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## A conservation strategy for khulan in Mongolia: background and key considerations

Petra Kaczensky, Bayarbaatar Buuveibaatar, John C. Payne, Samantha Strindberg, Chris Walzer, Nyamsuren Batsaikhan, Sanjaa Bolortsetseg, Ray Victurine, and Kirk A. Olson



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# A conservation strategy for khulan in Mongolia: background and key considerations

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Khulan leaving water in the South Gobi Region ©Petra Kaczensky

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# Abstract

Petra Kaczensky, Bayarbaatar Buuveibaatar, John C. Payne, Samantha Strindberg, Chris Walzer, Nyamsuren Batsaikhan, Sanjaa Bolortsetseg, Ray Victorine, and Kirk A. Olson. 2020. A conservation strategy for khulan in Mongolia: background and key considerations. NINA Report 1889. Norwegian Institute for Nature Research.

Asiatic wild ass (*Equus hemionus*), referred to as khulan in Mongolian, are among the most mobile ungulates globally. Their movements exceed the much better known migrations of caribou in the Arctic or wildebeest and zebra in the Serengeti-Maasai Mara ecosystem. These wide-ranging movements allow khulan to thrive in large numbers under the harsh climate and unpredictable conditions of Central Asia's resource-poor drylands. The very same harsh climate also gave rise to the traditional nomadic herding practised by local communities. However, this need to move makes khulan extremely vulnerable to the fragmentation and loss of habitat which is currently ongoing throughout their range. In turn, this mobility makes khulan an ideal umbrella species for largely intact and functionally connected dryland ecosystems, which could benefit many other threatened dryland species, ecological processes, and the local communities that rely on them (Fig. 1).

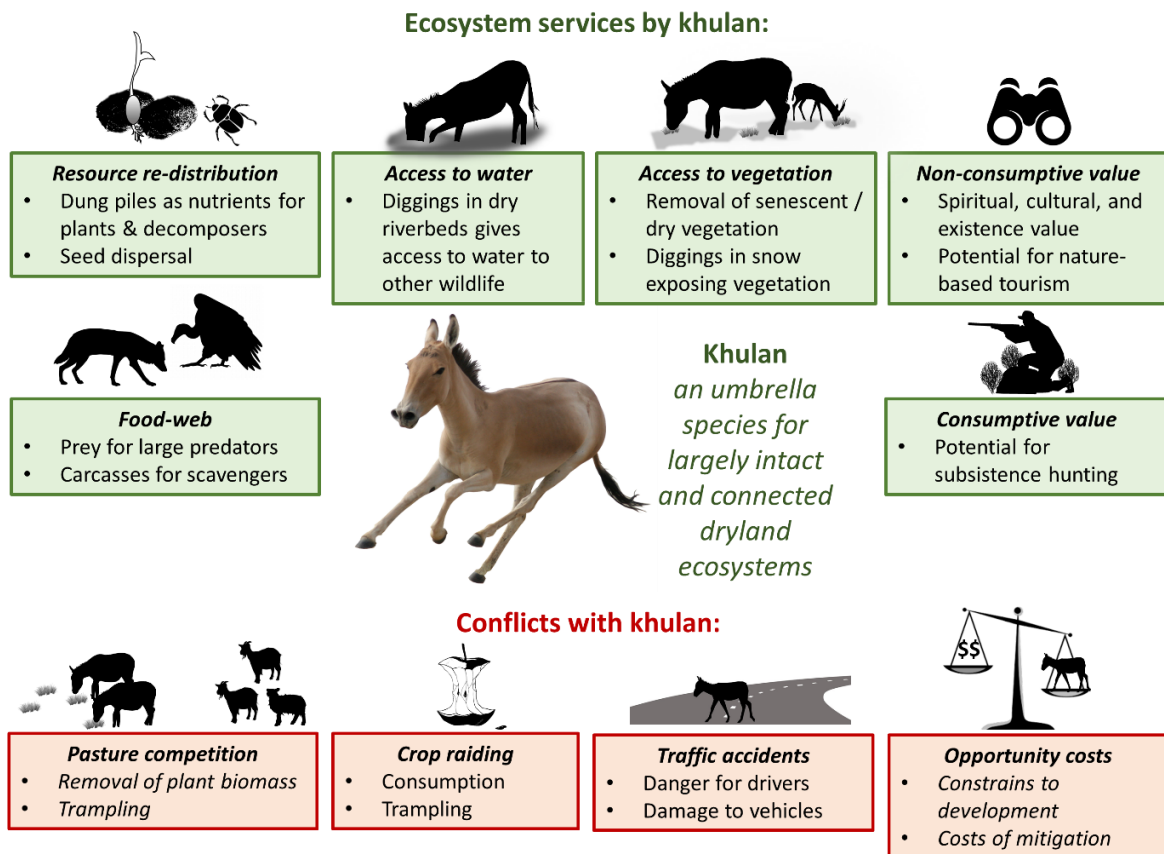


Figure 1: The ecological role of khulan in dryland ecosystems of Central Asia and the conflict potential in shared multi-use landscapes. Graphic: P. Kaczensky, Photo: E. Sos

Long-distance movements and aggregations of ungulates fascinate people worldwide and safeguarding this globally declining phenomena and its associated ecosystem service has become a conservation goal in itself, formally recognized by the Convention of Migratory Species (CMS) and the International Union for Conservation of Nature (IUCN) via the IUCN Connectivity Conservation Specialist Group (<https://conservationcorridor.org/ccsq/>). Mongolia signed CMS in 1999 and in 2002 added the khulan to the list of CMS species.

Other ecosystem services provided by khulan include large-scale nutrient re-distribution and seed dispersal, providing access to water for other species by digging in dry riverbeds, and facilitating access to vegetation for other wildlife by removal of senescent vegetation or digging craters in the snow. Khulan are prey for predators and carrion for scavengers, and a potential source of protein for local human communities. Their presence is also of spiritual, aesthetic, and cultural importance (“existence value”) for local people. Khulan, along with other species, have a largely untapped potential to add a wildlife component to Mongolia’s already thriving nature- and culture-based tourism.

But like all wildlife living in multi-use landscapes, khulan also cause conflicts. They compete with livestock for pasture, they can also raid crops, cause traffic accidents, and their conservation needs to be considered in land-use planning, thereby constraining development options or necessitating costly mitigation measures (Fig. 1). Balancing these costs and benefits in a way that provides for the needs of khulan and Mongolia’s economic development requires careful knowledge-based planning.

With an estimated 64,000 khulan, the Mongolian Gobi currently holds >80% of the global population and constitutes >70% of the species’ global breeding range (Fig. 2). The global fate of khulan is therefore tightly linked to its conservation in Mongolia. Even in Mongolia, khulan have become constrained to the least productive and most unpredictable areas in the south. And after the construction of the fenced Trans-Mongolian Railway in the 1950’s, they became extinct on the Eastern Steppe and are now only found in the Gobi.

On the IUCN Red List the khulan is currently listed as *Near Threatened*, but its status remains under close scrutiny because of multiple developments that may negatively impact the size, quality, and functional connectivity of the Gobi - Steppe ecosystem. These developments are happening simultaneously and at an unprecedented speed in an ecosystem which so far has remained in a near-natural state and include (Fig. 2):

- 1) The dramatic and unconstrained increase in livestock populations and a change in the traditional herding system, resulting in competition with, and displacement of, khulan from pastures.
- 2) The rapid development of the resource extraction sector (mining and oil) and the associated influx of people and technical infrastructure, resulting in habitat degradation, destruction, and new sources of disturbance.
- 3) The rapid expansion and upgrading of the transportation infrastructure to meet the needs of mining development, and to connect Mongolia to international markets, resulting in habitat fragmentation.
- 4) Climate change with increasing temperatures and an expected higher frequency of extreme events like droughts and severe winter storms (*dzuds*), resulting in local or regional die-offs in ungulates and longer-term changes in water and pasture availability.
- 5) At the same time, historical threats, like illegal killing of khulan, persist.

Mongolia has committed to large-scale conservation by setting aside >20% of its land surface as nationally protected areas and is aiming for a coverage of >30%. But for wide-ranging nomadic and migratory species like khulan, Mongolian gazelles, goitered gazelles, and saiga, protected areas alone will not be enough to safeguard their current population numbers and ecosystem functions. With the exception of the Great Gobi Strictly Protected Area (SPA), none of the protected areas are large enough to contain the movements of even a single khulan over an entire year, let alone its lifetime. This mismatch is particularly acute in the South Gobi Region, where most khulan now live. To maintain khulan at current population levels, they will need access to the multi-use landscape between protected areas and a high degree of landscape connectivity, both of which need to be explicitly considered in land-use planning and development.

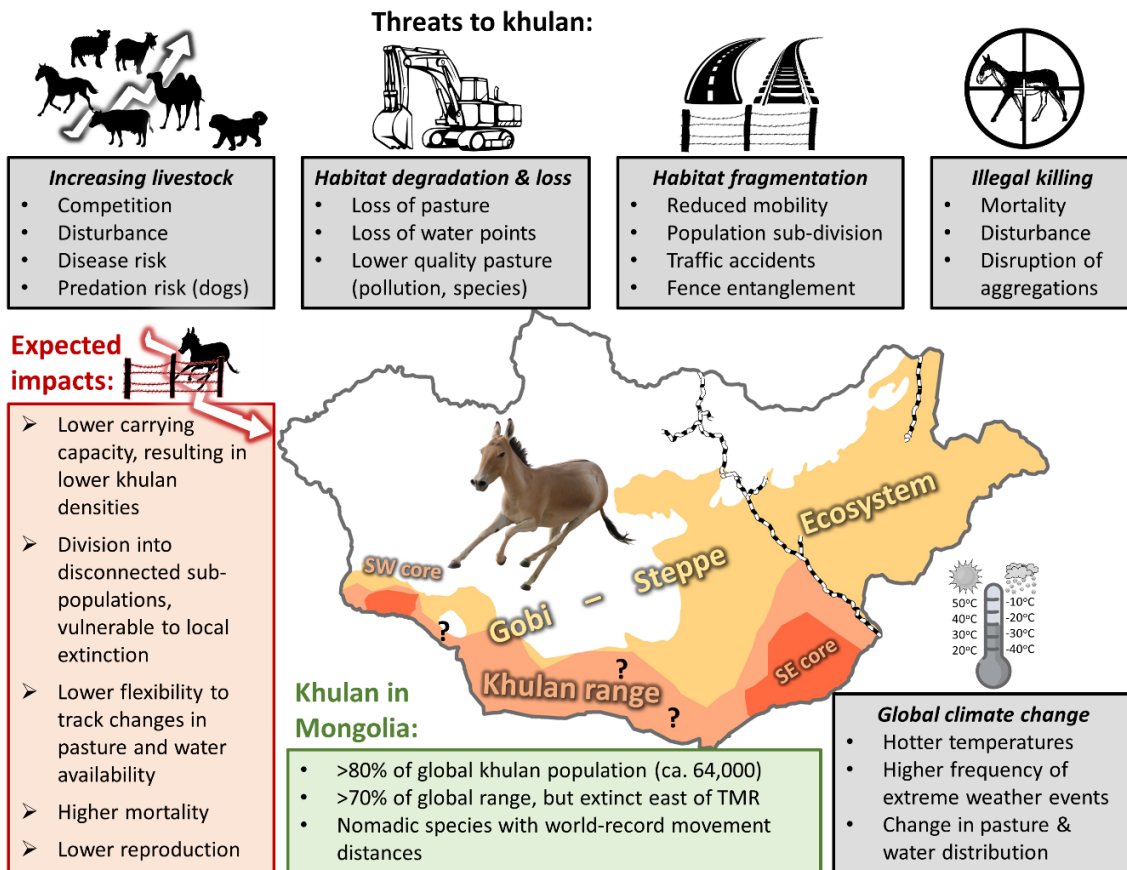


Figure 2: Current khulan distribution in Mongolia (red) showing the impact of fragmentation by the Trans-Mongolian Railway and ongoing threats with their expected impacts on khulan persistence in the Gobi-Steppe ecosystem (orange background) without targeted conservation actions. TMR = Trans-Mongolian Railroad, ? = khulan status needs further clarification in this part of the Gobi. Graphic: P. Kaczensky, Photo: E. Sos

