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The Great Gobi B Strictly Protected Area in Mongolia - refuge or sink for wolves *Canis lupus* in the Gobi?

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The Mongolian hunting law does not mention the wolf *Canis lupus*, which is generally interpreted in the way that wolves can be hunted anytime and anywhere, including in protected areas. We investigated whether the Great Gobi B Strictly Protected Area (SPA), a strict nature reserve in southwestern Mongolia, acts as a refuge or a sink for wolves in the Gobi. Our expectations were that wolves in the Gobi 1) have large ranges similar to those in other equally unproductive habitats, 2) experience a high hunting pressure, and 3) have recently become an important export item for cross-border trade to China. We combined GPS positions of two adult wolves, wolf harvest data and a market survey on wildlife products to address the above questions. Range use of the two collared wolves was huge, but varied widely between the two animals (6,670 km^2 for an adult female and 26,619 km^2 for an adult male) and over time. Reproductive status and residency status were only known during the initial 8-months monitoring period of the female. During this 'resident' period her range size was 1,275 km^2. Both wolves showed a clear preference of mountainous terrain over flat steppe, suggesting that only 21% of the SPA constitute preferred wolf habitat. Annual harvest in the park and its vicinity averaged 1 wolf/265 km^2 in 2002/03, 1 wolf/120 km^2 in 2003/04 and 1 wolf/310 km^2 in 2004/05. However, hunting pressure was unequally distributed and particularly high in the northeastern corner of the park. During the active monitoring period of wolf F1, 35 wolves were killed within her 'resident' range, suggesting a high hunting pressure. Most wolves were shot from motorised vehicles, possibly explaining the preference of wolves for mountainous terrain which is inaccessible for vehicles. The market surveys revealed products from ~2,000 wolves on the two border markets, a huge discrepancy to only 150 CITES permits officially issued annually. Although our data are insufficient to allow a truly quantitative assessment of the impact of human induced mortality on wolf conservation status in the Great Gobi B SPA, it points towards a potentially severe conservation problem requiring further attention.

Key words: Canis lupus, home range, hunting, management, Mongolia, wolf

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Wolf *Canis lupus* predation on domestic animals is one of the main reasons for wolf-human conflicts all over the global range of wolves (Kaczensky 1999, Treves et al. 2002, Mishra et al. 2003) and has been the main reason for wolf eradication in large parts of Europe (Boitani 1995, Breitenmoser 1998, Boitani 2003) and North America (Williams et al. 2002, Fritts et al. 2003). It is not surprising that in Mongolia, where rural economy is based on livestock, the wolf is largely regarded as a pest species (Enkhsaikhan 2002, Reading et al. 1998, Hovens et al. 2000, Mishra et al. 2003, Kaczensky 2007).

So far wolf conservation has not been an issue in Mongolia, mostly because wolf numbers are generally believed to be increasing (Enkhsaikhan 2002, Kaczensky 2007). However, reliable population estimates do not exist and little is known about wolf ecology in the central Asian steppe ecosystem. Under the harsh environmental conditions of the Gobi, wolves can be expected to have large ranges. Global primary production in the Gobi averages ~154 gC/m^2/year and thus is considerably lower than in other low productivity areas such as interior Alaska or northern Canada (~487 gC/m^2/year; Prince & Goward 1995, Prince & Small 2003), where wolves have been intensively studied. Wolf densities in Alaska and the Yukon are generally low (1 wolf/72-219 km^2) due to packs having large territories ranging within 665-1,645 km^2 (Fuller et al. 2003). Although wolves are habitat generalists and can make a living in a wide variety of habitats, factors allowing easy access for hunters have been shown to negatively influence wolf presence (e.g. roads; Mladenoff et al. 1995) and often confine wolves to the least accessible areas (e.g. large forested areas, mountain ranges, limited access areas; Boitani 2003). In the Gobi, local people frequently claim that "wolves retreat to the mountains where they are difficult to hunt" (P. Kaczensky, unpubl. data).

Harvest data can provide valuable information on population trends (e.g. the 10-year cycle of the Canadian lynx *Lynx canadensis*; Krebs et al. 2001), but may contain much noise due to poor data quality and factors that influence the hunters rather than the game species (e.g. Christensen 2005). Thus it is difficult to interpret hunting bags over extended time periods which include dramatic political and societal changes. Nevertheless, knowing the magnitude and trend of past hunting bags over relatively stable management periods can provide important hints on which harvest rates a population can sustain.

Wolf harvest and fur export data were centrally registered in Mongolia from 1927 until 1985 but ceased thereafter (Scharf et al. 2003, Wingard & Zahler 2006). Under the Soviet system, large-scale wolf hunts were organised and sponsored by the government. During the peak of wolf hunting in the mid-1930s and 1940s up to 18,000 wolves were bagged per year. But the annual bag quickly dropped and then fluctuated around 4,000 per year during 1950-1974 and 1980-1985 (Scharf et al. 2003, Wingard & Zahler 2006). With the collapse of the Soviet system, organised wolf hunts ceased and were never revitalised under the new Mongolian government, largely due to a lack of funds. In 1996, Mongolia became a member of the Convention of International Trade in Endangered Species (CITES) where the wolf is listed in appendix II (Clark et al. 2006). Since 2001, only 150 CITES permits were issues annually for the export of wolf products (UNEP-WCMC 2006, D. Galbadrakh, pers. comm. 2004).

