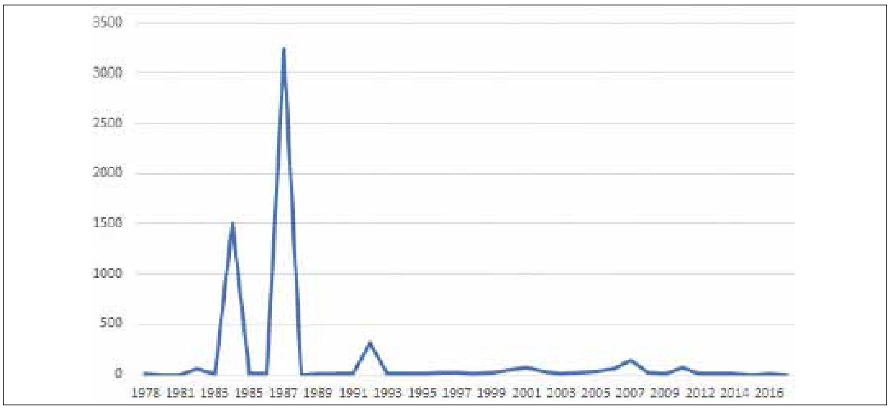

Fig. 2. Reported quantities of all Pallas's cat exports from range countries 1978 – 2016 (CITES trade database 2019).

38

ed that 44% of hunters targeted Siberian marmots and although total take per hunter was down compared to 2005, the total estimated take volume still indicates significant levels of illegal hunting, exceeding quotas by many magnitudes (Wingard et al. 2018).

In addition to marmots, pika are an extremely important species for the survival of Pallas's cats, as they are known to make up most of their diet (Ross et al. 2010b). Prey depletion is hence a serious threat for Pallas's cats as pika are poisoned, over-hunted and targeted as pests in China and Mongolia due to their competition, with livestock, for forage (Ross et al. 2016). It has been reported that whilst poisoning continues in China, pika populations have been reduced to less than 5% of pre-control densities (Lai & Smith 2003, Ross et al. 2016; Chapter 8 & 5). China is not alone in this practice as control of other Pallas's cat prey (i.e. rodents) in Russia also continues, however it is suggested that this only occurs at small localised scales which are not expected to threaten Pallas's cats (Shilova & Tchabovsky 2009, A. Barashkova, pers. comm., Ross et al. 2016; Chapter 3 & 5).

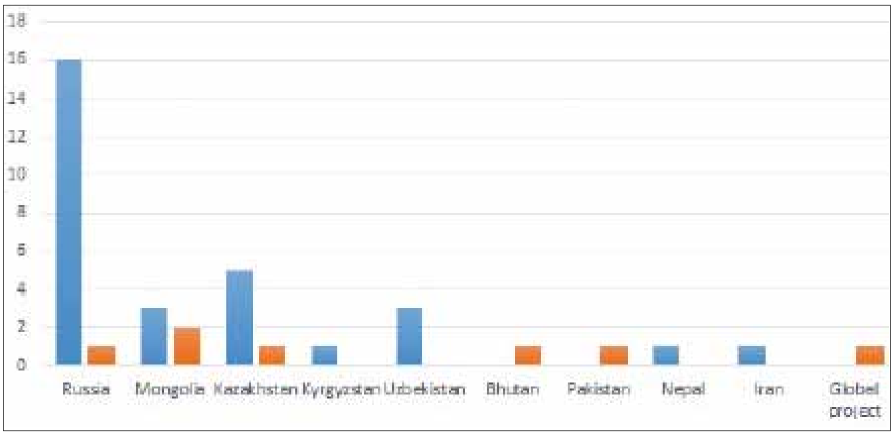

Fig. 3. Number of Pallas's cat field projects to date: completed (blue) & ongoing (orange; Chapter 3, PICA 2019)

Management and conservation

The Pallas's cat is recognised by species specialists and conservationists as a species of special conservation concern in every range country where its presence is known. It is an indicator species for steppe habitats, and efforts to improve our understanding on presence, distribution, population dynamics and threats would not only improve our ability to conserve the species, but also benefit other key species across its range. Data from questionnaires indicated that there are currently no formal national conservation management plans or conservation action plans for the species across any of the range countries.

Despite the lack of inclusion in national action plans there has been, and continue to be, several conservation and research projects undertaken across the range. Central Asia has likely had the largest amount of field projects with 33 projects being undertaken since 1992 (Chapter 3). The first recorded field project in Central Asia was undertaken in Russia in 1992, which focused on distribution, abundance and habitat preference of manul (SOM Chapter 3). Since then there has been 16 other projects in Russia, 5 in Mongolia, 6 in Kazakhstan, 3 in Uzbekistan and 1 in Kyrgyzstan. Outside of Central Asia there has been one project in each Iran, Nepal, and Bhutan, and a new project is currently being developed in Pakistan (PICA, pers. comm.). An over-arching project (Pallas's Cat International Conservation Alliance PICA (www.pallascats.org) supports the development of field project across range countries.

Although there has been a wide and prolonged interest in Pallas's cat field research, covering a period of 26 years and across nine range countries, there are unfortunately only six projects that are currently active (Fig. 2). Data from these projects does however indicate an increase in the development of specialised field monitoring techniques, increased species awareness and education throughout range country communities as well as an improved understanding of Pallas's cat distribution, habitat use and threats (Chapter 3). Another important tool in the long-term support to in situ conservation and research is the Pallas's Cat Working Group PCWG – http://www.savemanul.org/eng/). Established in 2012, the PCWG includes currently 30 members from 11 of the 16 range countries as well as specialists from non-range countries. Although Pallas's cats have not yet been integrated into any formal national plans, there are existing strategic plans focused toward sustainable management and biodiversity within all range countries (excluding Uzbekistan and Kazakhstan) that could indirectly benefit the species. As an obligation to the Convention on Biological Diversity, National Biological Strategies and Action Plans NBSAP's) have been developed by 14 of the 16 range countries, documenting a commitment to conservation and sustainable use of biological diversity and natural resources (CBD 2019). Current conservation efforts for Pallas's cats could give greater internation-al credibility and an increased potential for its future inclusion by regional authorities into strategic management plans.

Discussion

While some reports indicate that global trends in international wildlife trade are increasing (Roe 2008) data for Pallas's cats suggests that the current level of trade is significantly lower than that of the 19th and early 20th century. However, there is still a need to increase understanding of the risks and opportunities presented by trade in order to improve the management of its impacts on conservation and livelihoods (Cooney et al. 2015). With Pallas's cats absent from all formal national management or action plans it is likely, should they be included in the future, that this would benefit the species conservation. National and international policy can be a major influencer on conservation and livelihoods, particularly through determining whether legal trade can occur and under what conditions (Cooney & Abensperg-Traun 2013). For small, elusive species like the Pallas's cat where a detailed understanding of local populations is rarely available, it is easy for them to go unnoticed in terms of national conservation value. High profile species (e.g. rhinoceros, tigers, elephants) often dominate academic and policy debates to a point where complex international wildlife trade products, actors, networks and contexts are overlooked (Phelps et al. 2016). It is therefore important that efforts to increase the species recognition, e.g. inclusion in management plans, global aware-ness, improved education, are delivered at the same time as other conservation efforts e.g. threat control programme, training of border guards/customs officers, protection of key habitats. While it is recognised that many species require conservation action, the question of how to use limited and usually inadequate human and financial resources most effectively remains a critical issue when designing practical conservation strategies (IUCN/SSC 2008). The Pallas's cat conservation strategy (Chapter 10) should not only act as a catalyst for increased conservation action, but also as a tool to enable prioritisation of actions and the best use of all available resources. There are still considerable gaps in our knowledge of Pallas's cats which impact our ability to deliver targeted actions. However, with the PCWG as an international network, the PICA to support global awareness and the development of further projects, and the Conservation Strategy (Chapter 10), the potential for successful long-term conservation of the species has improved.

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Ex-situ conservation of manul

Throughout history the primary objective of ex-situ facilities i.e. zoological collections (zoos and aquariums) has evolved, moving away from simple exotic attractions and more toward specialised centres of education, research and conservation. In 1946 the World Association of Zoos and Aquaria WAZA was formed, albeit under its former name the International Union of Directors of Zoological Gardens IUDZG. WAZA has since acted as the "umbrella" organisation for the world zoo and aquarium community and has been instrumental in the global development and contribution of zoos towards conservation. This is highlighted by the WAZA vision "*A world where all zoos and aquariums maximise their conservation impact*" (Barongi et al. 2015). With over 300 WAZA member institutions and 700 million annual visitors it is clear to see the vast reach zoological collections have and the enormous potential for zoological institutions to become conservation leaders. Through a dedicated focus and global collaboration zoos continue to play a vital role in the primary elements of ex-situ conservation, these being; education, research, capacity building, in-situ support and ex-situ population management. This is highlighted by the annual financial contribution of zoos toward conservation of over $350 million.

