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# Pallas's cat Status Review & Conservation Strategy

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

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# 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 conserva-

tion 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 20$^{th}$ century in



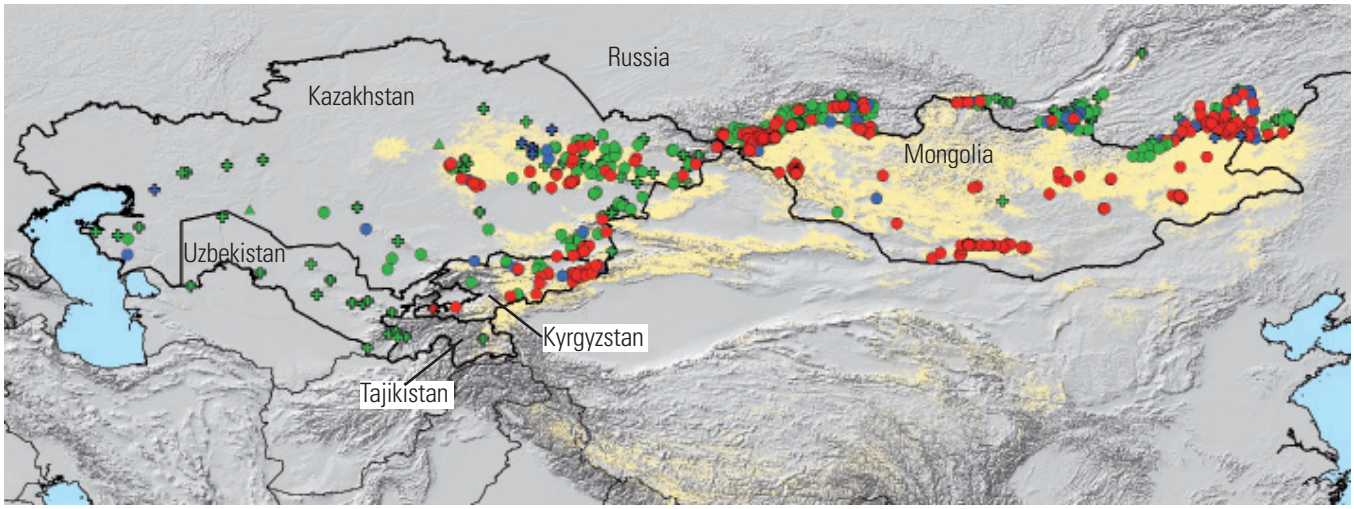


**Fig. 1.** Geographic distribution of the Pallas's cat in the study region, mapped according to historical (< year 2000; crosses) and contemporary (≥ 2000; circles) occurrence records collated in this study. Triangles = records where the timespan is unknown. Red = confirmed (C1); Blue = probable (C2); 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).

*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).

**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).

*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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