In the summer of 2004, a nationwide household and market survey suggested that as many as 20,000-30,000 wolves may presently be taken per year by Mongolian hunters (Wingard & Zahler 2006). Without knowing the size of the Mongolian wolf population, the impact on the conservation status of the wolf in Mongolia remains largely speculative. However, the 2004 survey suggests a hunting bag similar to the official harvest and fur export figures of the mid-1930s and 1940s, which could only be sustained for a few years and apparently resulted in the

disappearance of wolves from some steppe regions (Scharf et al. 2003).

Mongolia's human population is increasing at an estimated rate of 1.46%. Human encroachment on wildlife habitats, the easy access to weapons and vehicles, and the lack of law enforcement result in widespread depletion of wild ungulates (Pratt et al. 2004, Kaczensky et al. 2006, Wingard & Zahler 2006). Deprived of their wild prey, wolves can be expected to prey more heavily on livestock, which in turn is likely to increase persecution. A recent demand for wolf meat and wolf body parts in China could further accelerate this development (Wingard & Zahler 2006). Protected areas cover 13% of Mongolia and approximately 30% of the Gobi areas and could act as important refuge areas for wolves.

However, the Mongolian hunting law does not mention the wolf, which is generally interpreted in the way that wolves can be hunted anytime and anywhere. The Mongolian law on protected areas states in article 8 that hunting and carrying firearms is not allowed in strictly protected areas (SPAs) and article 9(1) states that in pristine zones only protection activities that preserve original conditions may take place (Enebish & Myagmarsuren 2000). But article 10 permits 'biotechnological measures' in conservation zones to enhance flora and fauna reproduction, which leaves some room for interpretation (Enebish & Myagmarsuren 2000, J. Wingard, pers. comm.).

Wolves are considered a threat to rare animals such as the wild bactrian camel *Camelus bactrianus ferus*, the reintroduced Przewalski's horse *Equus ferus przewalskii* and livestock (Reading et al. 1998, Hovens et al. 2000, Clark et al. 2006). Without a clear definition of the terms used in articles 9 and 10, the law leaves it either to the common sense or the imagination of the local wildlife manager as to which management actions concerning wolves are permitted in protected areas (Wingard 2004).

The Great Gobi B Strictly Protected Area (SPA) in southwestern Mongolia is a protected area of category Ia (Strict Nature Reserve; WCPA 2007). One of the key management objectives of a Strict Nature Reserve is "to preserve habitats, ecosystems and species in as undisturbed a state as possible" (WCPA 2007). Wolves are part of the Great Gobi B SPA ecosystem and thus their long-term survival needs to be secured. However, wolf control measures are broadly expected by local people and often encouraged and conducted by the local administrations (Enkhsaikhan 2002). In 2002, the Mongolian Ministry of Environment and Nature even paid bounties for wolves killed within the Great Gobi B SPA to protect reintroduced Przewalski's horses and livestock.

In our paper, we combine data sets from GPS telemetry, harvest statistics and market surveys to assess the role of the Great Gobi B SPA for wolf conservation in the Gobi. Our expectations were that wolves in the Gobi 1) have large ranges similar to those in other equally unproductive habitats, 2) experience a high hunting pressure, and 3) have recently become an important export item for cross-border trade to China.

Material and methods

Study area

The Great Gobi B SPA is part of the Greater Gobi Strictly Protected Area system established in 1975 and declared an International Biosphere Reserve in 1991 (WCPA 2007). The Great Gobi B SPA encompasses ~9,000 km^2 of desert steppe and desert habitat (Zhirnov & Ilyinsky 1986, Kaczensky et al. 2004, Kaczensky et al. 2007).

Despite its protected area status, the Great Gobi B SPA is used by about 110 families with close to 60,000 livestock mainly in winter and during spring and fall migration (Kaczensky et al. 2007). The region is in the centre of the Cashmere goat industry in Mongolia and the main income of local herders is generated from livestock products (National Statistical Office of Mongolia 2001, IPECON/NZNI 2003). The southern border of the park is also the international border between Mongolia and China (140 km). There are three important crossing points for trade between Mongolia and China within 100 km of the park: Bulgan, Baitag and Burgastai (Fig. 1). In addition, the provincial capital Gobi-Altai is located 120 km north of the park (see Fig. 1).

The climate of the Great Gobi B SPA is continental with long cold winters and short, hot summers. The average annual temperature is -0.5°C, but extremes range from -40°C in winter to +40°C in summer. Average snow cover lasts 97 days, but can be highly variable from year to year (Atlas of Mongolia 2004, O. Ganbaatar, pers. obs.). Average yearly rainfall is about 100 mm with most precipitation falling during summer (Atlas of Mongolia 2004).

The landscape is dominated by plains with low mountains in the east and rolling hills in the west. Elevations range from 1,000 m a.s.l. near the northwestern corner of the park to 2,840 m a.s.l. along the