Against the backdrop of ongoing changes within the current khulan range in Mongolia, we believe that there is an urgent need for a national khulan conservation strategy which aims to:

- Assemble a community of stakeholders from across Mongolia who are concerned about khulan conservation, feel impacted by khulan in their livelihoods, or may impact khulan or their habitat through their actions.
- Within this stakeholder community, build a common understanding of the threats to khulan conservation in Mongolia based on projected land-use changes.
- Develop a shared vision for the future of khulan conservation in Mongolia and a plan to guide its realization, focusing on urgent aspects of landscape-scale land-use planning, impact mitigation, and long-term monitoring.
- Build a commitment for immediate action for khulan and an enabling planning, regulatory and funding framework through which actions can be sustained.
- Leverage the khulan conservation strategy as a blueprint for similar conservation strategies for other wide-ranging ungulates falling under Mongolia’s commitment to the Convention of Migratory Species (CMS) and its Central Asian Mammals Initiative (CAMI).

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## Sammendrag

Petra Kaczensky, Bayarbaatar Buuveibaatar, John C. Payne, Samantha Strindberg, Chris Walzer, Nyamsuren Batsaikhan, Sanjaa Bolortsetseg, Ray Victorine, and Kirk A. Olson. 2020. A conservation strategy for khulan in Mongolia: background and key considerations. NINA Rapport 1889. Norsk institutt for naturforskning.

Det asiatiske villeselet (*Equus hemionus*), som i Mongolia kalles khulan, er blant de mest mobile hovdyrene i verden. Dette gjør det mulig for khulan å trives i store antall i det harde klimaet og de uforutsigbare forholdene i Sentral-Asias ressursfattige stepper. De samme forholdene har også gitt opphav til den tradisjonelle nomadiske husdyrhold som lokalsamfunnene praktiserer. Behovet for bevegelse gjør imidlertid khulan svært sårbar for tap og fragmentering av habitat som nå skjer i hele utbredelsesområdet. Samtidig gjør mobiliteten khulan til en ideell paraplyart for et i stor grad intakt og funksjonelt, sammenhengende steppøkosystem, som kan komme mange andre truede steppesarter, økologiske prosesser, og lokalsamfunnene som er avhengige av dem, til gode.

Andre økosystemtjenester som khulanan bidrar med inkluderer redistribusjon av næringsstoffer på stor skala og frøspredning. De gir andre arter tilgang til vann ved å grave i tørre elveleier, og de bidrar til at andre dyrearter får tilgang til vegetasjon ved å fjerne gammel vegetasjon og å grave groper i snøen. Khulan er bytte for predatorer, kadaver for åtseletere og en potensiell proteinkilde for mennesker. Khulan har, sammen med andre arter, et i stor grad uutnyttet potensiale til å legge dyreliv til som en komponent i Mongolias allerede blomstrende natur- og kulturbaserte turisme.

Som alt annet dyreliv i flerbrukslandskap, skaper imidlertid khulanan også konflikter. De konkurrerer med beitedyr om beitemark, de kan skade avlinger og forårsake trafikkulykker. Bevaringsbehovene deres må tas hensyn til i arealplanlegging, og de begrenser derfor utviklingsmulighetene og krever dyre avbøtende tiltak (Fig.1). Å balansere disse kostnadene og fordelene på en måte som imøtekommer både behovene til khulanan og Mongolias økonomiske utvikling krever nøye, kunnskapsbasert, planlegging.

Med sine estimerte 64.000 khulaner har den mongolske delen av Gobi over 80 % av den globale populasjonen og består av over 70% av artens globale utbredelsesområde (Fig. 2). Den globale skjebnen til khulanan henger derfor tett sammen med dens bevaring i Mongolia. Selv i Mongolia har khulanan blitt begrenset til de minst produktive og mest uforutsigbare områdene i sør. Etter konstruksjonen av den inngjerdede transmongolske jernbanen på 1950-tallet, ble den utryddet på den østlige steppen, og finnes nå kun i Gobi område.

Khulan er oppført som 'nær truet' på IUCNs rødliste, men statusen følges nøye på grunn av flere utviklingstrender som kan påvirke størrelsen, kvaliteten og funksjonaliteten på steppøkosystemet i Gobi. Disse utviklingstrendene skjer samtidig, og i en raskere hastighet enn vi tidligere har sett i dette økosystemet, som så langt har vært nær sin naturlig tilstand, og inkluderer:

1. Den dramatiske og ubegrensede økningen i husdyrpopulasjoner, og endring i den tradisjonelle husdyrhold, som resulterer i konkurranse og fortrenging av khulan fra beiteområder
2. Den raske utviklingen av ressursutvinningssektoren (gruvedrift og olje) og medfølgende tilstrømning av folk og bygging av teknisk infrastruktur, som fører til habitatdegradering og -ødeleggelse, og nye kilder til forstyrrelser.
3. Den raske utvidelsen og oppgraderingen av transportinfrastrukturen, for å møte behovene til gruveutviklingen og å koble Mongolia til internasjonale markeder, fører til habitatfragmentering.

4. Klimaendring med økende temperaturer og en forventet økt hyppighet av ekstreme hendelser som tørke og alvorlige vinterstormer (dzuds), som resulterer i lokale eller regionale dødsfall hos hovdyr og endringer over lengre tid i vann- og beitetilgjengelighet.
5. Samtidig er fortsatt historiske trusler, som ulovlig jakt på khulan, en trussel

Mongolia har forpliktet seg til storskala bevaring ved å sette til side over 20 % av landoverflaten som nasjonalt beskyttede vernområder, og de sikter mot over 30 %. For langtvandrende nomadiske og migratoriske arter som kulan, mongolske gaseller, persiagaselle og saigaantilope, vil imidlertid ikke vernområder alene være nok for å sikre de nåværende populasjonene og økosystemfunksjonene.

Med de pågående endringene i det nåværende utbredelsesområdet i Mongolia som bakteppe, mener vi at det er et presserende behov for en nasjonal bevaringsstrategi for kulan som kan fungere som et mal for lignende bevaringsstrategier for andre hovdyr som faller under Mongolias forpliktelser i Convention of Migratory Species (CMS) og dens Central Asian Mammals Initiative (CAMI).

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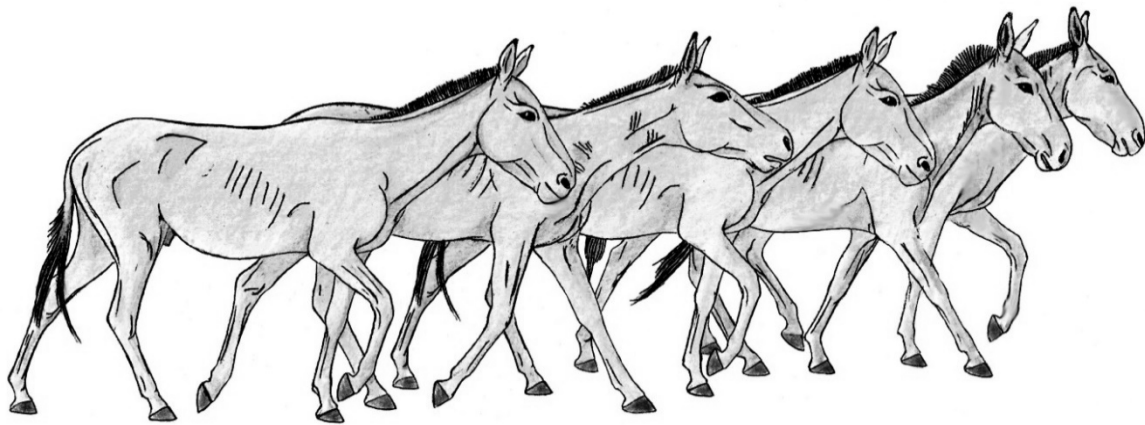
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# Contents

<b>Abstract</b> .....	<b>3</b>
<b>Sammendrag</b> .....	<b>7</b>
<b>Contents</b> .....	<b>9</b>
<b>Foreword</b> .....	<b>11</b>
<b>List of abbreviations</b> .....	<b>12</b>
<b>1 Introduction</b> .....	<b>13</b>
<b>2 Review of khulan status, ecology, and threats</b> .....	<b>14</b>
2.1 Summary facts on khulan .....	14
2.2 Distribution & status .....	15
2.2.1 Global distribution and status .....	15
2.2.2 Regional distribution and status – Khulan in the Mongolian Gobi.....	17
2.3 Biology .....	19
2.3.1 Systematics.....	19
2.3.2 Population genetics .....	19
2.3.3 Ecology .....	20
2.3.4 Movements .....	22
2.4 Ecological function and ecosystem services provided by khulan .....	24
2.4.1 Conservation value .....	24
2.4.2 Landscape scale nutrient re-distribution and seed dispersal .....	24
2.4.3 Providing access to water for other species by digging in dry riverbeds .....	24
2.4.4 Removal of senescent vegetation .....	24
2.4.5 Trampling of snow and digging in the snow .....	25
2.4.6 Prey for predators and carrion for scavengers .....	25
2.4.7 Spiritual and non-consumptive value.....	25
2.4.8 Consumptive value .....	26
2.5 Expected conflicts with khulan.....	26
2.5.1 Conflicts over pasture use .....	26
2.5.2 Damage to agriculture .....	26
2.5.3 Damage to weak fences .....	27
2.5.4 Traffic accidents.....	27
2.5.5 Disease transmission.....	27
2.6 Threats & threat analysis.....	28
2.6.1 Habitat loss and fragmentation.....	28
2.6.2 Habitat fragmentation .....	30
2.6.3 Illegal killing.....	38
2.6.4 Competition with livestock .....	40
2.6.5 Access to water.....	43
2.7 Lessons for regional land-use planning.....	46
2.8 Shortcomings of current impact assessment and mitigation practice.....	47
2.8.1 Environmental and Social Impact Assessments (ESIA).....	47
2.8.2 Mitigation measures.....	48
2.8.3 Monitoring programs.....	49

2.9 A possible way forward.....	50
2.10 Constraints on alleviating threats to khulan or khulan conservation.....	52
2.10.1 Biological constraints.....	52
2.10.2 Social constraints.....	52
2.10.3 Political and administrative constraints.....	52
2.10.4 Economic constraints.....	52
2.10.5 Climate change.....	53
<b>3 Conservation planning.....</b>	<b>54</b>
3.1 What is conservation planning? .....	54
3.2 Next steps.....	55
3.3 Key stakeholders and sectors .....	56
<b>4 References .....</b>	<b>57</b>
<b>5 Appendix .....</b>	<b>66</b>



## Foreword

This background document was compiled within the framework of the Oyu Tolgoi LLC (OT) Core Biodiversity Monitoring (CBM) program which is being implemented by the Wildlife Conservation Society (WCS) through a cooperative agreement with Sustainability East Asia LLC. The Norwegian Institute for Nature Research (NINA) was in turn sub-contracted by WCS to produce an early draft of this document.