Ex-situ conservation

There is an increasing need to ensure the integration of in-situ and ex-situ conservation planning to ensure that, whenever appropriate, ex-situ conservation is used to support in-situ conservation to the best effect possible (IUCN/SSC 2014). To date, ex-situ management has been used successfully to deliver conservation benefit for a range of threatened species (IUCN/SSC 2014). As the role of conservation management evolves it has been suggested that the boundary between ex-situ and in-situ management is becoming blurred (McGowan et al. 2016). The IUCN recognises the considerable set of resources committed worldwide to ex-situ conservation by the world's zoological and botanical gardens, gene banks, and other ex-situ facilities. The effective utilisation of these resources represents an essential component of conservation strategies at all levels (IUCN 2002). With regards specifically to in-situ population support, be it from reintroductions or reinforcement, there is no doubt that ex-situ management has played a significant role. Well known examples such as the California condor *Gymnogyps californianus*, Arabian oryx *Oryx leucoryx*, whooping crane *Grus americana* and the black footed ferret *Mustela nigripes*, to name a few, highlight this contribution (Maunders & Byers 2005). However, wild populations that may not require immediate conservation action from reinforcement or reintroductions, like the Pallas's cat, can still benefit from targeted ex-situ activities. Actions including species specific research, capacity building, education campaigns, awareness and fundraising are all available from ex-situ facilities. It is important however that additional activities undertaken in the ex-situ environment are transformed into tangible contributions to species conservation and where possible target their support toward range countries.

Ex-situ contribution to Pallas's cat conservation and research has been active for some time with individual zoological collections such as Cincinnati Zoo, Denver Zoo, Moscow Zoo and the Royal Zoological Society of Scotland RZSS having, historically, supported several projects. Although some of this support work continues, for example Moscow zoo still contribute to the Pallas's cat Study and Conservation Program led by the Siberian Environmental Centre, few were conducted with a long term or large-scale vision. In 2016 a tripartite partnership between RZSS, Nordens Ark and the Snow Leopard Trust gave rise to the Pallas's cat International Conservation Alliance PICA. PICA has since established a collective approach from zoological collections toward in-situ conservation support with 14 global zoological collections, representing all zoological regions holding the species, providing financial support. This funding along with core project funding from Fondation Segre and support from the Pallas's Cat Working Group PCWG allows PICA to develop range country education, conservation capacity building, support to in-situ field projects, research and long-term conservation planning. Zoos are also increasingly adopting an approach to species conservation, called the One Plan Approach. The One Plan Approach is a conservation planning framework that integrates all populations of a species, both in-situ and ex-situ, under all conditions of management, bringing together all responsible stakeholders and all available resources. The development of one integrated plan creates a greater collaboration between zoological facilities and other conservation organisations and is the most effective use of all populations and all existing expertise to promote the conservation of a species (Byers et al. 2013). PICA applies the One Plan Approach philosophy ensuring that there is a tangible connection between ex-situ and in-situ conservation efforts. PICA's key objectives focus on in-situ support, capacity building, education and research (PICA report). Since 2016 PICA has made great efforts to widen the Pallas's cat network by forming new connections between conservationists, researchers and specialists in ex-situ population management. This work supports the existing Pallas's cat community which has, in large, been driven by the PCWG, formed by experienced species-specific field researchers and conservationists. Through this community PICA has been able to connect directly with researchers working across Pallas's cat range countries and support their work financially or through the provision of field equipment. This would not have been possible without the direct support from ex-situ zoological institu-

Fig. 1. Pallas's cat on display at Nordens Ark Zoo, Sweden (Nordens Ark 2016).

Fig. 2. Pallas's cat kittens born at Chemnitz Zoo, Germany 2018 (Photo Chemnitz Zoo).

tions. To date PICA has supported six field projects/researchers working across Nepal, Russia, Kazakhstan, Mongolia, Bhutan, Uzbekistan and Kyrgyzstan. This work continues to bolster the existing efforts from individual zoological collections and the working group in support of Pallas's cat conservation and research.

Regardless of origin (ex-situ or in-situ) conservation action should always have a primary focus toward range country populations, threat mitigation and habitat protection whilst establishing a strong connection with local communities and authorities. With a collaborative approach through global partnerships and targeted pro-active support it is clear that ex-situ institutions can continue to play an important role in the long-term conservation of Pallas's cat.

Population management

According to the Zoological Information Management System ZIMS Pallas's cats were first recorded in zoological collections in the late 1950's (Barclay 2018a), however written records from Moscow zoo indicate specimens were held as early as 1949 (I. Alekseicheva, pers. comm.). Like many small cat species during this time exact knowledge on their biology, physiology, veterinary care and reproduction was scarce and as a result the population proved challenging to manage. Although challenges still exist with captive management of the species there are currently four managed populations in the European, Russian, North American and Japanese Zoological associations. As of August 2018, there were 177 Pallas's cats held across 60 global zoological collections coordinated jointly by regional breeding programmes in Europe, North America and Japan all of which are included in the Pallas's cat International studbook ISB managed by WAZA (Barclay 2018a). Since the 1950s 136 individual collections have managed a historical global population of 1,526 specimens (Barclay 2018a; Fig. 1, 2). Europe (including Russia) has consistently managed the largest population followed by North America and Japan.

Pallas's cats have also had a long history with several range country (Russian) zoological collections including Moscow zoo, Novosibirsk zoo, Leningrad zoo, and Chita zoos, as well as at the zoos of Rostov-on-Don, Seversk, Izhevsk, and Perm. This close connection to range country zoos has been an important tool in ex-situ population management as it offers a route for wild caught animals to enter zoos should this ever be necessary.

Within zoos captive populations are predominantly managed as breeding programmes, which include studbooks, the population management database for the species. Regional zoological associations often offer a range of management levels (high level to low level) to breeding programmes dependent on varying factors such as conservation status, population size, management challenges or education needs. Breeding programmes aim at conserving healthy populations of animals in captivity. The populations should be demographically robust, the animals behaviourally competent and genetically representative of wild counterparts, and the breeding programme should be able to sustain these characteristics for the future. In Europe the first studbook for Pallas's cat was developed by Moscow zoo in 1997 and managed until 2004. Since this time the studbook and breeding programme have been managed at the highest level as a European Endangered Species Programme EEP by the RZSS.

In addition to the European EEP the American Association of Zoos and Aquaria AZA manage a Pallas's cat Species Survival Plan SSP, the Eurasian Regional Association of Zoos and Aquariums EARAZA manage a Pallas's cat Research, Conservation and Breeding Programme and the Japanese Association of Zoos and Aquaria JAZA manage a Pallas's cat breeding programme. Animals from all these individual programmes are included in the wider WAZA Pallas's cat International Studbook, also managed by RZSS.

The first captive breeding event for Pallas's cat was documented in the International studbook in 1960 at the National Zoological Park, Washington (USA) although the offspring did not survive more than three days. The first surviving birth was recorded at Augsburg zoo (Germany) in 1971. This individual lived until it was three years old before it died whilst at Hannover zoo (Germany) in 1974 (Barclay 2018a). Range country zoos have also successfully bred the species with the first being Moscow zoo (1979) followed by Novosibirsk (1995). Subsequent births took place in Leningrad zoo, Seversk zoo and Perm Zoo (Barclay 2018a). By 2018, a total of 294 kittens were born at Russian zoos, with over 76% born between Moscow zoo (149) and Novosibirsk zoo (76). Since the 1960's there have been over 1,300 captive births recorded in the International studbook ISB.

Although data from captive management programmes of Pallas's cats may be considered somewhat biased given that populations are actively managed they still provide opportunities to improve our understanding of the species biology. From historical data we can accurately assess, at least for captive populations, a range of biological factors such as; seasonality, litter size, generation length, life expectancy, causes of death, sexual maturity, activity patterns and specific behaviours. Such data can in turn be used to assist field research projects.