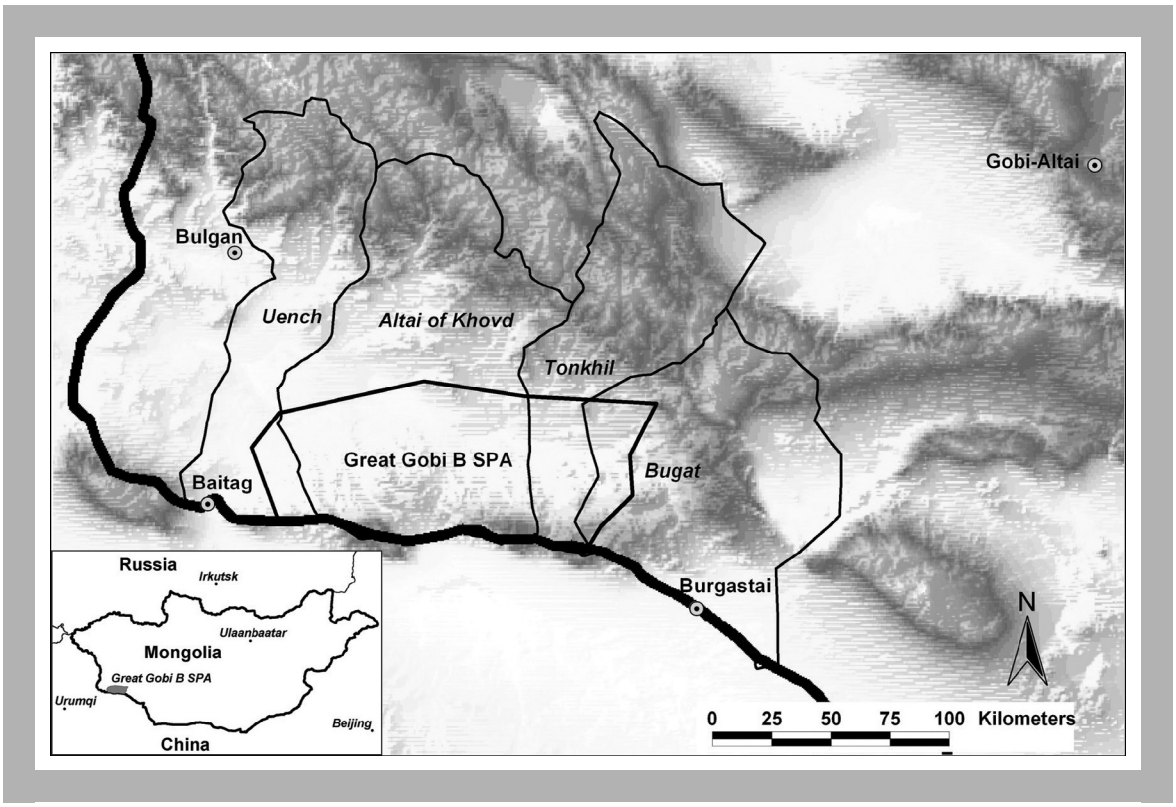

Figure 1. Location of the study area with the four districts (soums) that encompass the Great Gobi B Strictly Protected Area (SPA) in southwestern Mongolia with indications of the four most important markets for wildlife products in the vicinity of the park.

Mongolian-Chinese border. Desert areas are widely dominated by Chenopodiaceae such as Saxaul *Haloxylon ammodendron* and *Anabasis brevifolia*. The steppe areas are dominated by Asteraceae such as *Artemisia* spp. and *Ajania* spp., and Poaceae such as *Stipa* spp. and *Ptilagrostis* spp. (Hilbig 1995, von Wehrden et al. 2007).

The ungulate community consists of black-tailed gazelles *Gazella subgutturosa*, Asiatic wild ass *Equus hemionus* and reintroduced Przewalski's horses. In the mountains ibex *Capra sibirica* are common, but argali *Ovis ammon* have become rare. The grey wolf and the red fox *Vulpes vulpes* are the main mammalian predators. The status of the Corsac fox *Alopex corsac*, the Pallas' cat *Felis manul* and the wild cat *F. sylvestris* are unknown, whereas lynx *Lynx lynx* and snow leopard *Uncia uncia* are rare.

Satellite telemetry

We used satellite telemetry to study range use and movement patterns of wolves in the steppe ecosystem of the Great Gobi B SPA. In May 2003, we captured an adult, lactating female wolf (F1; 22 kg) using a Belise foot snare (Belise Enterprise, Quebec, Canada). In March 2004, we darted an adult male wolf (M1; 37 kg) from a jeep, following a chase method described for Asiatic wild asses by Walzer et al. (2007). Both wolves were anaesthetised with a combination of 5 mg/kg tiletamin and zolazepam (Zoletil; Virbac S.A., Carros, France) and 0.02 mg/kg medetomidin (Dormitor; Farmos, Turku Finland), which was partially reversed with 4 mg antipamezole (Antisedan; Farmos, Turku Finland) after handling.

We equipped both wolves with GPS satellite collars (TGW-3580; Telonics, Mesa, USA) programmed to collect three locations every 24 hours at 8:00, 16:00 and 24:00. Collars were designed to store all data on board and additionally to transmit the data every other day using an ARGOS satellite uplink. With this duty cycle collars were estimated to last 19 months. For animal welfare reasons and to allow collar retrieval, the collar of M1 was equipped with a pre-programmed drop-off (CR-2a; Telonics, Mesa, USA) which released the collar in September 2005. For the collar of F1, the release mechanism did not

arrive in time before deployment and thus the collar stayed on the animal until her death in December 2006. By coincidence, both wolves were killed independently of each other in December 2005; F1 because she ventured into the village of Bugat during plain daylight (suspected rabies infection) and M1 during a hunting trip by locals in the southeastern corner of the Great Gobi B SPA. For analysis, we used the GPS data stored in the retrieved collars, which was 2.5 times the number of locations received via the ARGOS uplink.

The attempted collaring of additional wolves by use of a jeep during 5-18 March 2004 was impeded by the scarcity of wolves and their signs encountered during the 12-day search period. Tracking conditions were favourable with a 10-20 cm layer of fresh snow covering 80-90% of the area and temperatures around -10°C. Excluding the range of the collared wolf F1, we only encountered wolves on three and their tracks on two occasions within a 4,000 km^2 search area. Even the accompanying local wolf hunters were surprised how little wolf activity we found.