The rationale for a conservation strategy is the long term conservation of khulan in Mongolia's Gobi-Steppe ecosystem and to assist OT in achieving their ambition of achieving a net gain on biodiversity associated with their mining activity in the South Gobi Region, which is a global stronghold of the species. This document aims to compile the existing background knowledge about khulan and the Gobi ecosystem relevant for the further development of this planning process.

The production of the final version was co-funded by the Research Council of Norway (grant 251112) and opened up for review by national and international experts. The document incorporates the latest data on khulan from the South Gobi Region – which includes GPS tracking data and various ground surveys to estimate population size, foal rates and mortality – compiled since 2013 as part of OT's CBM program. The document also draws heavily on over 20 years of experience and research by the author team on khulan and other wide-ranging ungulates throughout the Mongolian Gobi and elsewhere in Central Asia. Major international contributions to research on khulan in Mongolia were made by the Austrian Science Fund (FWF projects 24231, 18624, 14992) and The World Bank's Netherlands-Mongolia Trust Fund for Environmental Reform.

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Petra Kaczensky, Norwegian Institute for Nature Research

October 2020

## List of abbreviations

CAMI	Central Asian Mammals Initiative under CMS
CITES	Convention on International Trade in Endangered Species of Wild Fauna & Flora
CMS	Convention of Migratory Species
DEIA	Detailed Environmental Impact Assessment
EN, NT, VU	Endangered, Near Threatened, Vulnerable – IUCN Red List threat assessment categories
ESIA	Environmental and Social Impact Assessments
GAM	Generalized Additive Model
IUCN	International Union for Conservation of Nature
MAT	Multi-Agency Team
MAPU	Mobile Anti-Poaching Units
NM	National monument – IUCN category III protected area
NP	National park – IUCN category II protected area
NR	Nature reserve – IUCN category IV protected area
OT	Oyu Tolgoi copper and gold mine
SCS	Species Conservation Strategies under IUCN
SFU	Sheep Forage Units
SMART	Spatial Monitoring and Reporting Tool
SPA	Strictly Protected Area – IUCN category Ib protected area
SSC	Species Survival Commission under IUCN
TMR	Trans-Mongolian Railway
TNC	The Nature Conservancy
TT	Tavan Tolgoi coal mine
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

# 1 Introduction




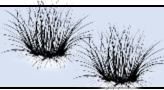
Massive herds of ungulates moving huge distances across the vast open steppes and desert plains of Mongolia rank among the wildlife wonders of the world and represent a defining part of the country's wild heritage. Movement has always been a necessity for wild ungulates like Asiatic wild ass (khulan, *Equus hemionus*), Mongolian gazelles (*Procapra gutturosa*), goitered gazelles (*Gazella subgutturosa*), saiga (*Saiga tatarica mongolica*) and wild camels (*Camelus ferus*), as well as for people and their livestock, as a way of coping with a harsh and unpredictable environment. To date, Mongolia has offered seemingly unlimited and unconstrained space for both wildlife and people to move in. However, change is coming. Although Mongolia has one of the lowest human population densities on Earth, recent years have seen a surge in socio-economic and infrastructure development. While many of these changes have been central to raising the standard of living of Mongolians, they also hold the potential to severely impact the future of wildlife (and of pastoralists) if they are not carefully planned and implemented. One of the central tenants of the UN's Sustainable Development Goals is that activities in different sectors have to be coordinated. Sustainability requires holistic thinking.

Conservation planning is an emerging discipline that aims to bring together stakeholders and representatives of different sectors so that their knowledge and interests can be discussed in a structured manner. The intended outcome is a detailed plan on how the synergies and conflicts of different interests can be integrated into a shared landscape, making space for both wildlife and development. One of the early steps in the conservation planning process is to generate an overview of the background information for the species or ecosystem in question, so that these processes can build on a common and up-to-date knowledge platform.

This report presents a summary of our state of knowledge for the khulan. In recent comparative studies the khulan has been identified as the world's most mobile wild ungulate. This trait represents both a major conservation value and a major conservation challenge in the face of development that fragments historical habitat. Although the actual area destroyed by a road or railway may be only in the order of tens of square kilometres, the barrier effect of unmitigated linear infrastructure can result in blocking khulans' access to thousands of square kilometres of habitat. As a result, khulan are the Mongolian species most urgently in need of a conservation plan. A plan that accommodates khulan will also provide a wide umbrella, benefiting many of the other species that occur in the same ecosystem. This report summarises both what we know about khulan biology and the current state of the threats which it faces, with a special focus on the Dzungarian Gobi and the South Gobi Region, which currently constitute the two population cores for khulan. The final section of the report includes some brief outlines of the next steps that are needed in the conservation planning processes.

## 2 Review of khulan status, ecology, and threats

### 2.1 Summary facts on khulan

<b>Status and distribution</b> 	
Khulan, <i>Equus hemionus</i>	One of seven species in the horse family (Equidae)
Population size:	64,000 (83% of global population!)
Current khulan range:	262,000 km <sup>2</sup> (ca. 30% of historical range)
Protected area coverage of current khulan range:	42%
IUCN Red List status:	Near Threatened
International conventions:	CITES Appendix I, CMS Appendix II
<b>Life history</b> 	
Life expectancy:	Up to 29 years in the wild <sup>1</sup>
Mean age of adults:	9.1 years <sup>1</sup>
Age at first foaling:	3-4 years
Gestation period:	11.5 month
Reproductive potential:	1 foal / year
Birthing and mating period:	June / July
<b>Movements</b> 	
Movement type:	Wide-ranging, nomadic
Max. speed:	75 km / hour
Straight line distance over 10-days:	77 km (Global record among terrestrial mammals!) <sup>2</sup>
Max. annual travel distance:	6,145 km (Global record among wide-ranging ungulates!) <sup>3</sup>
Typical annual range size:	6,000 km <sup>2</sup> (Dzungarian Gobi), 30,000 km <sup>2</sup> (South Gobi Region) <sup>4</sup>
Range restrictions:	Fences, linear infrastructure (TMR, international border to China) <sup>5</sup>
<b>Habitat</b> 	
Habitat:	Desert-steppe, semi-desert, desert
Prefers:	Areas with low livestock density and low human disturbance
Diet:	Grasses, forbs, and shrubs
Water:	Key resource – need to drink every 1-2 days <sup>6</sup>
Distance to water:	most common ≤7 km, with maximum distances of 15-20 km <sup>6,7</sup>

<sup>1</sup>Lkhagvasuren et al. 2017, <sup>2</sup>Tucker et al. 2018, <sup>3</sup>Joly et al. 2019, <sup>4</sup>Kaczensky et al. 2011, <sup>5</sup>Batsaikhan et al. 2014, <sup>6</sup>Payne et al. 2020, <sup>7</sup>Nandintsetseg et al. 2016,



## 2.2 Distribution & status

### 2.2.1 Global distribution and status

In the past, large herds of migratory wild asses (variously named locally as onager (Iran), khur (India), kulan (Central Asian “Stans”), khulan (Mongolia)) roamed the vast Eurasian Steppe from the eastern shores of the Mediterranean Sea in the west to the Mongolian-Manchurian Steppe in the north-east, and as far south as the Rann of Kutch in Gujarat, India. Today, only fragments of this once vast distribution range remain, with the largest intact area found in the Mongolian Gobi (Fig. 3).



Figure 3: Global distribution of Asiatic wild ass (*Equus hemionus*). Single individuals refers to areas where a few khulan may be present, but where there is no breeding core of >20 individuals.

The current global population of Asiatic wild ass is estimated at around 77,000 individuals in nine populations, of which five are original (Mongolian Gobi, Kalamaili/Xinjiang in China, Touran and Bahram-e-Goor in Iran, Little Rann of Kutch in India) and four reintroduced (Negev desert in Israel, Altyn Emel, Barsa Kelmes in Kazakhstan and Ustyurt in the border area between Uzbekistan, Turkmenistan, and Kazakhstan; Fig. 3). In addition, an unknown, but likely small number of animals seem to be present in China's Gansu and Inner Mongolia provinces, south-central and central Kazakhstan, several locations in Turkmenistan, and in central Iran (Fig. 3). With the exception of Badkhyz in south-eastern Turkmenistan, these latter animals originate from past or ongoing reintroduction programs (Kaczensky et al. 2016; Kaczensky et al. 2018a; Kaczensky et al. 2018b). The difference in the population estimate between the 2015 Red List assessment of 55,000 versus the estimate of 77,000 in 2019 (Table 1) is largely due to changes in how population estimates were calculated for the South Gobi Region (Buuveibaatar et al. 2017a) and an apparent increase in the khulan population in the Dzungarian Gobi from 2010 to 2015 (Kaczensky et al. 2017b) and in the South Gobi Region from 2015 to 2019 (Buuveibaatar et al. unpubl. data):

“This species is assessed as *Near Threatened* (NT), because a population decline of at least 20% is projected over the next three generations, based on old prevailing and newly emerging risks, thus approaching *Vulnerable* (VU) under A3bcd. Although the global population is large and currently appears stable, the rapid infrastructure development and the associated influx of people in large parts of the species range could quickly result in the re-emergence of old threats (i.e., increased competition with livestock for water and pasture, high poaching levels). Furthermore, linear infrastructure (i.e., roads, railways, canals) - if not carefully designed and mitigated - are likely to result in high mortalities if Wild Asses are impeded in their long-distance movements and become cut-off from important resources or refuge areas.” (Kaczensky et al. 2015b).