In captivity the main breeding season runs from January to May. January, February and March are the key months for mating with March, April and May the key months for parturition. The highest percentage of births occur in April (43%), followed by May (26%)

and March (18%). The mean litter size is 3.9 however litter sizes of 9 have been recorded (Barclay 2018b). One of the largest litters (6) where all offspring survived was recorded by RZSS Highland Wildlife Park in 2014 (Barclay 2018a). Pallas's cats can be sexually active in their first year with the youngest female to have bred being eleven months and eight days with the youngest male to have sired offspring being eight months and twenty-nine days. The average age for females at first birth is two years eleven months and five days, whereas the average age for males to sire their first litter is three years four months and ten days. The longest living male specimen, with known birthdate, was fifteen years and eleven months at death with the longest living female was sixteen years at death (Barclay 2018b). The current global population has a gene diversity of 95.4% and derives from 36 "founders" i.e. individuals that are related only to their direct descendants in the living population and assumed to be completely heterogenous (Barclay 2018c). Most of the founders arrived at Russian and former USSR zoos from the Trans-Baikal region, particularly from the Tyva Autonomous Republic, except for a small number of cats that came from Mongolia between 1985 and 1989 (I. Alekseicheva, pers. comm.). Most of the wild caught animals arrived in Russian zoos in the period from 1990 through 1999. From 1999 onwards, the transfer of wild animals into zoos reduced dramatically with only two separate transfers into regional (Russian) zoos: 7 animals were obtained by the Moscow Zoo and 4 by Novosibirsk Zoo (Barclay 2018a). With established populations across four zoological regions the objective for the global captive population is to develop and maintain a self-sustaining pop-ulation whilst retaining a high genetic diversity and low level of mean kinship.

Ex-situ research

Captive management and research provides zoos with a unique opportunity to increase the understanding of species and their behaviour. This can be particularly beneficial to species that are notoriously challenging to study in-situ. Cryptic behaviour, high altitude range, remote and hostile habitats and predominantly nocturnal or crepuscular daily activity patterns places the Pallas's cat firmly within this category. In addition to data extracted from captive breeding programmes i.e. birth seasonality, litter size, sexual maturity etc. zoos can, and have, undertaken various research projects that has helped shed new light on both animal behaviour and other species-specific issues.

A study in Moscow Zoo between 2006–2007 examined the activity budgets of Pallas's cats in relation to season, time of day and animal physiological status. Until this study very little quantifiable data relating to activity budgets from wild living animals had been collected with most information comprising of anecdotal evidence. Apart from activity budgets no data on seasonable behaviour in the species was found in any published materials (Alekseicheva 2009). It has however been suggested that wild living Pallas's cats move over greater distances during winter months to find better feeding territories (Kirilyyuk 1999). The study in Moscow zoo collected data from six individuals (three male and three females) four of which were proven breeders and two having mated but producing no offspring. Evidence from this study showed that, in captivity, Pallas's cat activity decreases in late winter and early spring and then increases in April and May. The study also showed a slight increase in activity from all but one animal during October to November. It was suggested that this change could be caused by an "inherited tendency" to increase body mass prior to the breeding season (Alekseicheva 2009). Other studies at Moscow Zoo's Breeding Station indicated that an increase in daily food consumption occurs as early as June (Demina 2006) but that it is in October when the behaviour of "food craving" begins (Alekseicheva 2009). All animals produced a pronounced peak of activity in February which was believed to be directly related to the breeding season. The highest activity was recorded in males that demonstrated sexual behaviour (Alekseicheva 2009).

In the wild Pallas's cats are considered to be predominantly crepuscular with most encounters occurring in early morning or after sunset (Alek 2000). Research from wild studies also found animals would start hunting one or two hours before sunset (Bannikov 1954). Evidence from the Moscow zoo study found that most daily activity for the males and females would peak at three separate periods throughout the day. The first activity peak occurred between 01:00 h and 08:00 h, the second between 10:00 h and 16:00 h with the final peak between 16:00 h and 23:00 h (Alekseicheva 2009). This evidence suggests that captive Pallas's cat exhibit both crepuscular and diurnal activity patterns.

A study at RZSS Highland Wildlife Park set out to record and analyse vocalisations from Pallas's cat as a means of monitoring and managing behaviour during the breeding season. This study used an automatic recording device to non-invasively collect vocalisations (above minus 16 decibels) from the breeding pair between December 2013 and February 2014. Recordings were collected and stored systematically each day with vocalisations separated into six categories; "base call", "hissing", "growling", "yowling", "fighting" and "mating". During a two-month period over 1,500 individual vocalisations were recorded. The "base call", which was considered the main mating call, was the most prominent call recorded during the study period. The peak vocal activity was noted as being most intensive between the hours of 02:00 h and 09:00 h. During a four-day period in mid-January 2014 the frequency of call "type" changed significantly from predominantly base calls, hissing and growling to mating and growling. This four-day period also correlated with a reduction in appetite from both cats.

Fig. 3. Pallas's cat featured alongside snow leopard during a Chinese giant lantern festival, RZSS Edinburgh zoo, Scotland (Photo RZSS, 2017)

Over the four-day period the results indicated this was the most intensive period of mating calls and as a result the male was removed from the female in preparation of an assumed pregnancy and birth. These results allowed for the animal management plan to be refined to limit any unnecessary disturbance around the enclosure. This data also allowed for the administering of oral medication (Clindamycin) to the female prior to birth to reduce the risk of parasitic infection from *Toxoplasma gondii*. Following a gestation period of 68–72 days the female produced a surviving litter of six kittens. Toxoplasmosis is a common cause of neonatal mortality within the captive population. Evidence suggests that Pallas's cats are rarely exposed to Toxoplasma in the wild and may be highly susceptible to this parasite from an evolutionary basis (Brown et al. 2005, Swanson et al. 2010).

This work has not only shed new light on species specific behaviours during the breeding season but also on the range and frequency of vocalisations. Since this study specific vocalisations have been made available to field researchers for use in field monitoring surveys. In 2018 a camera trapping study was undertaken in the Tian-Shan mountains of Kyrgyzstan using these vocalisations in conjunction with camera trapping surveys. Camera traps were setup up in Pallas's cat habitats where presence was already confirmed to test the effectiveness of vocal lures against that of olfactory lures. The study is due for completion in December 2018.

Ex-situ research that has involved the transfer of samples from the wild to captivity with the long term aim of artificial propagation in support of captive population sustainability has also been undertaken. Semen samples were collected from wild living Pallas's cats in the early 1990's by staff at Cincinnati Zoo's Centre for Conservation and Research of Endangered Wildlife CREW, working in collaboration with the Mongolian Academy of Sciences, Bristol University and the Wildlife Conservation Society (Oyuntuya et al. 2012). These samples, which have been cryogenically preserved since, have made it feasible for artificial insemination A. I. procedures to take place in the zoological facilities. In partnership with the North American SSP breeding programme CREW have been able to trial insemination procedures with captive born females using these samples with the objective of adding new (wild) founder genes to the captive population. Initial studies showed that frozen sperm from wild males had excellent motility post-thaw and could readily fertilize both Pallas's cat and domestic cat oocytes in vitro to produce developing embryos. Although A. I. with these frozen wild samples failed to result in any pregnancies, several full-term pregnancies have been produced by A. I. in U.S. zoos using both freshly-collected semen and frozen semen stored for 23 years before use (Swanson, in press). Further refinement of these semen freezing and A. I. procedures should allow viable offspring to be produced from wild specimens and facilitate increased collaboration with field teams to improve captive sustainability.

Education to conservation support

Zoos provides a unique experience for people as they see, hear and smell wild animals from their local environment and from all over the world. These experiences can often be the first point of contact between zoo visitors and the animals themselves making it a significant bridging moment in terms of zoo education. For small, unique and elusive species like the Pallas's cat that have, historically, been given a low level of media exposure (certainly when compared to the larger more iconic species) it can at times create challenges for people out-with range countries to establish a strong connection or understanding with the species. Even within range countries basic knowledge of the species can be somewhat lacking. Zoo education programmes can however help fill this gap by taking advantage of the daily encounters with zoo visitors and by supporting education campaigns across range countries. Developing these connections between people and animals helps to encourage empathy with the natural world and a sense of responsibility and stewardship, all of which can lead to more active support of conservation projects. Zoo education programmes offer a wide range of opportunities for visitor engagement and, dependant on certain factors e.g. connection to specific conservation projects, can be adapted accordingly to target individual species. With regards to Pallas's cats there are several activities undertaken by global zoological collections that not only aim to improve the visitor's knowledge of the species but aim to turn the experiences and connections into conservation support. These activities include daily zoo keeper talks, animal enrichment displays, public presentations, children's art competitions, media exposure, distribution of educational materials and fundraising events (Fig. 3, 4). Some collections, like that of Moscow zoo (who had the Pallas's cat as their zoo emblem) and Novosibirsk Zoo have taken Pallas's cat awareness one step further by establishing an annual zoo event "Day of the Pallas's cat". This event has the added ability of combining the positive role of ex-situ education with the education of zoo visitors from a range country.