Recording of killed wolves

Starting in the fall of 2002, we provided wolf harvest forms to the governors and district rangers of the districts (soums) of Bugat, Tonkhil, Altai of Khovd and Uench (see Fig. 1). In the forms, we ask the hunters about the date and location where a wolf was killed, and about the sex and age class of the wolf (pup, subadult, adult). The first set of forms were completed in our presence, but were somehow lost before our next visit. However, a Mongolian wolf hunt is a big event, and governors and rangers remembered quite well who killed wolves, and where and when. Thus, in the end, we collected all data via repeated interviews, trying to identify duplicates and discharging unsure events. With the help of the local rangers, we pinpointed wolf kill locations on a map based on area names and thus derived the approximate coordinates for the GIS. Informal interviews with local herders did not yield any additional wolves kills in the region and confirmed most of the recorded kills. As most wolves were killed during the winter months, we did not use the calendar years, but rather the period from 1 April until 31 March the next year as the relevant monitoring period.

For data analysis, we used only the wolves killed within the SPA plus a 30-kilometre buffer zone around the park. The 30-kilometre buffer is at the higher end of the distances travelled by our radio-collared wolves within 24 hours. Only in 2004/05, data from the whole area were available, whereas in 2002/03 only data from Bugat, Tonkhil and Gobi-Altai and in 2003/04 only data from Bugat and Tonkhil were available for analysis.

Market surveys

To get a rough estimate of the relative occurrence of wolf and other wildlife products in the domestic and Mongolian-Chinese cross-border trade, we surveyed the two border post markets (Baitag and Burgastai) and the two largest markets (Bulgan and Gobi-Altai) in the vicinity of the Great Gobi B SPA. In the winter of 2004/05, the border post Baitag was open for 20 days both in December 2004 and March 2005 and the border post Burgastai for 20 days both in February 2005 and April 2005. The two markets were surveyed by O. Ganbaatar and his staff on two consecutive days at the beginning of the opening period.

The markets at Bulgan and Gobi Altai were surveyed by two locals on a daily basis (in Bulgan during 07. 11. 2004-31. 03. 2005, and in Gobi Altai during 10. 11. 2004-23. 04. 2005). Both locals were working at the market and received an additional income from the park for casual checking of containers with wildlife products. We asked our market surveyors to avoid double counts, by trying to identify only newly offered wildlife products. However, the capability to identify new products is certainly limited. There was an informal agreement between the park and the local market agents that the aim of their mission was to get an overview of what is sold in which quantity and at what price. It was clearly understood that their data would not have any immediate legal consequences.

Data analysis

Given the total lack of information on the typical territory size of a wolf pack in the Gobi, our small sample size and the obvious changes in the space use of the two collared wolves over the monitoring period, we chose to delineate periods of similar range use rather than describe classical home ranges over a fixed time period. Because the reproductive or residential status of our wolves was only poorly known and range definition did not follow standard procedures (Laver & Kelly 2008), we set names for the different periods in quotation marks. For both wolves, we visually identified periods of different

range use by plotting a standardised distance of each GPS location to the capture point using the following formula:

$$\text{standardised distance to capture point} = \frac{\text{distance to capture point}}{\text{maximum distance to capture point}} - \text{average}\left(\frac{\text{distance to capture point}}{\text{maximum distance to capture point}}\right).$$