Accordingly, the down listing of Asiatic wild asses from *Endangered* (EN) in 2008 to *Near Threatened* (NT) in 2015 was not due to an improved conservation status, but rather the result of revised population estimates and calculations of the number of mature individuals from improved surveys.

*Equus hemionus* is listed under the Convention on International Trade in Endangered Species of Wild Fauna & Flora (CITES), with the Gobi khulan (*E. h. hemionus*) in Mongolia and China and the khur (*E. h. khur*) in India, under Appendix I and the Persian onager (*E. h. onager*) and Turkmen kulan (*E. h. kulan*) under Appendix II. The species, with all its currently recognized subspecies (see 2.2.1. for systematics), is also listed under the Convention of Migratory Species (CMS) in Appendix II.

Table 1: Status of Asiatic wild ass or khulan (*Equus hemionus*) populations globally.

ID	Area	Country	Origin	Population estimate	% of total	Area (km <sup>2</sup> )	Year	Source
1	Mongolian Gobi	Mongolia	O	64,000	83	261,803	2019	Kaczensky et al. 2015b, Buuveibaatar et al. unpubl. data
2	Kalamaili / Xinjiang	China	O	4,500	6	36,326	2017	Chu et al. 2009
3	Altyn Emel	Kazakhstan	R	>3000	4	5,545	2018	Protected area information 2018*
4	Barsa Kelmes	Kazakhstan	R	500	1	8,802	2019	Protected Area information 2017**
5	Ustyurt	Uzbekistan	R	75	<1	12,701	2018	Marmazinskaya 2019 pers. comm., own expeditions 2018
6	Touran	Iran	O	150	<1	14,931	2015	Kaczensky et al. 2018a
7	Bahram-e-Goor	Iran	O	700	1	4,082	2018	Kaczensky et al. 2018a
8	Little Rann of Kutch	India	O	4,000	5	16,811	2015	Kaczensky et al. 2015 Red List
9	Negev	Israel	O	250	<1	989	2015	Kaczensky et al. 2015 Red List
<b>Sum</b>				<b>77,125</b>		<b>361,990</b>		

\*Own field work in 2017 and 2019 suggests estimate is too high, more likely 2000; \*\*Own field work in 2017 and 2019 suggests that the estimate is acceptable

## 2.2.2 Regional distribution and status – Khulan in the Mongolian Gobi

The total distribution range of khulan in Mongolia covers roughly 262,000 km<sup>2</sup>, which most likely represents around 20% of its former or historical range (Fig. 4). However, the status of khulan in the area between Small Gobi A and Great Gobi A SPA and in Gobi Gurvan Saikhan NP is unclear and there is even concern that the species may be absent between the Trans-Altai Gobi and Small Gobi A SPA (Adiya et al. 2016).

In the south-west, the range is contiguous with the khulan range in Xinjiang (including the core distribution in the 17,577 km<sup>2</sup> Kalamaili NR; Wang et al. 2016). However, connectivity is currently severely compromised by the fenced international border (Linnell et al. 2016). In the east, the fenced Trans-Mongolian railway constitutes the border of the khulan range (Fig. 4).

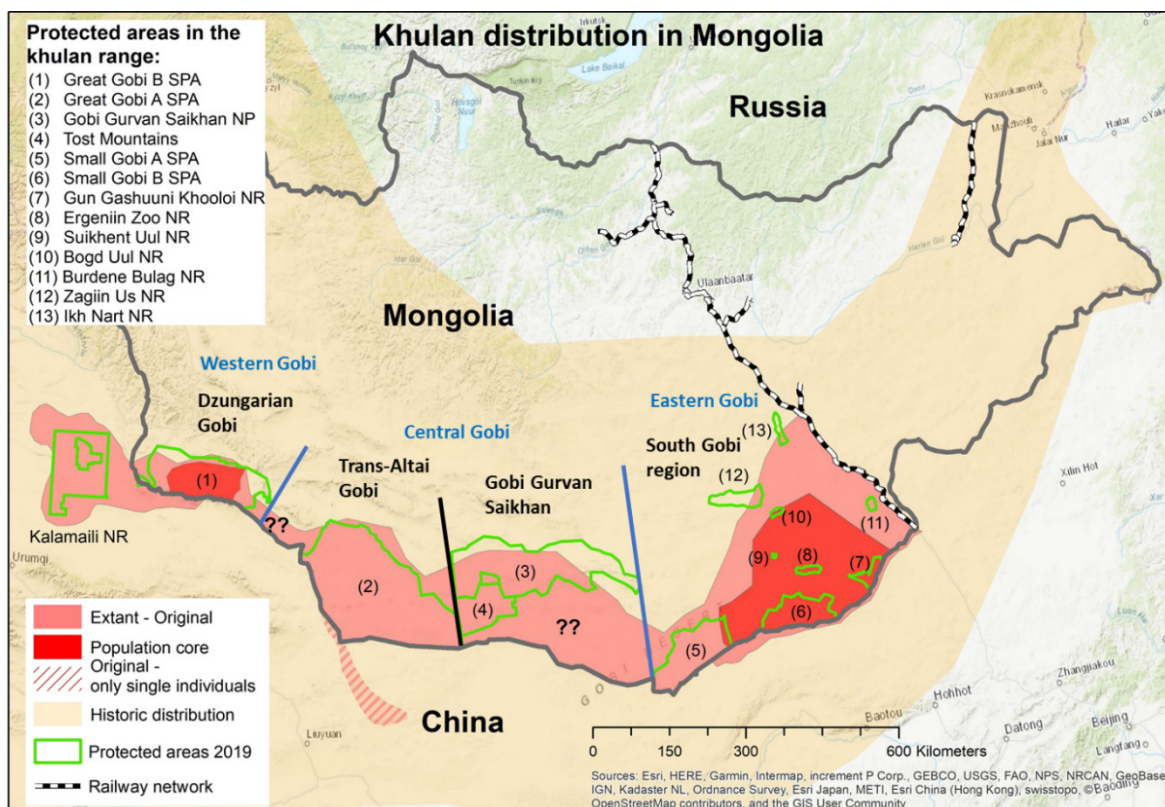


Figure 4: Khulan range in Mongolia and adjacent China with the network of national protected areas relevant for khulan conservation in the region. ?? = areas for which status and population estimates are currently missing; in addition, the status estimate for the Trans-Altai Gobi is rather old

With an estimated 64,000 individuals, the Mongolian Gobi supports >80% of the global Asiatic wild ass population and the situation in the Gobi determines the species' global status and trend. Given the rapid and dramatic socio-political changes in Mongolia, the future of khulan and other Gobi wildlife will depend on Mongolia's ability to become "a global model for demonstrating that major economic development projects can proceed without degrading ungulate migrations" (Batsaikhan et al. 2014).

Khulan in the Mongolian Gobi have been best studied in the Dzungarian Gobi in the south-west and the South Gobi Region in the south-east, with some additional information available for the Trans-Altai Gobi, but very little from the rest of the range (Buuveibaatar et al. 2016; Feh et al. 2001; Kaczensky et al. 2011b; Kaczensky et al. 2006b; Lkhagvasuren et al. 2017; Stubbe et al. 2012; Zhirnov and Ilyirsky 1986).

Recent population surveys suggest that the Dzungarian Gobi and the South Gobi Region represent the cores of the khulan population in Mongolia, housing 80% and 19% of the total

khulan population in Mongolia, respectively (Table 2). Population estimates from the Trans-Altai Gobi and from in and around Gobi Gurvan Saikhan are outdated (Reading et al. 2001). There is concern that very few khulan if any, may be found in those regions. Similarly there is concern that the species may be largely absent between the Trans-Altai Gobi and Small Gobi A SPA (Adiya et al. 2016; Sukhchuluun et al. 2013).

The national survey in 2003, estimated 18,411 ( $\pm$  898) khulan throughout the entire Gobi (Lkhagvasuren 2007) and another survey in 2009, estimated even fewer. However, the recent counts suggest that these two surveys greatly underestimated the population due to methodological constraints (limited number of ground transects to cover such a huge area).

Table 2: Khulan population estimates for Mongolia.

Area	Year	Study area (km <sup>2</sup> )	Method	Population estimate	95% CI or (95% CL)	% of total	Source
<b>Previous estimates</b>							
Dzungarian Gobi*	2010	11,027	Terrestrial point transect distance sampling	5,771	3,611–8,907		Ransom et al. 2012
South Gobi Region*	2013	150,000	Aerial strip transect survey	32,843	(10,571)		Norton-Griffiths et al. 2015
South Gobi Region*	2015	78,717	Terrestrial line transect distance sampling	35,899	22,680–40,537		Buuveibaatar et al. 2017a
<b>Most recent estimates</b>							
Dzungarian Gobi	2015	11,027	Point transect Distance Sampling	9,337	5,337–16,334	14	Kaczensky et al. 2017b
South Gobi Region	2019	78,717	Terrestrial line transect distance sampling	51,691	33,658–79,386	80	Buuveibataar et al. unpubl. data
<b>Sum</b>				<b>ca. 64,000**</b>			

\*Not included in total; \*\*We added ca. 2000 animals for the area between the Dzungarian Gobi and the South Gobi Region, but this number is just a guesstimate as no recent surveys for these areas are available.

The total khulan range in Mongolia covers an estimated 262,000 km<sup>2</sup>, of which some 42% is covered by national level protected areas (Fig. 3). The ca. 9,000 km<sup>2</sup> khulan population core in the Dzungarian Gobi is now more or less entirely within a protected area due to the recent enlargement of the Great Gobi B Strictly Protected Area (SPA; Fig. 4, Table 3).

However, only 17% of the ca. 56,000 km<sup>2</sup> population core in the South Gobi Region is within national protected areas (Table 3). This is of conservation concern, as individual khulan in this area typically roam over areas of about 30,000 km<sup>2</sup> on a yearly basis, yet none of the existing protected areas are that large. Analysis of GPS data from satellite collared animals further shows that khulan spend only about 23% of their time in these protected areas (Kaczensky et al. 2011b; Kaczensky et al. 2006b; Payne et al. 2020).

Table 3: Khulan range in Mongolia and relevant national protected areas. SPA=Strictly Protected Area (IUCN category I), NP=National Park (IUCN category II), NR=Nature Reserve (IUCN category VI), NM=National Monument (IUCN category III), also see: <https://www.protectedplanet.net/country/MN>. For visual overlap with khulan range see Fig. 4.