It is important however that whilst zoos deliver a diverse range of education-based activities that they also try to evaluate the impact of these activities with regards to zoo visitor perceptions toward the natural world, species and conservation.

A study conducted across several North American zoological collections (members of AZA) helped to shed light on the impact of targeted education programmes within the zoo environ-

Fig. 4. Pallas's cat public enrichment display, Parken Zoo, Sweden, 2010 (Photo Parken Zoo).

ment. Over three-year period more than 5,500 zoo visitors were surveyed across twelve AZA accredited institutions with the aim of identifying the changes in visitors thinking towards awareness and understanding of zoos and the role they play in conservation. Results showed that 61% of visitors found that their experience supported or reinforced their values and attitudes towards conservation (Falk et al. 2007). Zoo visits also prompted 54% to reconsider their role in environment problems and conservation action, and to see themselves as part of the solution (Falk et al. 2007). Most visitors (54%) also said that their visit experience strengthened their connection to nature (Falk et al. 2007). This study highlights the positive impact zoos education programmes can have in not only changing the mind-set of zoo visitors but in translating this into greater support toward conservation projects.

Zoo education programmes are not always restricted to the ex-situ environment and at times can also offer additional skills and expertise in support of in-situ action. A recent project from PICA utilised existing ex-situ skills, focused on educational design, to develop Pallas's cat specific posters, leaflets and pockets guides to be used across range countries. These materials were translated into multiple range country languages and have since been made available, with additional financial support, to field researchers and distributed across range countries including Mongolia, Nepal and Kyrgyzstan (Fig. 5). This work highlights the positive connection that can be made between ex-situ and in-situ education programmes and how this can directly support the efforts across range countries. For most zoo visitors that will never have the privilege of visiting Pallas's cat range countries zoo-based education programmes play an important role in not only increasing the awareness of a species but also by inspiring and developing some of the next generation conservationists. With greater interest and support towards Pallas's cat's conservation, research and education it is clear to see that ex-situ facilities fulfil a valuable role in global conservation efforts.

Fig. 5. Children receiving PICA educational posters, Kyrgyzstan 2018 (Photo PICA).

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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).

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).

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.

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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Pathogens and parasites as potential threats for the Pallas's cat

Pathogens may be important factors affecting population dynamics of different wild mammalian species (Roelke-Parker et al. 1996, Daniels et al. 1999, Goncharuk et al. 2012, Bevins et al. 2012). There are several examples of different pathogens leading to a decrease in number or even extinction of different populations of mammals in the wild (Roelke-Parker et al. 1996, Meli et al. 2009). These have been epizootics caused by mutated canine distemper virus CDV in the Serengeti in 1994, and feline leukemia virus in Doñana National Park (Spain). Sometimes also very unusual pathogens may result in the death of animals. For example, Eurasian lynxes in a Netherlands zoo succumbed to the Bluetongue virus (Jauniaux et al. 2008), and the lethality of CDV to bears has been previously described (Cottrell et al. 2013). Knowledge of potential threats and risks for animal species, including infectious/invasive pathogens, may has critical value for their conservation.

Very little is known about the natural sources of most infections in wild cats. At the same time, many species or populations of Felidae, including the Pallas's cat, are already seriously threatened by factors such as reduced and fragmented range, habitat destruction and poaching of the predators themselves or their prey. Thus, otherwise minor diseases can potentially be devastating if occurring in feline populations that are already small or in decline. In addition, the Felidae are susceptible to a wide array of highly lethal or debilitating microparasites (Appel 1994), many of which are either native to, or easily transmitted by domestic species (Roelke-Parker et al. 1996). Free-ranging domestic cats and dogs might be regarded as the most likely source of different pathogens for wild cats.

It is very difficult to obtain data on felids, especially small species, and their mortality in the wild when addressing the reasons of their death. Correctly diagnosing causes of mortality is very difficult since the animals need to be studied when they are ill or immediately after death. This is additionally hampered by habitats difficult to access such as the ones of the Pallas's cat. In this case, data obtained from captive individuals becomes very valuable. It is known, that *Toxoplasma gondii* may result in deaths of adult and young Pallas's cats in captivity. Some authors believe that toxoplasmosis prevents the accumulation of a sustainable captive population of this cat. Captive breeding of Pallas's cats has been successful; however, the kittens' survival has been low (40%; Swanson 1999, Kenny et al. 2002) primarily because of susceptibility to *Toxoplasma gondii* (Dubey et al. 1988, Basso et al. 2005). However, some other infectious agents may result in death of Pallas's cats too. Our analysis showed that in the Moscow Zoo, feline panleukopenia virus FPV caused the deaths of Pallas's cats in 43% of the cases (of 37 analysed animals). Among younger animals (up to 6 years of age) this percentage was even higher with 59% (T. S. Demina, pers. comm.). Another 8% of animals died of co-infections (toxoplasmosis and panleukopenia) and 14% of toxoplasmosis. Respiratory infections (rhinotracheitis and calicivirus) caused 5% of deaths of Pallas's cats (Fig. 1). To sum up, infectious pathogens resulted in the death of 76% of captive Pallas's cats, and among animals up to 6 years old this number increased to 96%. Most of these animals were vaccinated against rabies, feline calicivirus, panleukopenia and herpesvirus but based on the results this vaccination was not effective (later the vaccine producer has been changed).

Little is known about the effect of these path-ogens on Pallas's cats in the wild. To date, cases of death of wild Pallas's cats from FPV and undetermined causes have been documented in the wild in Russia (Kirilyuk & Puzanskii 1999). In comparison with captive Pallas's cats, a low prevalence of some pathogens has been found in Mongolian and Daurian wild Pallas's cats (Dubey et al. 1988, Basso et al. 2005, Brown et al. 2005, 2010, Naidenko et al. 2014). Brown et al. (2005) showed that prevalence of antibodies to *T. gondii* was 13% (2/15) in wild cats in Mongolia, but 100% (9/9) in tested cats in captivity. Another potential pathogen in wild Pallas's cats is *Cytauxzoon* documented in Mongolian cats but not in captivity (Ketz-Riley et al. 2003). These studies were conducted in Mongolia where the density of feral domestic cats is extremely low. In Russia, free-ranging domestic cats inhabit the same area as the Pallas's cat. However, little is known about the prevalence of different pathogens in these domestic cats, although they could potentially be an important source for infections in Pallas's cats.

The presence of pathogens in the Pallas's cat populations was studied in the northern range (Daurian reserve, Russia) more thoroughly than at other sites. On the northern edge of the range the seroprevalence to different pathogens was analysed for Pallas's cats (Naidenko et al. 2014), domestic cats (Pavlova et al. 2015) and their potential prey (Pavlova et al. 2016; Table 1). The Pallas's cats (n = 22) were serum positive to 5 of the 15 potential pathogens that were assessed

Fig. 1. Rhinotracheitis in captive Pallas's cat in Moscow zoo (Photo T. Demina).

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Table 1. Serum prevalence of Pallas's cats, domestic cats and their potential prey species to different pathogens (Naidenko et al. 2014, Pavlova et al. 2015, 2016).

Pathogen	Test system	Pallas's cat	Domestic cat	Prey species*
Toxoplasma gondii	EIA, Hema, Vector-Best (both Russia)	2/22	9/61	10/273
Feline panleukopenia virus FPV	Dot-test Immunocomb (BioGal, Israel)	0/20	27/60	
Feline herpes virus FHV	Dot-test Immunocomb (BioGal, Israel)	0/20	0/61	
Feline calicivirus FCV	Dot-test Immunocomb (BioGal, Israel)	0/20	37/60	
Canine distemper virus CDV	EIA, Hema (Russia)	0/16		
***Chlamydia* sp.**	EIA, Hema (Russia)	0/16		
Mycoplasma sp.	EIA, Hema (Russia)	2/16		
Feline immunodeficiency virus FIV	Speed-test, BVT (France)	1/19	6/58	
Feline leukemia virus FeLV	Speed-test, BVT (France)	1/21	6/58	
Feline coronavirus FCOV	Dot-test Immunocomb (BioGal, Israel)	0/3		
Influenza A virus	EIA, Narvak (Russia)	2/22	0/60	89/136
Pseudorabies virus	EIA, Narvak (Russia)	0/8		
Candida sp.	EIA, Hema (Russia)	0/14		
***Trichinella* sp.**	EIA, IDVet (France)	0/19	1/61	13/251
Coxiella burnetti	EIA, IDVet (France)	0/19	2/55	0/148
Bluetongue virus	EIA, IDVet (France)			