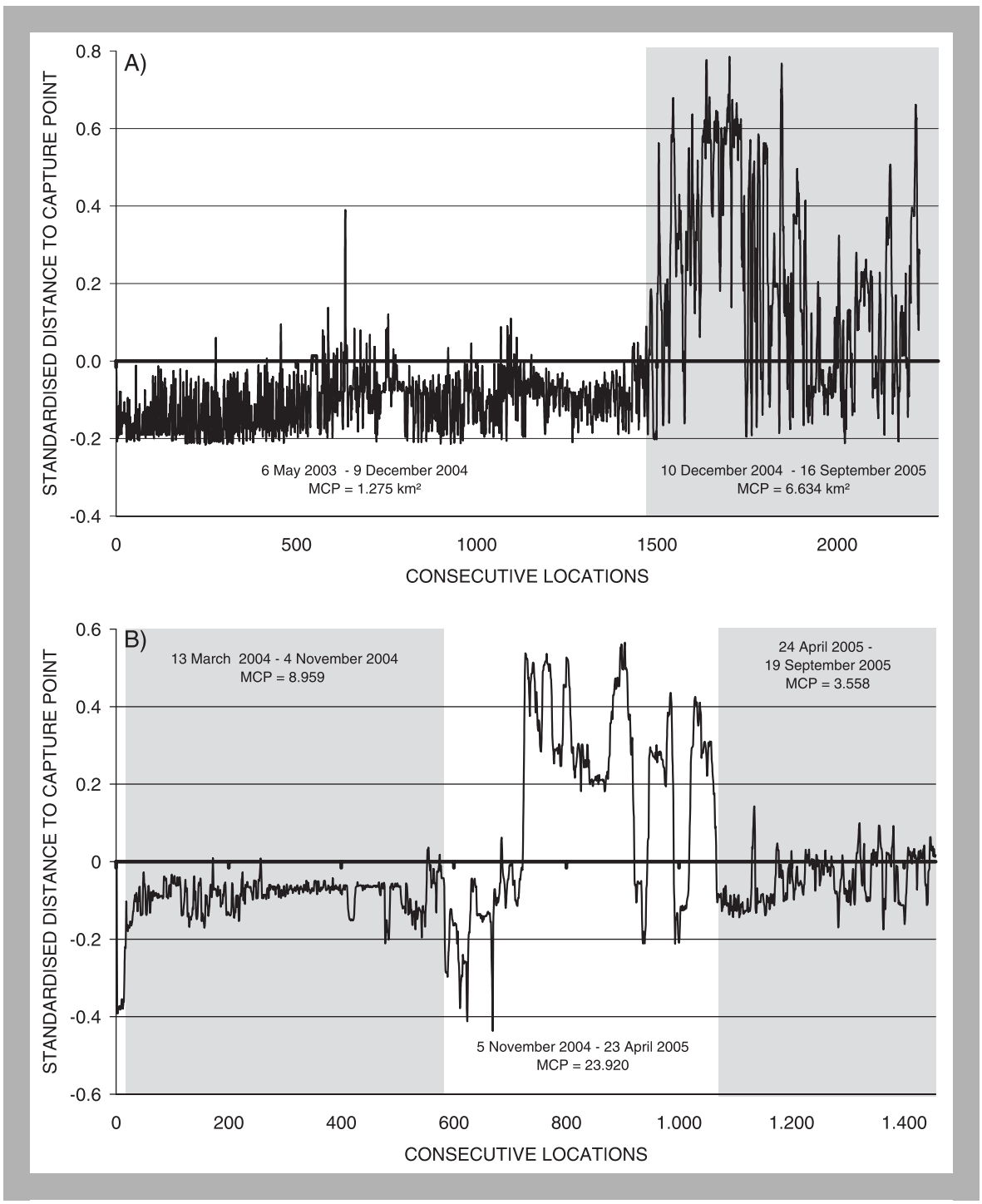

Figure 2. Standardised distance of successive locations to the capture point for identifying different periods of range use by female F1 (A) and male M1 (B).

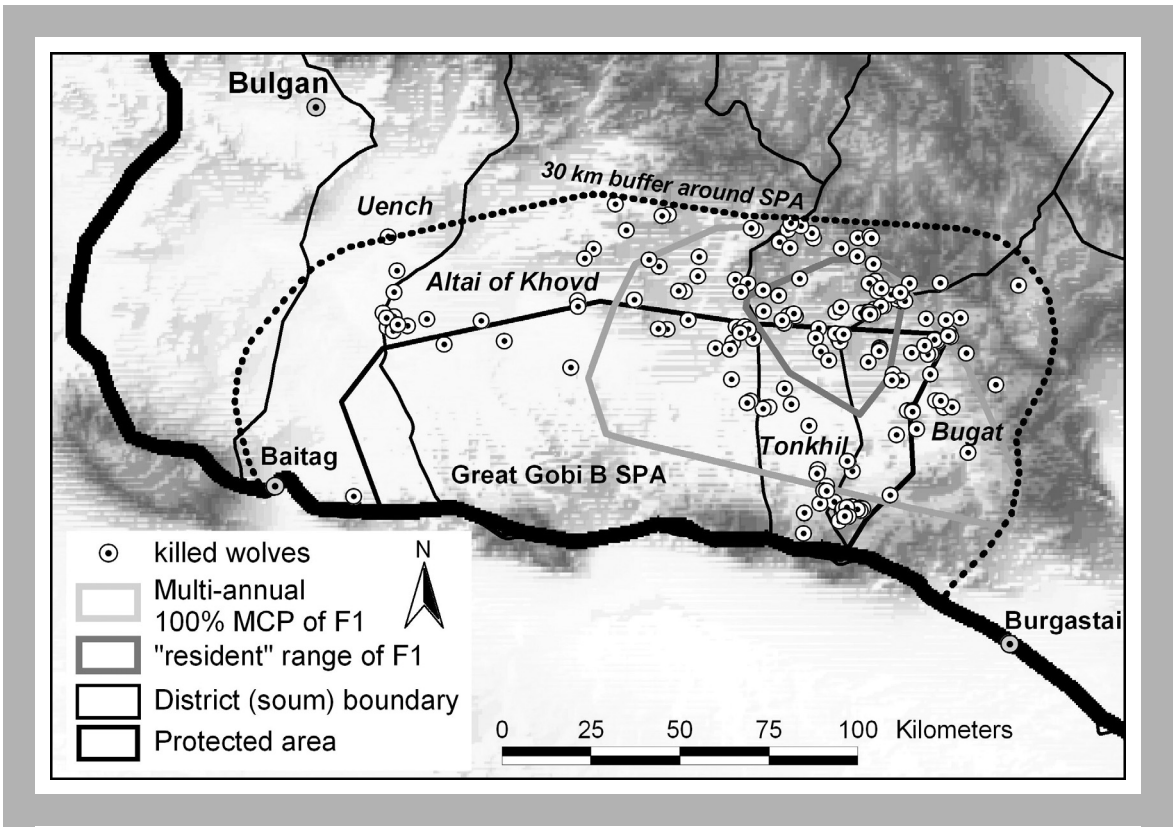

Figure 3. Location of 184 wolves killed in and around the Great Gobi B Strictly Protected Area during the hunting seasons of 2002/03-2004/05.

We subsequently determined the 100% minimum convex polygons (MCP) from all GPS locations during this period. We additionally calculated the total area covered over the entire monitoring period (multi-annual MCPs) to get an idea of which area the same wolf might be expected to roam.

To test whether wolves prefer inaccessible mountainous terrain over the flat steppe, we derived elevation and slope from digitised 1:100,000 topographic maps. We classified slopes of $\leq 5^{\circ}$ as flat and easily accessible for vehicles, slopes of 5-20° as inaccessible for vehicles, and slopes of $>20^{\circ}$ as steep and inaccessible for riders. We refer to areas as mountain ranges when the slope was $>5^{\circ}$. We compared use and availability of flat, inaccessible for vehicles and steep terrain by the two wolves using non-parametric χ^2 statistics, comparing the slope of the GPS locations with the available proportions of the three slope categories within the 100% multi-annual MCPs.