Nr <sup>1</sup>	Protected area	Total area (km <sup>2</sup> )	Overlap with khulan range	
			(in km <sup>2</sup> )	(in %)
1	Great Gobi B SPA <sup>1</sup>	18,391	15,156	82
2	Great Gobi A SPA	46,333	46,333	100
3	Gobi Gurvan Saikhan NP	26,972	17,928	66
4	Tost Mountains NR	7,432	7,432	100
5	Small Gobi A SPA	11,478	11,478	100
6	Small Gobi B SPA	6,826	6,826	100
7	Gun Gashuuni Khooloi NR	1,413	1,413	100
8	Ergeliin Zoo NR	598	598	100
9	Suikhent Uul NM	48	48	100
10	Bogd Uul NR	257	257	100
11	Burdene Bulag NR	362	362	100
12	Zagiin Us NR	2,736	720	26
13	Ikh Nart NR	666	279	42
<b>Sum</b>		<b>123,512</b>	<b>108,830</b>	<b>42</b>

<sup>1</sup>Corresponds to number in Fig. 4

## 2.3 Biology

### 2.3.1 Systematics

Recent genetic analysis of archaeological, historical, and modern samples suggests that there is only one species of Asiatic Wild Ass. Thus, all previously recognized species, including the modern *Equus hemionus* and *Equus kiang* as well as the extinct *Equus hydruntinus* (which went extinct during the Holocene) are likely to be one and the same species (Bennett et al. 2017). However, sampling of kiang has been restricted to a limited spatial extent and a limited number of individuals, and future research is needed on whether or not Asiatic wild ass and kiang constitute different species. As a result, for the purpose of this report we shall follow the existing convention and consider *E. hemionus* to be distinct from *E. kiang*.

The subdivision of the modern *Equus hemionus* into four different subspecies, namely Indian khur *Equus hemionus khur*, Persian onager *Equus hemionus onager*, Turkmen kulan *Equus hemionus kulan*, and Gobi khulan *Equus hemionus hemionus* has also been recently questioned, as genetic differentiation strongly points towards regional subpopulations (as a result of population fragmentation and genetic drift) rather than subspecies (Kaczensky et al. 2018a).

### 2.3.2 Population genetics

Genetic analysis of samples collected in the period 2002-2005 in Mongolia showed a high level of genetic diversity and low degree of inbreeding as compared to other wild ass and wild equid populations (Kaczensky et al. 2018a; Kaczensky et al. 2011b).

This same data set showed gene flow across the entire range of the species in the Mongolian Gobi, but also identified a partial genetic boundary between the Dzungarian and Trans-Altai

Gobi. The most likely explanation for the reduced gene flow between these two regions is the mountain range separating the two areas, which is enhanced by the international border fence which hinders circumnavigation of these mountains by a southern route (Kaczensky et al. 2011b).

However, these data are now >15 years old, and in the interim, new man-made linear barriers have appeared, largely associated with recent mining development and the need for better connections between urban centres, with international trade partners (i.e., China's Belt and Road initiative), and with border security measures in the region (i.e., upgrading border fences; see Linnell et al. 2016).

### 2.3.3 Ecology

#### 2.3.3.1 Diet

Khulan, like all equids, have high-crowned teeth and enamel extending past the gum line (hypsodont teeth) providing extra protection against wear and tear. Furthermore, equids break down their plant-based food with the help of microbial action in the hind gut (hind gut fermenters) in a process that does not require them to interrupt food intake by rumination (in contrast to deer, sheep, and cattle). These adaptations allow equids to process large quantities of low-quality, abrasive food including senescent grass and woody browse (Schoenecker et al. 2016).

Khulan, like other equids, are primarily grazers. However, diet analysis shows that a wide spectrum of grasses, forbs, and shrubs are consumed by khulan. In the Dzungarian Gobi and Kalamaili NR in China, *Stipa* grasses, saxaul (*Haloxylon ammodendrum*) and *Anabasis* scrubs are of particular importance (Burnik Šturm et al. 2017; Sugimoto et al. 2018; Xu et al. 2012). Khulan seem more flexible in their diet choice than horses. For example, in winter, when herders and their livestock are present, khulan in the Great Gobi B SPA consume a significant proportion of shrubs, which may help them reduce competition with livestock by avoiding grass dominated pastures favoured by herders (Burnik Šturm et al. 2017).

#### 2.3.3.2 Water use

Hind gut fermentation requires a relatively large volume of water for microbial fermentation (Sneddon et al. 1998). Therefore, khulan need regular access to water, normally drinking 12-15 litres per day, and up to 24 litres on hot days. In winter, khulan can meet their water requirements by eating snow (Bannikov 1981; Kaczensky et al. 2010; Zhang et al. 2015). In the Mongolian Gobi, individual khulan most often use 20-30 different waterpoints per year. Although certain key waterpoints are re-used year after year, many other waterpoints are only visited in some years, likely due to factors such as environmental variation (pasture availability, year-to-year variation in precipitation, water flow and quality), competition, predation, and disturbance (Nandintsetseg et al. 2016, Kaczensky et al. 2020 *in Press*, Payne et al. 2020).

In the Mongolian Gobi, individual khulan on average visit waterpoints every 1-2 days. During the growing season, vegetation greenness and to a lesser extent ambient temperature, and snow-cover during the non-growing season, are the most important factors influencing khulan visitation rates to water (Payne et al. 2020). As a consequence, khulan have to visit waterpoints more frequently during periods when it is hot and/or the vegetation is dry.

In the Dzungarian Gobi, where winter snow is a constant, it reliably liberates khulan from the need to visit waterpoints in winter. This provides khulan with access to additional pastures in winter, thereby reducing grazing pressure during a critical time of the year. However, in the rest of the Gobi snow cover is less reliable than in the Dzungarian and the absence of snow in combination with very cold temperatures results in small or stagnant waterbodies freezing solid. Thus very cold conditions reduce the availability of open water, potentially resulting in water scarcity comparable to or even more severe than during a summer drought (Payne et al. 2020).

Compared to horses, khulan seem to have a higher water use efficiency, which may be one reason why they can exploit pastures further away from water (Kaczensky et al. 2008, Burnik Šturm et al. 2017). Cut-off values for pasture use away from water seem to be in the range of 15-20 km (Bannikov 1981; Nandintsetseg et al. 2016), although half of the time khulan do not venture further than 7.2 km when re-visiting the same waterpoint (Payne et al. 2020). Using the latter value, an average waterpoint in the South Gobi Region provides a potential grazing range of 163 km<sup>2</sup>. Recent rain, which leaves ephemeral pools and snow cover can temporarily release khulan from the need to visit water points (Kaczensky et al. 2019; Payne et al. 2020).

### 2.3.3.3 Habitat use

Asiatic wild ass are large herbivores adapted to a cursorial life on open plains. In the Mongolian Gobi, khulan seem to show little preference for any particular plant community type, but avoid steep slopes, and pastures with very low productivity (Kaczensky et al. 2008). However, the most important variables (negatively) influencing khulan habitat use are livestock and human disturbance (Kaczensky et al. 2011b, Buuveibaatar et al. 2016).

Khulan habitat use is also influenced by fencing, as the animals seem unwilling to jump fences and are unable to crawl under fences. As a consequence, fenced national borders or fenced roads and railways constitute absolute barriers to their movements (CMS 2019).

Experience with a fence constructed around the Oyu Tolgoi (OT) mine site, made of smooth (non-barbed) wire and in a way that the wires can be dislocated from their attachment to the pole when pushed, has shown that khulan can learn to move through such a fence when there are desirable resources (water and pasture) on the other side (L. Myagmarjav pers. comm. 2019, based on several khulans going in and out of the OT mine site fence).

### 2.3.3.4 Social organisation

Khulan are social animals and tend to occur in groups most often numbering 4-6 animals (Buuveibaatar et al. 2017a; Feh et al. 2001; Kaczensky et al. 2015a). However, khulan do not live in stable social groups like horses, but rather in groups of varying composition (fission-fusion groups), with the only stable unit being females and their foals (Kaczensky et al. 2008; Rubenstein et al. 2015; Sundaresan et al. 2007).

Small groups of khulan can merge into larger groups, at times numbering in the hundreds or even thousands of animals (Bannikov 1991, Buuveibaatar et al. 2017, Kaczensky et al. 2015a). These large aggregations likely form where animals converge on water sources or when making use of particularly nutritious pastures. The large variation in group size gives khulan high flexibility to react to changes in resource distribution. In combination with their high mobility (see 2.2.4 Movement Ecology) this allows khulan to access and exploit resources over a large range making them less vulnerable to localized events (i.e., droughts, *dzuds*, disturbance). The fission-fusion type social organisation likely also allows information transfer about the availability of resources at the population level, although the mechanisms on how information is transferred are still poorly understood (Bryson and Kaczensky 2009; Rubenstein et al. 2015; Sundaresan et al. 2007).

Breeding season in the Gobi starts at the end of June, but stretches well into July and for some khulan even into the beginning of August (Kaczensky unpubl. data). Stallions seem to occupy temporary mating territories, often returning to the same locations in consecutive years (Kaczensky unpubl. data, Neumann-Denzau and Denzau 2007), a system similar to “lekking”, also observed in the Tibetan antelope (*Pantholops hodgsonii*) another wide-ranging, migratory ungulate (Buzzard et al. 2008). However, no formal investigations into what constitutes a mating range have been conducted so far. It is also unclear how important specific sites are for these mating aggregations and how human disturbance affects khulan mating success and foaling rates the following year.

### 2.3.3.5 Population dynamics

Population dynamics is a topic about which comparatively little is known for khulan beyond basic parameters. Khulan are long-lived animals with life expectancies of >20 years in the Mongolian Gobi. The oldest tooth age of a skull collected in the Gobi was 29 years (Lkhagvasuren 2015; Lkhagvasuren et al. 2013). The mean age of all skulls (for animals >3 years) was 9.1 years. Population modelling based on the age distribution of skulls, estimated adult survival rates of 85% during prime reproductive age of 5-10 years (Lkhagvasuren et al. 2017).

The age at first reproduction seems to be most commonly three years for mares and five years for stallions. Mares can produce a foal annually under favourable conditions until at least 15 years of age. The sex ratio at birth is close to 50:50 (Bannikov 1981; Saltz and Rubenstein 1995; Volf 2010).

The onset of foaling seems tied to climate and happens earlier in the southern part of the species range (i.e., starting in mid-May in the Aral region of south-eastern Kazakhstan (based on camera trap images) or as early as mid-April in Badkhyz in south-eastern Turkmenistan (Bannikov 1981, N. Hudaykuliev pers. comm. 2015).

In the Mongolian Gobi, birthing seems to occur from the end of June until end of July. During an aerial survey in 2013, the first foal was seen on a picture on 15 June, with more frequent images of foals by late June (Norton-Griffiths et al. 2015; J. Payne unpubl. data). During a ground survey in 2019, the first foal was observed on 11 June 2019 (B. Buuveibaatar pers. obs.). A camera collar deployed in October 2015, recorded the birth of a foal on 16 July 2016 (Kaczensky et al. 2019).