**the seroprevalence to these pathogens was different for different species. Bold names: pathogens which Pallas's cats were found to be serum positive for, but data is not published yet.*

by kits of Hema and Narvak (both – Moscow, Russia), IDVet and BVT (both France) and Immunocomb (BioGal, Israel; for details see Naidenko et al. 2014, Pavlova et al. 2015, 2016). Later we continued this study, increased sample size to 40 Pallas's cats and tested the serum prevalence to sixteenth pathogen (bluetongue virus). For the first time we found few individuals serum positive for four more pathogens (feline calicivirus, feline coronavirus, *Chlamydia* sp., *Trichinella* sp.). It is very difficult to estimate the negative effect of pathogen exposure on Pallas's cats: some of them usually do not have a lethal effect (for example, *Trichinella*, *Mycoplasma*, *Chlamydia*), but may be dangerous when the immunity is low. Some other pathogens may not be dangerous for Pallas's cats: canine distemper virus is considered to be dangerous only for large and medium-sized cats (Daoust et al. 2009, Seimon et al. 2013, Gilbert et al. 2015, Sulikhan et al. 2018), and mortality caused by feline leukemia virus has so far only been described for *Lynx*, *Puma* and *Felis* genera (Hoover & Mullins 1991, Sleeman et al. 2001, Cunningham et al. 2008). The effect of these three pathogens seems to be the most relevant: *Toxoplasma gondii*, feline panleukopenia virus FPV and feline calicivirus FCV. Nevertheless, the effect of Toxoplasma on Pallas's cats in the wild is unknown. Brown et al. (2005) showed that prevalence of antibodies to *T. gondii* was 13% in wild cats in Mongolia. Seroprevalence of Pallas's cats to *Toxoplasma* in Daurskii reserve was similar (9%; Naidenko et al. 2014), although the number and density of domestic cats (the main vector of *Toxoplasma*) is much higher there than in Mongolia. However, the seroprevalence of domestic cats to *Toxoplasma* in Dauria was comparable to that of Pallas's cats and did not depend on their population density (14.8%; Pavlova et al. 2015). The main prey species of Pallas's cats are also in contact with *Toxoplasma*, although serum prevalence in those species was not high (Pavlova et al. 2016). To sum up, the lower serum prevalence to *Toxoplasma* of domestic cats in Mongolia and Dauria in comparison with the domestic and wild cats in the Russian Far East (near Vladivostok (up to 39%, Naidenko et al. 2019)) probably relates to the climatic conditions: extremely dry climate with extremely low winter and extremely high summer temperatures.

Pallas's cats positive to FPV and FCV have never been detected in the wild (although we found one of forty Pallas's cat serum positive to FCV). However, antibodies to both pathogens were detected in domestic cats in the same area, and the effect of animal density was found to be significant whereas the effect of gender was not (Pavlova et al. 2015). For FCV and FPV: domestic cats in the village were positive for these viruses more frequently (76% and 54%, respectively) than domestic cats at the herdsman stations (44% and 33%, respectively), where the density of the animals was much lower (Pavlova et al. 2015). It is difficult to imagine that Pallas's cats did not have contact with these pathogens when they visit herdsman stations and villages or encounter domestic cats in the steppe. It is more probable (based on captivity data) that these pathogens are lethal to Pallas's cats (in Moscow zoo FPV is the main source of mortality (see above)). Thus, these pathogens are possibly an important threat for Pallas's cats in the wild. Climatic conditions of Dauria create a natural barrier for Toxoplasma dissemination, but for FPV and FCV an increase of domestic cat density enhances threats to Pallas's cats. The vaccination of domestic cats with a polyvalent vaccine against FPV, FCV and feline rhinotracheitis (herpes) virus seems the most reliable way to reduce this threat to wild Pallas's cats. Similarly, vaccination of Pallas's cats in zoos is the most effective means to prevent their infection with these potentially lethal pathogens.

Another aspect is the distribution of helminths in Pallas's cats. The information about them is extremely scarce. We know 9 helminths' species of Pallas's cats (Konyaev et al. 2012, Esaulova et al. 2017) which mostly have the same helminths (7 species) as other cat species in Siberia and the Russian Far East (tiger *Panthera tigris*, leopard *Panthera pardus*, snow leopard *Panthera uncia*). There are flat tapeworms (two species) and roundworms (7 species). One Acanthocephala species was also described as parasite of Pallas's cats (Esaulova et al. 2017). The percentage of Pallas's cats with helminths' eggs in faeces was much lower than in tiger and leopards that was explained by weather conditions in Dauria (Esaulova et al. 2017). Mainly these pathogens may be dangerous for the carriers when the habitats are unfavourable, for example, when prey abundance is low. However, at present we have no efficient way of affecting or controlling the distribution of these pathogens in the wild.

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PALLAS'S CAT GLOBAL ACTION PLANNING GROUP

Conservation Strategy for *Otocolobus manul*

The Pallas's cat or manul *Otocolobus manul* is a characteristic species of the lowland and mountain steppes of south-western and Central Asia's and the Himalayas. Because of its specific habitat requirements and its dependence of a variety of small mammalian prey, this archaic cat is an indicator of a healthy ecosystem. For thousands of years, it has shared its living space with nomadic herders. Only when motorised transport and heavy equipment became available in the 20th century, man has started to alter these marginal, low productive habitats considerably. We know very little about the long-term and large-scale changes in the distribution and abundance of the Pallas's cat, but we can assume that increasing human pressure on the steppe habitats and its fauna have impacted the small cat's population in recent decades and that further development may have an increasingly negative effect if not sensibly mitigated.

But to conserve the manul as a flagship species of the Asian steppes, we must understand its ecology and population dynamics. This requires more systematic observation of its conservation status, more research to close important gaps of knowledge, and at the same time, we need start reducing obvious threats. But these works are slowed down by the vast and fragmented distribution of the species, its generally low abundance and the shortage of funds for research and conservation. All this calls for concentrating our efforts and for a range-wide cooperation between scientific institutions, conservation organisations and the relevant authorities of all range states. The first step for a range-wide cooperative conservation approach has been taken at the Global Pallas's Cat Action Planning Meeting in Nordens Ark, 12–15 November 2018, where the Pallas's Cat International Conservation Alliance PICA, the Pallas's Cat Working Group PCWG and the IUCN SSC Cat Specialist Group Cat SG met to review the conservation status of *Otocolobus manul* (see previous chapters in this Special Issue) and to develop the here following range wide Conservation Strategy. The meeting has been attended by 28 participants (Appendix I; Editorial Fig. 1), including species experts from 8 of the 16 range countries, and was supported by the Fondation Segré, Nordens Ark, the Royal Zoological Society of Scotland and Cincinnati Zoo.

Planning process and workshop procedures

The strategic planning workshop followed the IUCN guidelines for strategic planning for species conservation (IUCN – SSC Species Conservation Planning Sub-Committee 2017) and the practical guidelines for strategic and project planning in cat conservation developed by the Cat SG (Breitenmoser et al. 2015; Chapter 1). The planning process was participatory and consensus driven, engaging all participants of the workshop into the development of the Conservation Strategy through repeated group work and plenary discussion, allowing capturing the knowledge and expertise of all participants. The workflow followed the "Zielorientierte Projekt Planung" ZOPP, included the analyses of threats and gaps (Table 1) and resulted in the development of a logical framework (LogFrame; Table 2). The status review, shown as a part of the process in Editorial Fig. 2, was prepared before the meeting and shared with the group in several presentations (previous chapters of this Special Issue).

Following Breitenmoser et al. (2015), the strategic planning process included six steps:

1. Development of a Vision, a wishful perspective for the next 25–50 years, describing the ideal future scenario for the species. It reflects an optimistic view of the future of the Pallas's cat and is meant to be a source of inspiration;
2. Development of a Goal, a more concrete intention than the Vision. It is a feasible, realistic and measurable long-term aim (10–20 years) for the conservation of the species;
3. Threat and Gap Analysis, in order to understand which obstacles and shortcomings are preventing us from reaching the Goal and Vision;
4. Development of Objectives, which support reaching the Goal and directly address important Threats and Gaps as identified under Step 3;
5. Development of (several) Results to reach every Objective. Results are the direct outcome of the implementation of a LogFrame and should hence be SMART (specific, measurable, achievable, relevant and time-bound);
6. Development of a number of Actions or Activities to achieve each Result, including a time line, actor, if possible methods and a budget. Implementation of Activities is the ultimate goal of the strategic planning process. However, careful planning, monitoring and evaluation avoid "jumping into action" without a clear pur-pose and hence reduce the risk of losing (financial) resources and precious time.