We analysed all locational data in ArcView 3.2 using the Spatial Analyst (ESRI, Environmental Systems Research Institute, Inc., Redlands, California, USA) and Animal Movement (Hooge & Eichenlaub 1997) extensions. For all statistical analyses, we used SPSS 14.0 (Statistical Package for the Social Sciences; SPSS Inc., Chicago, Illinois, USA).

Results

Telemetry

The collar of female F1 acquired 2,228 GPS locations from 06. 05. 2003 until 16. 09. 2005 and thus exceeded the expected monitoring time of 19 months by 10 months. The collar of male M1 lasted the expected 19 months until drop-off and acquired 1,456 GPS locations from 06. 03. 2004 until 19. 09. 2005. Both collars were in excellent condition upon retrieval and showed only moderate wear. On average, both collars managed to realise 2.59 locations per day, a success rate of 86%. GPS locations were more of less evenly distributed over the months, as well as over the three acquisition periods (08:00: 34%, 16:00: 32% and 00:00: 34%).

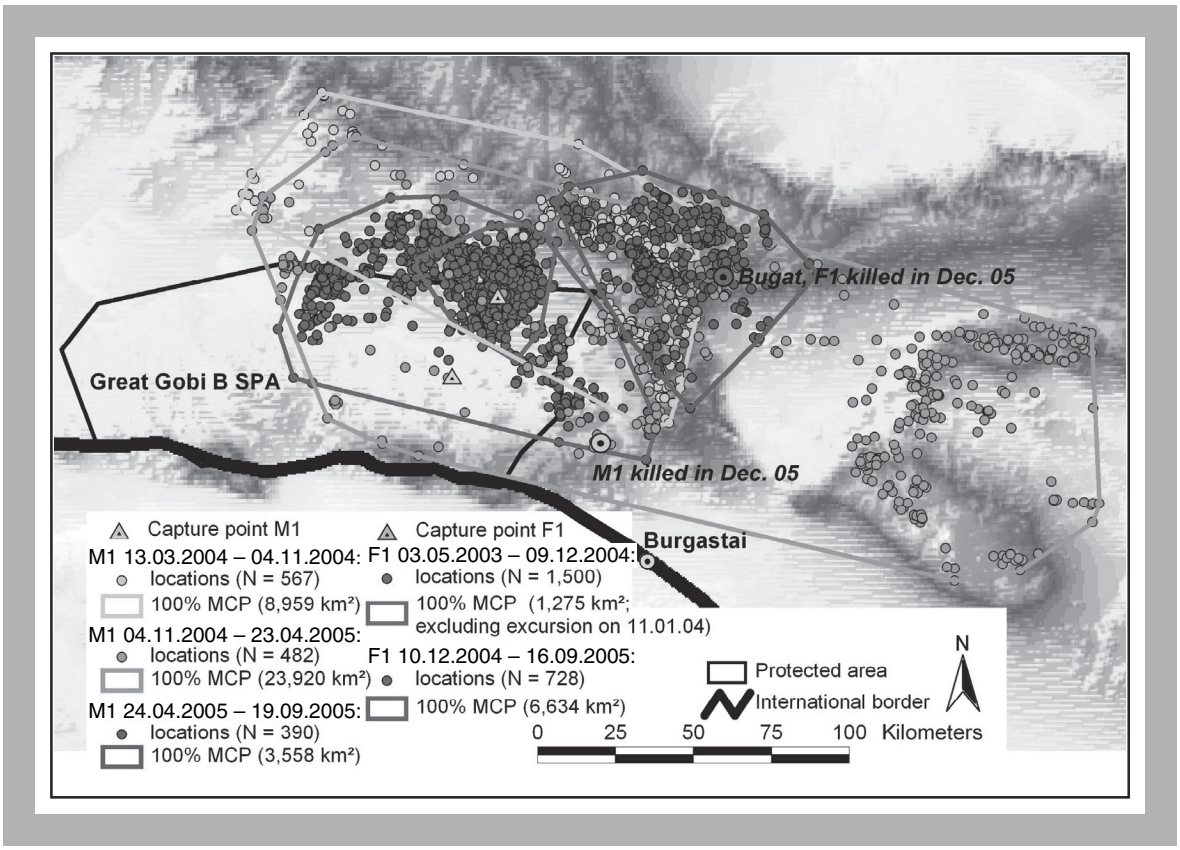

Figure 4. GPS locations and range sizes (minimum convex polygons; MCP) of female F1 and male M1 during the different periods of range use.

During the 29-month monitoring period, female F1 covered a total area of 6,670 km^2 (100% MCP). However, the monitoring period can be split in two rather distinct periods: a 20-month 'resident' period in which F1 lived in an area of 1,275 km^2 and a 9-month 'extension' period in which F1 enlarged her range to 6,634 km^2 (Figs. 2A & 3). In 2003, we confirmed reproduction by F1, but for the following years we have no information on the reproductive status of F1 or her pack mates. The core of F1's home range included several medium-sized mountain ranges with a maximum elevation of 2,020 m a.s.l. (Fig. 4). F1 clearly preferred mountainous terrain and used the flat steppe significantly less than available ($\chi^2 = 4{,}230.6$, df = 2, $P < 0.001$). In December 2005, F1 was killed in the village of Bugat, well outside of her previous range (see Fig. 4). Because her behaviour suggested a rabies infection, it is unclear whether she had actually shifted her range or her movement was disease related.