Females give birth to a single foal and come into estrous 1-2 weeks post-partum. Hence the peak mating period is closely linked to the peak birthing season in summer. Females are polyestrous, with estrous recurring every 21-25 days until conception or the end of the breeding season in late summer (Asa 2002; Schook et al. 2013).

The age structure of wild and feral equid populations can vary considerably depending on environmental conditions, but seems remarkably consistent among species under the same environmental conditions. The age structure of a typical wild equid population consists of 8–15% foals, 13–28% juveniles, and 71–78% adults without specific reference to season (for overview see Ransom et al. 2016). Annual survival averages 71% for foals and 88% for adults. Annual population growth rates in wild and feral equid populations averages 12% but can vary widely depending on habitat conditions, the occurrence of extreme events, predation, and management regime (Ransom et al. 2016).

In the South Gobi Region, foal rates, calculated as the percentage of foals in the total khulan population, have varied between 6.0 to 18.7% over a 10-year time series between 2003-2012 (Stubbe et al. 2012). Recent estimates have been 18.9% in 2017, 12.5% in 2018, and 14.7% in 2019. Foal survival into the yearling category was estimated at 82% for the 2017 cohort and 53% for the 2018 cohort (Buuveibaatar and Olson 2019; Payne and Kaczensky 2018).

### 2.3.4 Movements

Movement ecology is among the aspects of khulan ecology that has been best studied due to multiple satellite collaring projects conducted during the last 20 years. In the Mongolian Gobi, khulan roam over ranges of thousands of square kilometres and their movements are among the largest reported for terrestrial mammals globally and nationally (Joly et al. 2019; Nandintsetseg et al. 2019; Tucker et al. 2018). Annual or bi-annual ranges of individual khulan (expressed as minimum convex polygons (MCPs) vary based on biogeographic region and landscape dynamics, and typically are 6,000 km<sup>2</sup> in the Dzungarian Gobi, 15,000 km<sup>2</sup> in the Trans-Altai Gobi, and 30,000 km<sup>2</sup> in the South Gobi Region (Kaczensky et al. 2006, Kaczensky et al. 2011b, Payne et al. 2020).



Recent findings from the Gobi suggest that water availability and switching among the sparsely located water bodies may be one key driver for the high mobility of khulan during the growing season (Nandintsetseg et al. 2019; Nandintsetseg et al. 2016; Payne et al. 2020). Other drivers are likely linked to overall pasture productivity, unpredictability of pasture and water availability, and human disturbance.

Given their large annual ranges, only the two Great Gobi A and B SPAs are large enough to provide year-round protected habitat for khulan. In the South Gobi Region, where most khulan are found in Mongolia, none of the protected areas are large enough to contain the movements of even a single khulan over an entire year, let alone its lifetime (Table 3). Although the protected area network is a very important contribution to khulan conservation, at certain points in time almost the entire khulan population is located outside the SPAs. Hence without maintaining connectivity across the multi-use landscape, the khulan population will not be able to prevail in its current abundance nor fulfil its ecological function (see 2.3 Ecological function and ecosystem services).

Khulan movements in the Gobi fall into the category of nomadic movements and differ in multiple aspects from those of migratory or range resident movements. Nomadic movements are categorized by their unpredictable nature; they vary widely within and between years resulting in very large ranges. Migratory movements can also result in large ranges, but the movements follow a predictable temporal and spatial pattern i.e., along an altitudinal or latitudinal gradient and result in discrete seasonal ranges. Range resident movements, on the other hand, result in a clearly defined range, which is used year-round over many years (Teitelbaum and Mueller 2019).

Nomadism in combination with a flexible fission-fusion social system (where group membership as well as group size varies) allows khulan to make the most of the available resources in an unpredictable environment that is prone to extremes. Contrary to range resident species, khulan can buffer the effect of local or temporary resource-poor seasons/years by moving to less affected areas. In the Dzungarian Gobi, this strategy allowed khulan to avoid the worst of the deadly 2009/10 *dzud*, which resulted in massive losses of range resident animals like reintroduced Przewalski's horses and wintering livestock (Kaczensky et al. 2011b).

Nomadic movements are most likely observed in large ecosystems where vegetation productivity is low (i.e., drylands) and where environmental conditions (i.e., the amount and distribution of rainfall) are highly variable from year to year or in systems prone to extreme events. While this nomadism provides a species with maximum flexibility for resource use, it poses extreme challenges for species conservation because it requires flexible and large-scale conservation planning in maintaining to maintain overall landscape connectivity.

Forcing migratory or nomadic species to become range resident greatly lowers the carrying capacity of the landscape by restricting the population's ability to track resources, avoid predators, and minimize exposure to parasites (Fryxell et al. 1988). Reduced mobility in combination with smaller population sizes makes populations more vulnerable to localized events and reduces their resilience to climate change (Bolger et al. 2008; Harris et al. 2009; Wilcove and Wikelski 2008).

## 2.4 Ecological function and ecosystem services provided by khulan

Although there have been few specific studies on the ecological functions and ecosystem services provided by khulan, it is possible to identify some likely elements based on what we know about their general biology and from studies of other equids in similar environments.

### 2.4.1 Conservation value

Globally the impact of human activity and development is leading to dramatically fragmented habitats and reduced animal movements (Tucker et al. 2018). In the Anthropocene, space in which wild animals can freely move is becoming the most valuable conservation commodity. Accordingly, the unfenced, open plains of Mongolia and the wide-ranging movements of its wild ungulates are an almost unique phenomena of exceptional global value. This is particularly the case for khulan, as Mongolia not only hosts 80% of the global population, but is also home to the populations of this species that are the most mobile of any ungulate on earth (Joly et al. 2019). The migrations of Mongolia's wild ungulates dramatically exceed those of the far more internationally recognized Serengeti ungulates in East Africa.

### 2.4.2 Landscape scale nutrient re-distribution and seed dispersal

Equid faeces are large and plant matter not as digested as ruminant faeces, providing more nutrients for decomposers. Equid faeces also contain more intact seeds capable of germination than ruminant faeces, and thus facilitate seed dispersal over long distances (Ghasemi et al. 2012; Peled 2010).

### 2.4.3 Providing access to water for other species by digging in dry riverbeds

In the South Gobi Region, khulan dig for water in dry riverbeds where subsurface flow exists. These water access craters can be up to half a meter deep and also provide water for other wildlife which otherwise would be unable to access it (Fig. 5).



Figure 5: Khulan digging for water in a dry riverbed. Photo: P. Kaczensky

### 2.4.4 Removal of senescent vegetation

Due to their long-crowned teeth and digestive system, khulan are able to feed on coarse or senescent vegetation, thereby stimulating regrowth particularly in steppe regions. In under-grazed steppe systems, their large-scale movements can be expected to create a mosaic of different habitats, supporting a variety of other steppe species.

### 2.4.5 Trampling of snow and digging in the snow

During periods of deep snow cover, groups of khulan walking through the snow create travel corridors for smaller wildlife (Fig. 6). Furthermore, a group of khulan digging for the vegetation under the snow also provides access to forage for smaller, shorter-legged, and weaker herbivores like gazelles.



*Figure 6: Khulan digging for food in the snow in the central steppe of Kazakhstan. Photo: D. Gliga & N. Petrova*

### 2.4.6 Prey for predators and carrion for scavengers

Today, wolves are the main wild predators on the Central Asian plains that are large and strong enough to prey on khulan. However, the quantitative effects of wolf predation on khulan have never been studied and it is generally believed that wolves primarily prey on foals, old or sick khulan. Nevertheless, khulan can be expected to provide an additional prey base for wolves and their carcasses (be it from predation or other causes) will be available for scavengers (i.e., vultures, foxes).

### 2.4.7 Spiritual and non-consumptive value

The presence of khulan and wildlife in general has a high existence value. During interviews, local herders in the Gobi have often pointed out the beauty of khulan and the general spiritual importance of wildlife, or as a herder stated “Nature can be beautiful in itself, but it’s the wildlife that makes it more beautiful and lively and people can see it and feel happy” (Kaczensky 2007). Khulan and other charismatic wildlife symbolize Mongolia’s natural heritage and are of cultural, spiritual, educational, and scientific value. Furthermore, khulan are relatively easy to see and if properly managed could enhance the touristic value of the region and provide additional opportunities to promote community-based eco-tourism in the Gobi.

## 2.4.8 Consumptive value

Hunting khulan for sports and meat is an activity that has been enjoyed for centuries throughout the species' range by nobility and local people (Goldberg 2018; Nutt 1873; Wingard and Zahler 2006). Khulan can make use of marginal pastures distant from water and regulated harvesting could also be an incentive for local herders to share their grazing, leave marginal areas ungrazed, refrain from poaching, and even report on poachers. However, khulan are currently protected throughout their global range, and any change in this status would require careful planning and a robust monitoring system.

## 2.5 Expected conflicts with khulan

### 2.5.1 Conflicts over pasture use

Throughout their range, khulan are regarded as pasture competitors when perceived as being "too numerous". In the Dzungarian Gobi, where herders and their livestock spend the spring, fall and winter in the khulan range, herders are particularly concerned about khulan depleting their winter pastures (Kaczensky et al. 2006a). When large groups of khulan are encountered in fall or winter near these pastures, there are occasions when herders actively chase them away (O. Ganbaatar pers. comm). The same has been reported from the South Gobi Region during periods of poor pasture conditions (i.e., droughts, B. Buuveibaatar pers. obs. 2019). Furthermore, local herders believed that khulan destroy the pasture with their hooves, digging out plants and their roots, thereby causing erosion. Local people also claimed that other herders sometimes kill khulan to discourage other khulan from using certain pastures.

### 2.5.2 Damage to agriculture

Where khulan enter cereal fields (Fig. 7), melon plantations, orchards, vineyards or the like they can cause massive damage through trampling and crop consumption. In Turkmenistan, Iran, India and Kazakhstan these conflicts generally result in attempts to scare khulan or illegally kill them (Dave 2010; Esmaili et al. 2019).



*Figure 7: Potential for conflict documented by a Turkmen kulan equipped with a camera collar and showing that the animal is standing in a wheat field in north-central Kazakhstan in summer 2018. Photo: KULANSTEPPE project*

### 2.5.3 Damage to weak fences

Although khulan are unwilling to jump over or crawl under fences, they are known for their ability to knock down fence posts which are poorly anchored in the ground. In Mongolia this behaviour is only observed along the old and largely derelict fence line which constitutes the Mongolian side of the international border with China (Fig. 8). In addition, some khulan have learnt to push through the wildlife-friendly fencing around the OT mine site to access pasture and water on the other site (L. Myagmarjav pers. comm. 2019). The same happens to weak fences around agricultural plots, as currently observed in Israel and Iran.