The Strategy was finally summarised in the LogFrame Matrix (Table 2), which provides a short, tabulated overview of the elements and facilitates the monitoring and evaluation of the Conservation Strategy.

Conservation Strategy

Our ***Vison*** for the Pallas's cat is a

Prospering manul populations across the historic range, living in harmony with people as a valued symbol of the steppe and mountain grassland ecosystem.

The wording of the Vision was carefully chosen:

- *Prospering manul populations* means viable, ecologically functional and sustainable Pallas's cat populations able to persist in the long-term;
- *Across the historic range* highlights that the species should not only be conserved across its current range but also recover in every part of its historic (> 1750) and projected range from Armenia and Azerbaijan in the west to China in the east, forming viable and connected populations;

Table 1. Identified Threats (current and emerging) as well as Gaps, weighted per region: South-west Asia (SWA), Central Asia and Russia (CA & R) and the Himalayas and China (H & C). Threats were ranked according to their importance (1 = minor, 2 = medium, 3 = major) and the capacity available to meet them were assessed (1 = poor, 2 = medium, 3 = good). Threats assessed to be out of the influence of the Conservation Strategy are written in italics.

Threats	**Importance**			**Capacity**		
	SWA	CA & R	H & C	SWA	CA & R	H & C
Infrastructure development (mining, road construction, resource extraction)	2	1	2 (China 3?)	1	1	1
Habitat destruction and habitat fragmentation (unsustainable grazing regime, fire, increased agriculture)	2	2	3	1	1	3 (locally), 1–2 (regionally), 3 (India: good capacity, poor implementation)
Population fragmentation	2	2	2	1	1	1/2
Illegal killing (including unintentional killing)[1]	1	2	1	2	2	1 (India) 2 (Nepal)
Legal hunting	–	1	–	–	2	–
Illegal trade	1	1	–	2	2	2
Dog attacks (e.g. herding dogs)	2	3	3	1	2	1 (good knowledge)
Poisoning of prey	2	1	2 (Tibet 3?)	1	3	2 (Nepal)
Diseases	1	2	2 (no inf.)	1	2	1
Development (infrastructure)	2	3	2	1	2	2
Increasing human pressure[2]	?	–	2? (site specific)	1?	–	2 (Nepal 1)
Political instability	2	2	1	1	–	–
Climate change	1	–	3	1	–	1 (Nepal), 2 (India)
Gaps and shortcomings						
Lack of knowledge on basic ecology, pop. dynamics, genetics, diseases, etc.)	3	3	3	2	3	3 (general monitoring) 1 (Nepal)
Lack trained researchers, rangers for law enforcement, monitoring, research	2	3	2	2	3	2–3
Lack of network and knowledge exchange	1	2	1/2	3	3	3
Lack of awareness	2	2	1	2	3	3 (social media)
Lack of stakeholder collaboration including governments	2	2	1 (site specific)	2	3	3 (Nepal) 1 (India)
Lack of regulation and law enforcement	2	2	1	2	2	1–2
Lack of financial means	2	3	3 (Nepal) 2 (India)	2	1	–

[1] Although the motivation for illegal (poaching) and unintentional (bycatches) killing may be different, they are clustered here because in practice, the reasons are often not known and all killing is, with the exception of the legal hunting in Mongolia, an illegal act.

[2] Including population growth, but also resettlement, changed land use, etc.

- *Living in harmony with people* stresses that the long-term survival of the Pallas's cat depends on the attitudes and comportment of people. Pallas's cats should be tolerated by local people and be allowed to live across sufficiently large and minimally disturbed steppe habitats;
- *Valued symbol of the steppe and mountain grassland ecosystem* implies that the Pallas's cat should not only be known and tolerated by the local people but also valued and cared for as an ancient part of the natural heritage and a flagship symbol of a unique ecosystem.

Our ***Goal*** is to initiate

A sustainable, science-based conservation programme to protect and restore Pallas's cat populations, addressing present and emerging threats, which is supported by the local people as well as the respective governments.

The wording of the Goal was again carefully and deliberately developed:

- *Sustainable, science-based conservation programme* highlights that conservation efforts should lead to long-term maintenance of the population(s) and be informed by the best available science, including efficient ways of monitoring the population trend, which again implies capacity development and scientists working on Pallas's cat conservation in all range countries;
- *Protect and restore Pallas's cat populations* indicates that not only the existing populations should be protected but that populations should also be restored within the historic range and connectivity be maintained and improved;
- *Addressing present and emerging threats* emphasises that we worry not only about present threats but also about emerging ones such as climate change, diseases, or infrastructure development;
- *Supported by the local people as well as respective governments* indicates that the conservation of the Pallas's cat will need the support of local people and all relevant governmental institutions. It will be of crucial importance to incorporate stakeholders, national governmental agencies and to gain the support of local people to achieve an effective long-term conservation of the species.

Threat and Gap analysis

Current and emerging Threats as well as information Gaps and shortcomings in our understanding or capacity were listed and discussed in three regional and one international working group. The three regional working groups noted problems specific to their region. The international working group concentrated on general problems and on threats mentioned in the literature. Similar or equal Threats and Gaps were grouped in the plenary discussion. The final list of Threats and Gaps were ranked per region according to their significance, but also the capacity available to address them (Table 1). We focussed on Threats and Gaps which can be addressed directly or indirectly when implementing the Strategy. However, although some Threats such as climate change, increasing human population and political instability were considered beyond the reach of this Strategy, they are listed in Table 1, because we all recognise their importance.

Objectives and Results

Based on the Goal and the Threat and Gap analysis, three working groups developed Objectives, addressing the eight major Threats and Gaps identified: land use, use and trade, human caused mortality and co-existence, knowledge and information, capacity development, network and information transfer, awareness and education, and finances. Each Objective addressed a particular challenge that needs to be addressed in order to reach the Goal and Vision. The Objectives as proposed by the working groups were then discussed in the plenary and finalised. The same procedure was then applied to define a number of Results for each Objective. Results are concrete achievements needed to reach an Objective; they often address a very specific challenge. Results are formulated to be SMART (specific, measurable, achievable, relevant and time-bound) and should be reached within 3–5 years.

Land use addresses the need to conserve habitat and prevent habitat destruction and fragmentation by increasing protected areas and minimise the impact of infrastructure and agriculture development.

Objective 1: **To prevent habitat destruction and fragmentation and mitigate negative impact of infrastructure and agriculture development.**

Result 1.1: Number of protected areas in key Pallas's cat habitats (community PAs) increased in Pallas's cat range countries in 10 years.

Result 1.2: Impact of agriculture/livestock husbandry and infrastructure development on Pallas's cat is understood and recommendations for manul-friendly practices are given to the range countries by 2025.

Result 1.3: Pallas's cat conservation is included in Global Snow Leopard Ecosystem Protection Program GSLEP landscape management plans by 2025.

Use and trade covers the problem of lack of knowledge on the legal and illegal use and trade of Pallas's cats and their impact on the population, the lack of political awareness and capacity to tackle these issues.

Objective 2: **To make legal hunting sustainable (Mongolia purpose only), stop illegal killing and illegal trade in Pallas's cat.**

Result 2.1: Mongolian Pallas's cat population size and distribution is known and impact of hunting on the population discussed with the Mongolian authorities in charge by 2025.

Result 2.2: The drivers and extent of illegal killing and illegal trade on Pallas's cat are understood, compiled in a report and submitted to all range countries by 2025.

Result 2.3: Border guards and custom officers are trained in identification of Pallas's cats and derivates by 2023.

Human caused mortality and co-existence tackles the lack of knowledge on the relative importance and causes of Pallas's cat mortality and how to mitigate those as well as problems relating to coexistence of people and their way of life with the Pallas's cat.

Objective 3: To understand and reduce human-caused mortality of Pallas's cat (free-ranging dogs, poisoning, etc.).

Result 3.1: Information on relative importance and causes of Pallas's cat mortality are compiled across the range by the end of 2021.

Result 3.2: Mitigation programmes addressing the main causes of Pallas's cat mortality are initiated by the end of 2023.

Knowledge and information concerns the need to enhance the understanding and knowledge on the species to identify most urgent conservation needs and to guide and prioritise effective conservation measures.

Objective 4: To increase the scientific research and understanding of the species basic ecology and population dynamics.

Result 4.1: The six most critical research needs are identified and prioritised across the range by the Pallas's Cat Working Group PCWG by the end of 2019.

Result 4.2: Priority research projects (as identified under Result 4.1) are launched to increase knowledge and to guide conservation strategies in each of the regions by the end of 2021.

Capacity development addresses the need to enhance capacity in regard to Pallas's cat research, surveys and conservation across its range, including the training of scientists and the development of accurate monitoring and surveying methods.