During the 19-month monitoring period, M1 covered an area of 26,619 km^2 (100% MCP). Also, in this case, the monitoring period can be split in distinct periods: an 8-month 'resident' period during which M1 lived on an area of 8,959 km^2, followed by a 6-month 'roaming' period during which M1 covered 23,920 km^2, and followed by another 'resident' period during which M1 returned and lived on an area of 3,558 km^2 (see Figs. 2B & 3). M1 mainly roamed in the high mountains with elevations up to 3,750 m a.s.l. of the southern tip of the Altai range (see Fig. 4). M1's highest GPS position was at 3,600 m a.s.l., and he also clearly preferred mountainous terrain over the flat steppe ($\chi^2 = 1{,}038.60$, df = 2, $P < 0.001$). For M1, we lack any information about reproductive status or possible associations with other wolves.

Harvest data

In 2002/03, 60 wolves were killed in the Bugat, Tonkhil and Altai-Khovd part of the study area (15,912 km^2), in 2003/04, 46 were killed in the Bugat and Tonkhil part of the study area (7,074 km^2) and

Table 1. Wildlife products detected between November 2004 and April 2005 on the four most important markets in the vicinity of the Great Gobi B SPA in southwestern Mongolia.

	Number of	Wolf					Skins of							
Market	monitoring days	Frozen carcasses	Head	Skin	Knuckle bones	Teeth	Lynx	Fox	Corzack	Manul	Marten	Marmots	Deer antlers	Other*
Baitag	4	897	200	6	10	50		1003				400	80	1
Burgastai	4	820		230	30			1350		325	150		100	2
Altai	137	1090		176				2040	879	506	154		72	
Bulgan	165	38		18			1	104	1	9		135	28	42
Sum		2845	200	425	40	50	1	4497	880	840	304	535	280	45

Other* includes 21 hares, nine snow cocks, seven eagle owls, seven wild boar and one muskrat.

in 2004/05, 78 were killed in the Bugat, Tonkhil, Altai-Khovd and Uench part of the study area (18,670 km^2). This corresponds to a harvest rate of roughly 1 wolf/265 km^2 in 2002/03, 1 wolf/120 km^2 in 2003/04 and 1 wolf/310 km^2 in 2004/05. However, hunting pressure was unevenly distributed and was particularly high in the north and northeastern part of the park. During the active monitoring period of F1 in 2003/04 and 2004/05, 80 wolves were killed within the area of her multi-annual home range (1 wolf/80 km^2) and 34 wolves (1 wolf/38 km^2) within her smaller 'resident' range (see Fig. 3).

Of the 184 wolves killed from July 2002 until February 2005, 20 (11%) were trapped. All others were shot, usually from a jeep or motorbike. Only few were shot from horseback, ambushed at a kill or taken from a den. Almost no wolves were shot in the central, flat, very dry and remote part of the SPA (see Fig. 3). It remains to be investigated if the reason for this lack of hunting in the central part of the park is due to difficult access or a lack of wolves. The majority (83%) of wolves were killed during the winter months from October until March (Fig. 5).

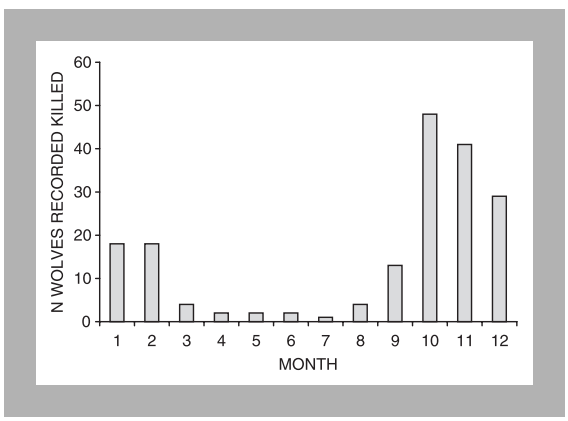

Figure 5. Monthly distribution of 184 wolves killed in and around the Great Gobi B Strictly Protected Area during the hunting seasons of 2002/03 - 2004/05.

Of 130 wolves for which we had an age and sex estimate, 62% were claimed to have been males and 38% females. Furthermore, 92% were claimed to have been adults and the remaining 8% either young wolves or pups.

Market survey

In the winter of 2004/05, red fox and wolf products were by far the most frequent wildlife products found on the markets (Table 1). Because frozen carcasses, skins and heads cannot be derived from the same animals, these products sum up to a total of 3,470 wolves killed of which 2,153 were offered on the cross-border markets. However, double counts were possible as products may have been traded within the markets, as well as among the markets (e.g. from Altai and Bulgan to Baitag or Burgastai). In addition, no information was available about the origin of any of the wildlife products. In one case, a pack of ~60 wolf skins was claimed to have arrived from the area of Lake Hovsgul, some 800 kilometres away.

Discussion

We are fully aware that with a sample size of two collared wolves we can only provide circumstantial evidence on wolf densities and the expected impact that the present harvest rate has on the wolf population in the Great Gobi B SPA. To complicate things further, range-use pattern changed over the monitoring period and range sizes of the two wolves differed by almost a factor four. However, at least in 2003, F1 was a confirmed breeder. With 1,275 km^2, the 'resident' range of F1 equalled in size with those territories described from other rather unproductive habitats in the high Arctic of Alaska and Canada (Fuller et al. 2003). The subsequent 'extension' period may be explained by the disintegration of the pack

due to the loss of pups or pack mates during the 2003/04 and 2004/05 hunting seasons. The range of M1 seemed way too large for a resident wolf, suggesting that M1 may have been a disperser or a floater.