*Figure 8: Khulan crossing the old fence line on the Mongolian side along the international border with China (a second new and very robust fence exists on the Chinese territory, which poses an absolute barrier). Photo: P. Kaczensky*

### 2.5.4 Traffic accidents

When kulan cross busy transportation corridors, they can cause serious traffic accidents due to their large size. Regular khulan-vehicle collisions are reported from Israel (i.e., from 2009-2013, 26 wild asses were killed by traffic in Israel; (Warner 2014)) and Iran (S. Esmaeili pers. comm. 2016), while so far only one occasion of a khulan-vehicle collision was documented on the OT mining road – the only mining road systematically surveyed for traffic and wildlife fatalities in Mongolia (L. Myagmarjav pers. comm. 2019; the incident occurred in December 2018).

### 2.5.5 Disease transmission

Khulan are subject to the same diseases and parasites as other wild (i.e., Przewalski's horse) and domestic equids (horses and donkeys; Painer et al. 2010). Free-ranging khulan have tested PCR-positive for various equine herpes viruses (Costantini et al. 2018) and seroconverted to a variety of influenza A viruses (Soilemetzidou et al. 2020). To our knowledge, larger disease outbreaks among Asiatic wild ass have not been documented and are possibly very rare. Furthermore, we are not aware of documented cases of disease transmission from khulan to domestic equids. However, the outbreak of African horse sickness in the 1960s in India apparently resulted in a major decline and the subsequent extinctions of smaller khur populations (Corbet and Hill 1992 in Moehlman 2002). The khulan's high mobility, large ranges and shared pastures with domestic equids has potential for livestock-khulan spill over events to occur. The extensive khulan ranges would potentially facilitate disease spread over large areas.

## 2.6 Threats & threat analysis

Past population decreases and range contractions have been attributed to a combination of land conversion, overhunting, and displacement by and competition with livestock for pasture and water (Bannikov 1981; Kaczensky et al. 2015b; Moehlman 2002; Ransom and Kaczensky 2016). This has eradicated khulan from 80% of its former range. The Mongolian Gobi currently holds >80% of the global population and constitutes >70% of the global breeding range and therefore is the most important stronghold of the species.

The same threats remain in place today. But currently we consider the biggest threat to khulan conservation in the fact that multiple developments which negatively impact the size, quality, and functional connectivity of the Gobi-Steppe ecosystem are happening simultaneously and at an unprecedented speed in an ecosystem which so far has remained in a near natural state.

These developments include:

- 1) The dramatic and unhindered increase in livestock numbers paired with a change in the traditional herding system, resulting in competition with, and displacement of, khulan from pastures.
- 2) The rapid development of the resource extraction sector and the associated influx of people and technical infrastructure, resulting in habitat degradation, destruction, and new sources of disturbance.
- 3) The rapid expansion and upgrading of transport infrastructure (road and rail) to meet the needs of the mining development and to connect Mongolia to international markets (i.e. China's Road and Belt Initiative, Appendix A3), resulting in habitat fragmentation (Batsaikhan et al. 2014; Lkhagvasuren et al. 2011; Olson and van der Ree 2015).
- 4) Climate change with increasing temperatures and an expected higher frequency of extreme events like droughts and severe winter storms (*dzuds*), resulting in local or regional die-offs in ungulates and longer-term changes in water and pasture availability (Dashkhuu et al. 2015; Hijjoka 2014; IPBES 2018; Nandintsetseg and Shinoda 2013).
- 5) At the same time, historical threats, like illegal killing of khulan, persist.

In the following section we provide an overview of the key threats and a short description of how and why these threats are relevant to khulan conservation.

### 2.6.1 Habitat loss and fragmentation

#### 2.6.1.1 Habitat loss to agriculture

Grasslands are globally among the least protected biomes, and the conversion of grasslands into agricultural areas, particularly the ploughing of the Eurasian steppe to grow cereals, has dramatically reduced the habitat available for large ungulates like khulan. When khulan enter cereal fields, melon plantations, or orchards, conflicts arise with farmers, which either result in exclusion of khulan through fencing, farmers chasing them away, or killing them (i.e. in Iran, Turkmenistan, Kazakhstan, and Israel). Consequently, conversion of drylands into agricultural plots (i.e. by irrigation) results in khulan habitat loss, often coupled with increased mortality.

The proportion of irrigated land in the khulan's range is currently small and conflict levels seem very low to non-existent. However, if plans for a water pipeline from the Kherlen or Orkhon rivers are ever realized (Tuinhof and Buyanhisnig 2010; see also: Appendix Fig. A2) the situation could change dramatically. A significant risk, however, also comes from small-scale farming for vegetables or hay along rivers or around oasis in the Gobi. These plots tend to be fenced to exclude livestock and wild ungulates. As a result, khulan not only lose access to productive pasture but also see their access to water blocked (Fig. 9; also see: 2.5.5 Access to water).



Figure 9: Area fenced for hay-making including a portion of a small stream at the edge of Great Gobi B SPA in July 2017. Photo: P. Kaczensky

### 2.6.1.2 Habitat loss to urban and industrial development

Urban, industrial, and mining developments also destroy habitat by converting pastures into built-up areas, fencing off access, potentially polluting pastures with chemicals or dust, and by creating disturbance (Fig. 10). For example, the 2014 mining map layer for Mongolia, showed 87 active mining licenses which intersect the khulan range (see also Fig. 11). Unfortunately, we do not have access to a time series of spatially explicit data on land-use changes and industrial development, nor the most recent shape files of active mining licences, linear infrastructure or other development projects (i.e., green energy, touristic infrastructure, etc.) from the respective agencies in Mongolia. We hence cannot provide comprehensive spatially explicit information on habitat loss, but can rather point to the overall development based on our combined knowledge of ongoing developments and mapping exercises based on satellite images.



Figure 10: Left: Coal dust blown off coal deposits along the Ailbayan mining road near the Khangai border, right: Air and garbage pollution at the Tsaagan Khad coal reloading station near the Gashuun Suhait border crossing. Photo: P. Kaczensky

Villages and mines are connected by a secondary network of tracks, which is only incompletely represented in existing road layers. A recent update for the South Gobi Region using Open Street Map layers, our own mapping of tracks, and obvious tracks digitized from Google Earth gives a better overview of the existing network of connective roads – most of which seem to receive little traffic so far (Payne and Kaczensky 2019, see also 2.5.2 Habitat fragmentation). However, in the vicinity of villages, mining sites, and paved roads an increasing number of other infrastructure (i.e. buildings, camps) and dirt tracks have become visible over the last 5-10 years, suggesting

an increasing human presence which may result in habitat disturbance and loss (Fig. 11). From Google Earth alone the use or purpose of buildings and camps cannot be determined unambiguously and local knowledge or field investigations are needed to verify and complete the updated disturbance layer in order to understand how khulan react to these disturbances.

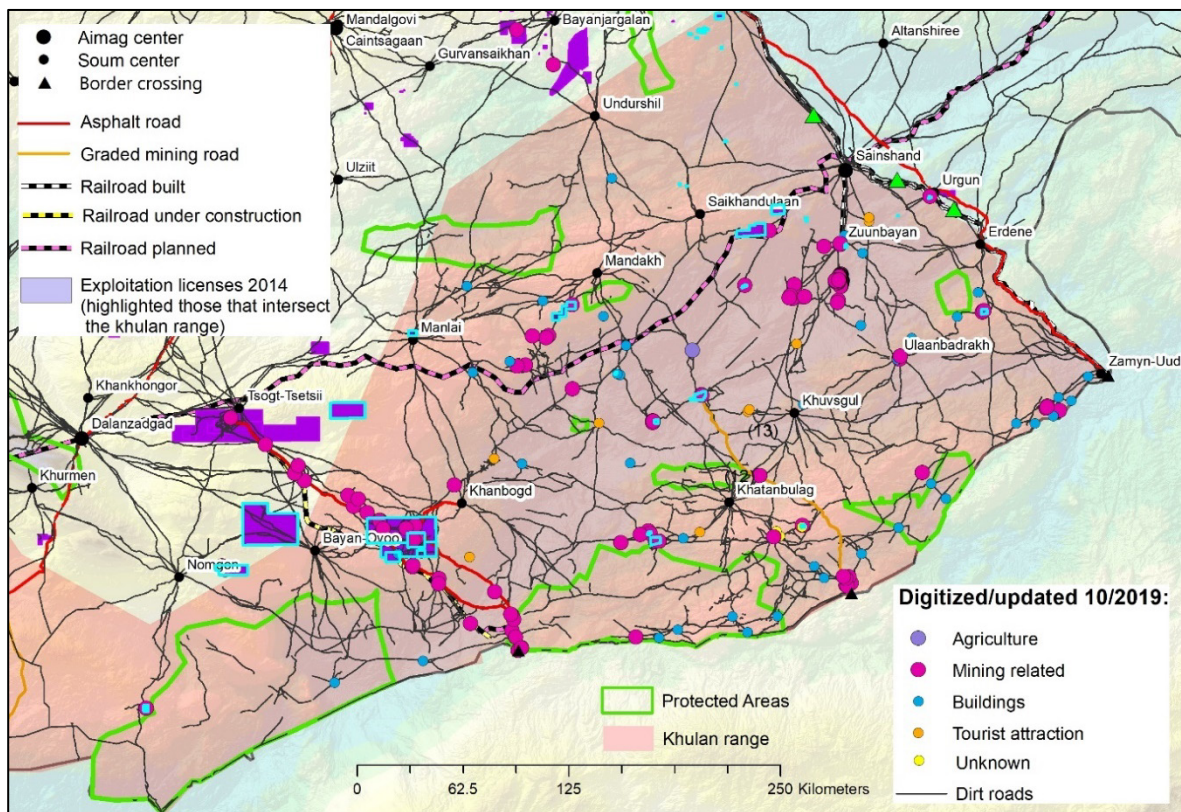


Figure 11: Updated road network (Open Street Map, own tracks, generic road layers) and points of disturbance from high resolution satellite images from Google, Bing or ESRI (see Payne and Kaczensky 2020). The exact nature of these “disturbance” points still needs to be ground-truthed.

Illegal artisanal gold mining (“ninja mining”) emerged in the 1990s and has resulted in the localized mechanical destruction of pastures, pollution of water sources, subsistence poaching, and in clashes with local protection authorities (Munkherdene and Sneath 2018, Batbayar and Purev-Ochir 2014). Legalizing small-scale gold mining and the rapid development of legal mining, has reduced but not eliminated the conflict. We were unable to map or assess the impact magnitude of the remaining artisanal mining activities on khulan and other wildlife for this report, but the situation should be clarified.