Objective 5: To develop science and conservation capacity in field ecology and conservation in Pallas's cat range countries.

Result 5.1: The major gaps in capacity for research and conservation are identified in each country by the PCWG by the end of 2020.

Result 5.2: Capacity building programmes to address gaps in research and conservation (as identified under Result 5.1) are initiated by the end of 2022.

Network and information transfer refers to the necessity of creating a Pallas's cat network and to enhance the information exchange in order to improve collaboration among experts and project implementers and to ensure that all available information is effectively disseminated.

Objective 6: To develop the global network (PCWG) and participation of Pallas's cat specialists to increase knowledge and conservation of manul.

Result 6.1: By 2020 a PCWG with an agreed organisational structure and roles of members with at least one member per range country and experts from non-range countries is established.

Result 6.2: By 2020 PCWG a formal relationship (e.g. MoU) with the IUCN SSC Cat Specialist Group is agreed.

Result 6.3: By 2021 review on projects detailing successes and failures of conservation activities/engagement is produced, shared and regularly updated (e.g. a web tool).

Awareness and education addresses the need to enhance global awareness and education for the species by producing education materials and guidance documents, development of training workshops and improve the cooperation between projects and information sharing.

Objective 7: To increase global awareness and education on Pallas's cat to support conservation efforts for the species.

Result 7.1: By 2021 educational material is produced, translated to the range country languages and made (freely) accessible and available.

Result 7.2: By 2023 best practice guidance documents for species identification and monitoring are produced to inform experts, project implementers and range country wildlife units.

Result 7.3: By 2024 training workshops with governmental environmental agencies across all range countries are completed.

Result 7.4: By 2021 all existing projects on Pallas's cat are connected via social media to increase global profile (see also Result 6.3).

Result 7.5: By 2020 a shared Pallas's cat image and video database for use with global awareness activities is established.

Finances refer to the necessity to ensure funding for the long-term conservation of the species by engaging further stakeholders and institutions into the conservation efforts for the Pallas's cat.

Objective 8: **To increase engagement with funders to promote long-term coordinated financial support for conservation efforts.**

Result 8.1: By 2020 a minimum of 25k Euros over 3 years are secured to deliver conservation recommendations from global meetings of the PCWG.

Result 8.2: By 2020 zoos are engaged and provide €10’000 per year to Pallas’s cat conservation.

Result 8.3: By 2020 PICA has secured additional support for Pallas’s cat projects from at least 2 new potential funders.

Because Results are formulated to be SMART, they need a quantitative or qualitative indicator allowing tracking the progress. These indicators were not yet defined at the workshop, but they should be included in a more elaborated LogFrame or work plan for the implementation of the Strategy.

Activities

Implementing conservation measures is the ultimate purpose of the planning process. Activities were hence defined to reach the Results, Objectives and ultimately Goal and Vision. Sets of Activities were developed by the working groups and discussed in the plenary to meet the respective Result. Typical timeline for an Activity is 1–3 years. Activities need to be very specific, including an actor and time-line, but ideally also selected methods, monitoring and assessing progress, and last but not least a budget. To define such details was not possible during the workshop at Nordens Ark. The simple LogFrame presented below (Table 2) hence will need to be refined (e.g. at the level of Objectives or Results) to become a more practical working tool for the implementation of the Strategy.

Conclusions

The Conservation Strategy presented here is the first attempt to develop a long-term plan for the conservation of the Pallas’s cat across its entire current and historic range. It was designed by the participants at the workshop in Nordens Ark (Appendix I). Although developed in a collaborative and participatory way, not all range experts and range countries were able to participate, and no stakeholder involvement was possible at this global level. The Strategy is therefore intentionally kept general in some parts and defines foremost Activities within the reach of the group that met in November 2018 at Nordens Ark. However, the Strategy is based on the best information presently available and the assessment of the conservation status of the Pallas’ s cat according to IUCN Red List rules and the IUCN recommendation for strategic planning in species conservation. We therefore recommend this Strategy to be considered for the development of National Action Plans and for the design of further research and conservation projects.

The group that developed this Strategy will advance the cooperation within the PCWG (see e.g. Objective 6 and related Results/Activities). The institutions that met at Nordens Ark agreed to enhance their collaboration and invite additional individuals and institutions to join in. A steering group within the PCWG will oversee the implementation of the Conservation Strategy and facilitate the monitoring and regular evaluation of the progress, reviewing the Strategy at intervals of about 5 years (or whenever adequate). To enhance the outreach and implementation of the Strategy, it will be submitted to the Range States’ authorities in charge of species conservation or wildlife management, as well as to international institutions involved in nature conservation in Central Asia. An efficient collaboration and cooperation between all stakeholders, including governmental agencies, species experts, researchers, local people and international organisations as well as the continued sharing of information and knowledge on the status and distribution of the Pallas’s cat are essential for the implementation of this Conservation Strategy and the long-term conservation of the Pallas’s cat.

Photo V. Kirilyuk

Table 2. Activities (three digit numbers) by Objectives and Results. Time line is the expected date for finishing or the approximate period for implementing the respective Activity. Actor indicates the responsible implementer(s). For Activities beyond the responsibility of the participants of the workshop, no time line or actor were defined.

Activity	Time line	Actor
Objective 1. To prevent habitat destruction and fragmentation and mitigate negative impact of infrastructure and agriculture development		
Result 1.1 Number of protected areas in key Pallas's cat habitats (community PAs) increased in Pallas's cat range countries in 10 years		
Activity 1.1.1 Review of official (international, national and sub-national) plans and programmes on creating and enlargement of protected areas	end of 2020	PCWG/PICA will coordinate with 1–2 point persons in each range country
1.1.2 Identify key Pallas's cat habitats based on scientific knowledge and conduct national consultative meetings and prepare recommendations for the governments	end of 2025	
1.1.3 Analyse the regimes and zoning of existing PAs and make recommendations to increase effectiveness of the protected areas for manul conservation	end of 2028	
1.2 Impact of agriculture/livestock husbandry and infrastructure development on Pallas's cat is understood and recommendations for manul-friendly practices are given to the range countries by 2025		
1.2.1 Review the threats and challenges of agriculture/livestock husbandry and infrastructure development to Pallas's cat	end of 2021	PCWG/PICA will coordinate with 1–2 point persons in each range country
1.2.2 Ensure environmental impact assessment are conducted for large infrastructure projects and that issues with possible impact on the Pallas's cat are included	end of 2021	
1.2.3 Make recommendations for governments, companies, farmers and pastoralists in regard to manul-friendly practices	end of 2025	
1.3 Pallas's cat conservation is included in GSLEP (Global Snow Leopard Ecosystem Protection Program) landscape management plans by 2025		
1.3.1 Consult, cooperate and mutually agree with the GSLEP working group on our activities and plan	end of 2020	PICA/SLT will coordinate with 1–2 point persons in each range country
2. To make legal hunting sustainable (Mongolia purpose only), stop illegal killing and illegal trade in Pallas's cat		
2.1 Mongolian Pallas's cat population size and distribution is known and impact of hunting on the population discussed with the Mongolian authorities in charge by 2025		
2.1.1 Carry out nation-wide research of the Pallas's cat distribution and population size in Mongolia	end of 2020	PCWG/PICA will coordinate a point person in Mongolia
2.1.2 Analyse the status of legal hunting and trade, and its potential impact on the national population	end of 2023	
2.1.3 Make recommendations and provide them to the relevant governmental body	end of 2025	
2.2 The drivers and extent of illegal killing and illegal trade on Pallas's cat are understood, compiled in a report and submitted to all range countries by 2025		
2.2.1 Study and analyse the status of illegal hunting and trade in each range country	end of 2021	PCWG/PICA will coordinate with 1–2 point persons in each range country
2.2.2 Assess its impact on the Pallas's cat population for each country	end of 2022	
2.2.3 Compile a report and present it to the governments	end of 2024	
2.3 Border guards and custom officers are trained in identification of Pallas's cats and derivates by 2023		
2.3.1 Produce guidelines for the identification of Pallas's cat and its derivatives for border guards and custom officers	end of 2020	PCWG/PICA will coordinate with 1–2 point persons in each range country
2.3.2 Contact CITES, TRAFFIC, INTERPOL and NGOs currently working on traffic monitor and control of wildlife trade in the range countries	end of 2020	
2.3.3 Organise trainings for border guards and custom officers in the relevant countries	2021–2023	
3. To understand and reduce human-caused mortality of Pallas's cat (free-ranging dogs, poisoning, etc.)		
3.1 Information on relative importance and causes of Pallas's cat mortality are compiled across the range by the end of 2021		
3.1.1 Identify a point person per range country to help formulate the survey	July 2019	PICA will coordinate the point persons
3.1.2 Define questionnaire to compile information about Pallas's cat mortality	July 2019	
3.1.3 Develop and distribute survey protocol for field specialists and practitioners, collect and compile information	May 2020	
3.2 Mitigation programmes addressing the main causes of Pallas's cat mortality are initiated by the end of 2023		
3.2.1 Identify main mortality causes of Pallas's cats based on survey results and produce report with recommendations on mitigations in each country language	Dec. 2020	PICA