Assuming that the 'resident' range of F1 is more typical for established packs in the Gobi, a hunting bag of 34 wolves within two seasons is high. Based on snow tracking and direct observations from 2002 until 2004, we are confident that there was no second wolf pack within the 'resident' range of F1. Although a female wolf can have up to 10 pups, the average litter size is 5-6 (Fuller et al. 2003). To sustain a harvest of 34 wolves, the pack of F1 would have to produce and successfully raise 15 pups annually, which is an impossible number.

Monitoring wolf harvest over only three hunting seasons does not allow for any trend estimates nor for an analysis of factors influencing wolf harvest. But repeated over extended time periods, harvest data could potentially yield insight into wolf population dynamics (e.g. Jędrzejewska et al. 1996). Additional information on the population status could be derived from age and sex composition of killed wolves. In a highly exploited wolf population, one would expect a high percentage of pups due to compensatory reproduction and a predominance of newly formed pairs (Hayes & Harestad 2000, Fuller et al. 2003). Wolves typically disperse from natal packs after they are two years old (Fuller et al. 2003). If the Great Gobi B SPA acts as a dispersal sink, most wolves that are being killed should be young adults (2-3 years old). Unfortunately the present method of data collection is not suitable to address this issue. Upon checking several wolf carcasses, it became clear that local hunters classified pups killed in the fall as adults and rarely checked the sex, but rather assumed that they killed a male.

Both of the collared wolves showed a clear preference for mountainous terrain over the flat steppe. Although we lack a clear proof for a causal relationship, this preference may be a consequence of people chasing down wolves with motorised vehicles. If the habitat choice in respect to slope is representative for wolves in the Gobi, only 21% of the predominantly flat Great Gobi B SPA constituted preferred wolf (retreat) habitat.

The high harvest rate within the park can be explained by a much higher wolf density than suggested by our preliminary data or by the immigration of wolves from the surrounding mountain ranges where they are difficult to hunt. As long as wolves thrive outside the park, the high reproductive potential and the long-range dispersal ability of wolves could well ensure immigration and subsequent reproduction of wolves in the Great Gobi B SPA.

However, even when the present wolf harvest level within the Great Gobi B SPA does not result in an eradication of wolves, the fact remains that a significant number of wolves are harvested from a category I protected area. Even considering the ambiguous definition of articles 9 and 10 of the Mongolia law on SPA (Enebish & Myagmarsuren 2000), this can hardly be interpreted as a protection activity "to preserve the original natural conditions" of the SPA, and it is clearly in opposition to management objects stated by the IUCN protected area categories (WCPA 2007).

Motivations for killing wolves were mainly to protect livestock and performing a 'manly' activity (Kaczensky 2007, N. Enkhsaikhan, unpubl. data). However, since spring 2004, informal interviews also revealed that the high prices paid in China for frozen wolf carcasses were an additional incentive (O. Ganbaatar, pers. comm.). The high number of wolf products discovered during our market surveys supports the economic perspective of wolf hunting and is in accordance with data collected by Zahler & Wingard (2006) in 2004. In the winter of 2004/05, we discovered products of ~2,000 wolves on the two border markets Baitag and Burgastai, which is a huge discrepancy to the 150 CITES permits issued annually. Our data highlights that the trade in wolf parts is totally uncontrolled, not only at a national level but also at the international level.

Management recommendations

Implementation of a radical switch from encouraging or tolerating wolf hunting in the SPA to complete protection is problematic because it will most likely result in negative attitudes of local herders towards park management and nature conservation in general. Herders strongly oppose wolf protection, because wolves are made responsible for the loss of 1-2% of the local livestock and wolf hunting is seen as a necessity to allow herds to thrive (Enkhsaikhan 2002, Mishra et al. 2003, Kaczensky et al. 2007). Because local people depend heavily on livestock, methods to reduce wolf predation and incentives for wolf conservation need to be developed, similar to programmes developed for snow leopards (Mishra et al. 2003).

In a first step, it would be important to improve control and restrict wolf hunting to certain people, areas and seasons. Presently uncontrolled wolf

hunting within the SPAs legalises armed access to the park, which in turn facilitates poaching which has been identified as a major threat to Mongolia's biodiversity (Clark et al. 2006, Wingard & Zahler 2006). In addition, there seems to be a trend towards a commercialisation in the trade of wildlife products which affects wolves as well as most of their prey species (Kaczensky et al. 2006, Wingard & Zahler 2006). The conservation of wolves and their prey species is currently limited by the absence of reliable monitoring data, a lack of awareness of the fate of species and ecosystems, and a lack of capacity and funds (Clark et al. 2006, Kaczensky et al. 2006, Reading et al. 2006, Wingard & Zahler 2006).

Full protection of wolves will be met by strong opposition by the local people, but unrestricted wolf hunting will result in a highly disrupted wolf population and will facilitate poaching of other wildlife species. In a first step towards resolving this dilemma, we propose the following actions:

- Registration of motorised hunting parties before a wolf hunt at the park headquarter or with the regional ranger;
- an obligatory control of all wolves killed in and around the SPA (according to sex, age class, location of kill and means of killing);
- random checking of vehicles by rangers for weapons and wildlife carcasses during the peak wolf-hunting season in fall and winter;
- development of alternative wolf reduction programmes involving the local population (i.e. support of organised wolf hunts in the buffer zone, but no hunting in the SPA itself);
- documentation of all wolf damages and wolf signs (especially reproduction) by rangers during field work and through informal interviews of herders;
- monitoring of border posts and near border markets to assess the magnitude of the cross-border trade in wildlife products;
- development and distribution of an education kit on the uniqueness of the Great Gobi B SPA and its wildlife, including wolves and other predators;
- further research on wolf ecology in steppe ecosystems.

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