Activity	Time line	Actor
3.2.2 Increase awareness of local people and governmental agencies (brochures, internet) about Pallas's cat mortality and identify partners for collaborative work	2023	PICA
4. To increase the scientific research and understanding of the species basic ecology and population dynamics		
4.1 The six most critical research needs are identified and prioritised across the range by the Pallas's Cat Working Group (PCWG) by the end of 2019		
4.1.1 Identify six most important research needs based on gap analysis (see above)	End 2019	Steering group
4.1.2 Request review of proposed research needs with PCWG and share with partners/range countries	July 2019	PICA, steering group
4.2 Priority research projects (as identified under Result 4.1) are launched to increase knowledge and to guide conservation strategies in each of the regions by the end of 2021		
4.2.1 Identify priority areas for presence/absence survey throughout the range with point-person	End of 2019	Jim Sandersan (PCWG) and Urs Breitenmoser (Cat SG)
4.2.2 Conduct survey with obvious proofs (photograph, genetic/physical evidence) in identified priority areas	End of 2021	(point-person with funding through PICA)
4.2.3 Review monitoring techniques in each region and standardise methodologies and produce monitoring guidelines available to interested people	End of 2019	Sergey Naidenko will consult with the PCWG and GSLEP
4.2.4 Develop standardised protocols for genetic sample collection storage and analysis for Pallas's cats	End of 2019	Helen Senn will consult with PCWG
4.2.5 Develop genetic and other biological samples database and strategy for biological sampling	Mid-2020	Helen Senn and Sergey Naidenko, consult with PCWG
4.2.6 Coordinate genetic and disease sampling analysis with point person in each range country	End 2022	Helen Senn and Bill Swanson
4.2.7 Combine data from Russian sources to understand the range of Pallas's cat population fluctuations in this region	End of 2020	Vadim Kirilyuk, Anastasia Antonevich, Anna Barashkova
4.2.8 Develop standardised protocols for biological sample collection storage and analysis for Pallas's cats disease ecology	March 2020	Bill Swanson will consult with PCWG
4.2.9 Identify social scientist in range countries and connect them with local biologists to assess human dimension aspects	End of 2019	Shekhar Kolipaka
5. To develop science and conservation capacity in field ecology and conservation in Pallas's cat range countries		
5.1 The major gaps in capacity for research and conservation are identified in each country by the PCWG by the end of 2020		
5.1.1 Identify a point person for each range country to help formulate the survey	End of 2019	PICA to coordinate point person
5.1.2 Define the questionnaires to get information about research and conservation capacity gaps in each range country and advice on capacity building	End of 2021	Point person of each range country
5.1.3 Distribute survey protocols to science and conservation partners in each country and compile information	May 2022	Point person and PICA
5.2 Capacity building programmes to address gaps in research and conservation (as identified under Result 5.1) are initiated by the end of 2022		
5.2.1 Identify based on surveys the main capacity needs for science and conservation in range countries and write report summarising the compiled information	End of 2020	PICA
5.2.2 Present survey results to government and conservation stakeholders in each country and advice on capacity building	End of 2021	Point person of each range country
6. To develop the global network (PCWG) and participation of Pallas's cat specialists to increase knowledge and conservation of manul		
6.1 By 2020 a PCWG with an agreed organisational structure and roles of members with at least one member per range country and experts from non-range countries is established		
6.1.1 Attendees to agree structure of PCWG: coordinating individual, regional representatives, steering committee	Spring 2019	PCWG, PICA, Cat SG
6.1.2 Inform to all non-attendees and potential additional PCWG members	Spring 2019	PCWG, PICA, Cat SG
6.1.3 Create list of existing websites for steering committee and select web hosting site for PCWG (new or existing)	Spring 2019	Coordinator (t.b.d.) and steering committee
6.1.4 Agree on roles for membership and process for joining PCWG; steering committee to propose terms of reference and membership conditions and roles (see also 3.1.1, 5.1.1)	July 2019	PCWG, PICA, Cat SG

Activity	**Time line**	**Actor**
6.2 By 2020 PCWG a formal relationship (e.g. MoU) with the IUCN SSC Cat Specialist Group is agreed		
6.2.1 MoU drafted by steering committee and circulated to membership for comments	July 2019	Steering committee, PCWG, PICA, Cat SG
6.2.2 Steering Committee to agree and sign MoU with IUCN SSC Cat Specialist Group	End of 2020	Steering committee, Cat SG
6.3 By 2021 review on projects detailing successes and failures of conservation activities/engagement is produced, shared and regularly updated (e.g. a web tool)		
6.3.1 Create a record database for project information hosted on PCWG webpage and share with members	End of 2019	PCWG volunteer member
6.3.2 Coordinating individual per project to update annually information on database	Annually	
7. To increase global awareness and education on Pallas's cat to support conservation efforts for the species		
7.1 By 2021 educational material is produced, translated to the range country languages and made (freely) accessible and available		
7.1.1 Collect and formulate key education messages (species description, life stories, threats, how to guide)	July 2019	Julia Hoffmann, PICA
7.1.2 Develop standardised education materials using key messages	End of 2019	Julia Hoffmann, PICA
7.1.3 Translate materials into all range country languages	2020	David Barclay (PICA)
7.1.4 Distribute materials through coordinating individuals to make publicly available	After 2020	PCWG, PICA
7.2 By 2023 best practice guidance documents for species identification and monitoring are produced to inform experts, project implementers and range country wildlife units		
7.2.1 Create standardised protocols for Pallas's cat identification (carcass, field signs, samples incl. genetic, lives specimen, skins)	2020	Volunteer from PCWG, Sergey Naidenko
7.2.2 Create basic field monitoring protocol (camera trapping, snow tracking, field sign)	Spring 2020	Ehsan Moqanaki
7.2.3 Identify key stakeholders and create contact list for document distribution	Spring 2020	Steering committee
7.2.4 Make best practice monitoring document available on networks website	Spring 2020	Coordinating individual
7.2.5 Translate document into all range country languages	Spring 2021	PICA
7.3 By 2024 training workshops with governmental environmental agencies across all range countries are completed		
7.3.1 Create workshop guideline and training materials linked to Activities 7.2.1 and 7.2.2	2021	Steering committee
7.3.2 Identify PCWG representative per range country to organise and deliver workshop	Nov. 2019	Coordinating individual
7.3.3 Create contact list for environmental agencies relevant for manul conservation for all range countries	July 2019	Regional PCWG members
7.4 By 2021 all existing projects on Pallas's cat are connected via social media to increase global profile (see also Result 6.3)		
7.4.1 Create list of active social media profiles from projects, members etc.	July 2019	PCWG members
7.5 By 2020 a shared Pallas's cat image and video database for use with global awareness activities is established		
7.5.1 Create storage space within webpage	Oct. 2019	Coordinating individual
7.5.2 Identify individual to collect and upload images/database	Oct. 2019	Coordinating individual
7.5.3 Create and sign terms of use document for sharing of images/videos, make accessible for funders	July 2019	Steering committee
8. To increase engagement with funders to promote long-term coordinated financial support for conservation efforts		
8.1 By 2020 a minimum of 25k Euros over 3 years are secured to deliver conservation recommendations from global meetings of the PCWG		
8.1.1 Secure funding and assign a minimum of 50% of funds toward priority research (4.1 and 4.2)	Annually	Steering committee / Funding project
8.1.2 Agree decision process of funding prioritisation and channelling process of funds	July2019	Steering committee / PICA
8.2 By 2020 zoos are engaged and provide €10'000 per year to Pallas's cat conservation		
8.2.1 Share annual (project) reports and educational material with zoos to support fund-raising efforts	Annually	PICA, Julia Hoffman
8.3 By 2020 PICA has secured additional support for Pallas's cat projects from at least 2 new potential funders		
8.3.1 Identify list of potential funders and application deadlines	2019	PICA
8.3.2 Prepare project proposals to secure additional funding	2019	Steering committee, PICA

Appendix I

List of participants of the Pallas's cat Global Action Planning Meeting 12–15/11 2018

Attendee	Country	Email
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