## 2.6.2 Habitat fragmentation

### 2.6.2.1 Fences

For khulan, fences constitute absolute barriers as the animals seem unwilling to jump and unable to crawl underneath them. In Mongolia this is well demonstrated by the fence along the international border with China and the fenced Trans-Mongolian railway (TMR), both of which currently act as range-restricting barriers, blocking khulan from former habitat in the Eastern Steppe (Batsaikhan et al. 2014; Linnell et al. 2016; Figure 4). The Trans-Mongolian railway was built in the 1950s and was fenced to prevent collisions of livestock and wildlife with the train. The fence constitutes an absolute barrier (Fig. 12) and separated khulan in the Eastern Steppe from those in the Gobi. By the 1970s, khulan were no longer found in the Eastern Steppe (Bannikov 1981).





Figure 12: Khulan walking parallel to the fenced Trans-Mongolian railway. Photo: P. Kaczensky

However, the example of khulan entering the no-man's land behind the partly derelict border fence on the Mongolian side also shows that khulan are able to find, and willing to use, openings, when those are large enough (optimal dimensions that encourage khulan passages still need to be determined).

Experience with a fence constructed around the OT mine site, made of unbarbed wire and in a way that the wires can be dislocated from the supporting pole, has shown that some khulan can learn to push through the fence when there are plentiful resources (water and pasture) on the other side (M. Lkhagvasuren pers. comm. 2019, based on several khulan going in and out of the fenced area). While such a fence is unlikely to stop small or large livestock, it is effective in stopping vehicles and may be a wildlife-friendly alternative for border fencing.

A pilot project to improve connectivity along the TMR was initiated in 2019 and currently consists of two test openings (a third location has been identified, but not yet opened) to evaluate their use by khulan and assess safety risks (concerning livestock and wildlife collisions with the train; Fig. 17). On 16 March 2020, camera traps at one of these pilot openings documented the first crossing of this barrier by a khulan, once again setting hoof onto the Eastern Steppe after an absence of >50 years (Fig. 13; also see: <https://news.mongabay.com/2020/06/animal-crossing-a-wild-ass-makes-history/>). The picture is a clear proof of concept that this barrier for migratory ungulates in Mongolia can be successfully mitigated. More openings and fence re-design for smaller ungulates are needed to truly re-establish functional connectivity between the Gobi and Eastern Steppe and re-establish khulan in the east.

However, at the same time, new railways are being built, including one that crosses through the heart of the South Gobi khulan range, and the discussion on fencing of new railways under construction or in planning stage has resumed. This is a worrisome development and contrary to the commitments and connectivity goals developed for Mongolia within the Convention of Migratory Species (CMS) Central Asian Mammals Initiative (CAMI, see CMS/CAMI 2015).



Fig. 13: Historically important image of a khulan crossing the TMR at a pilot opening in the fence in March 2020. Photo: Kirk Olson, WCS.

### 2.6.2.2 Roads and railroads

The structural presence of roads and railways *per se* do not seem to constitute a major obstacle to khulan movements. In Mongolia, khulan are frequently observed to cross unpaved, and even paved roads including the OT roads (Figure 14) in the South Gobi Region and the Altain Khuder road between the Dzungarian and Trans-Altai Gobi (O. Ganbaatar pers. comm.). Evidence from Kazakhstan suggests that they are also able to cross railway tracks (8 crossings of the railway between Aral and Zhezkazgan by a collared khulan in summer 2019, P. Kaczensky unpubl. data). However, very little is known about what road parameters (traffic volume and timing, embankment height, and slope) or surrounding habitat make it more or less likely for khulan to cross.

However, what is known is that transportation routes become barriers if traffic volumes are high. Crossings of the paved mining roads from the OT mine site and Tavan Tolgoi (TT) mine site to the Gashuun Sukhait were 53% and 13% lower, respectively, compared to the expected number of crossings based on the density of khulan tracks in the area (Payne and Kaczensky 2017). An analysis of 14 roads on which traffic was monitored for several months with mobile traffic counters found that traffic volume was a significant predictor of khulan road crossing rates (Payne and Kaczensky 2017). Khulan crossings of the OT road, where a permanent traffic counter is installed, showed that khulan cross the OT road more often at night and there was a statistically significant effect of traffic volume on the probability of khulan crossings (Fig. 14; Payne and Kaczensky 2017).

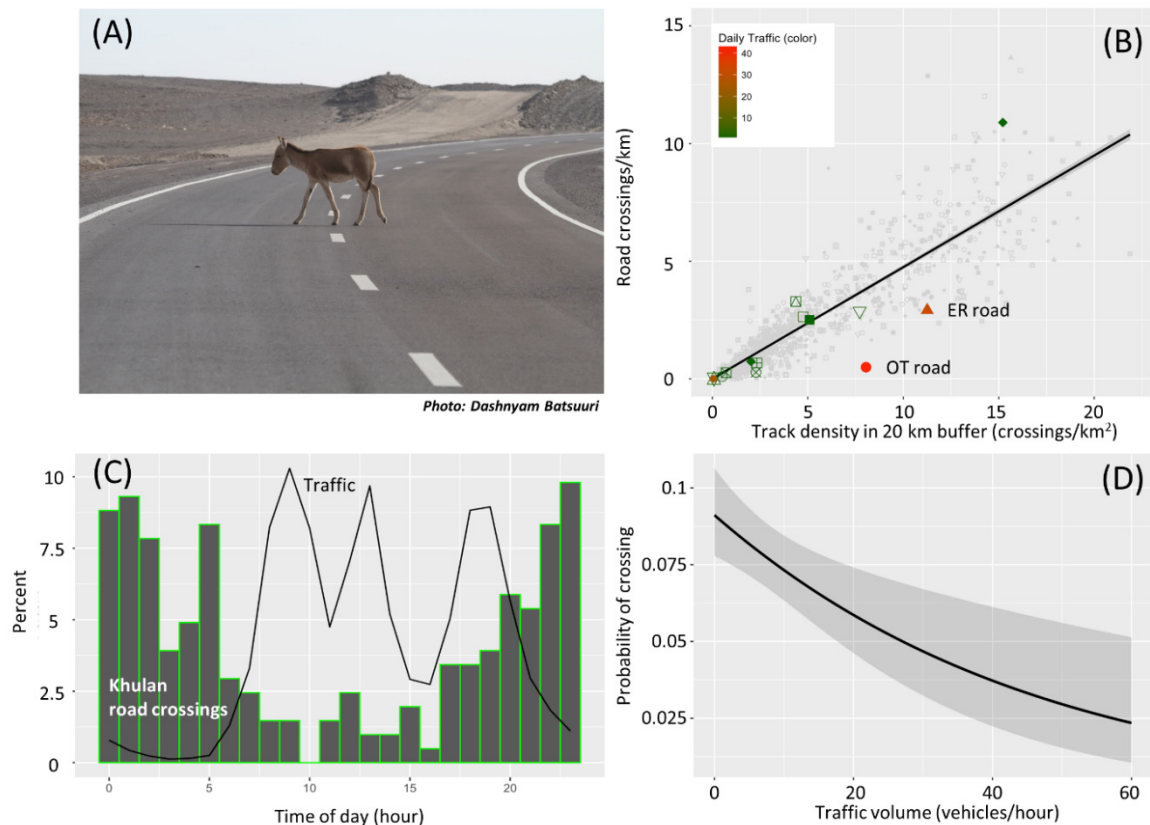


Figure 14: (A) Young khulan crossing the OT road (Photo: D. Batsuuri), (B) Khulan road crossing frequency versus khulan movement track density for 14 Gobi roads (colour) and 940 pseudo-roads (grey), (C) Timing of traffic volumes by hour ( $N=2,592$ ) and khulan crossings ( $N=204$ ) over the day, (D) Probability of a khulan crossing the OT road compared to traffic volume based on logistic regression. As traffic increases, the probability of crossing in a particular hour drops from about 9% at its peak to around 2.5% at its lowest level. The analysis period was August 2013 to November 2016. For further details see Payne and Kaczensky 2017.

Presently, it appears that the OT / TT mining corridor greatly reduces the chance of khulan crossings, but does not act as a full barrier. However, the current traffic levels of 500 vehicles/day are well below the traffic volumes that can be expected when the mine reaches full production, as underground exploitation has not yet started. Furthermore, the Environmental and Social Impact Assessment (Oyu Tolgoi 2012) predicts non-mine traffic volumes of >1,600 vehicles per day once the OT road eventually becomes part of the national highway network. In combination with the TT road and the railroad spur under construction, the OT / TT mining corridor can be expected to become a major movement barrier as it lacks coordinated and aligned mitigation measures. There are currently no dedicated wildlife crossing structures along the:

- OT mining road despite the need for those structures clearly being stated in the Environmental and Social Impact Assessment (EISA; Oyu Tolgoi 2012).
- TT mining road, an obligation that was apparently missed in the EISA.
- TT – Gashuun Sukhait railway under construction. Twenty-three crossing structures (8 bridges and 15 box culverts) will be implemented, including a long viaduct where the tracks cross the Undai river bed. However, most of these structures do not conform with the Wildlife Crossings Standards for Mongolia (Mongolian Agency for Standardization and Metrology 2015; i.e. Fig. 15).

And even those crossing structures which work along the TT – Gashuun Sukhait railway will be of limited use if neither of the roads running parallel to the new railway line have any crossing

structures. Very positive for khulan and other migratory wildlife is the absence of a fence along this railway under construction, which will allow khulan to cross the railway track.



Figure 15: Crossing crossings structures to be implemented along the Tavan Tolgai - Gashuun Sukhait railway corridor (status: July 2017). Whether these crossings will also work for khulan and other wildlife is unknown. Note: the dimensions of the box culverts do not comply with the Mongolian standards for wildlife crossings which require a minimum height of 3m and a minimum undissected width of 10m. Photo: P. Kaczensky

Currently the core of the South Gobi Region is mostly free of roads with higher traffic volumes. Of 18 different roads monitored by temporary traffic counters in 2016 and/or 2018, 14 had traffic volumes of <1 vehicle/hour. Only the three mining roads and the Sainshant – Zagiin Uud road had higher traffic volumes (Table 4).

Table 4: Traffic on the most heavily travelled roads in the South Gobi Region that were monitored in 2016 and 2018. Additional traffic data was collected for 2017 & 2019, but was not available for this document.

Road	Road type	Traffic volume (vehicles / hour)	
		Jul – Nov 2016	Mar-Dec 2018
TT to Gashuun Sukhait border crossing	Paved mining road	44	114
OT to Gashuun Sukhait border crossing	Paved mining road	32	21
Ailbayan to Khangii border crossing	Unpaved mining road	2.5	2.1
Ulaanbaatar to Zamin Uud	Connective road	24	NA

Additional roads and railroads have been discussed by government planners for the South Gobi Region, and additional heavy-traffic roads that dissect the khulan range from north to south can be found west of the South Gobi khulan range (Table 5, Fig. 16). If not carefully aligned and mitigated, these traffic axes will likely cause significant barriers to the connectivity of the khulan, goitered gazelle, Mongolian gazelle and saiga ranges (Lkhagvasuren et al. 2011).

Particularly severe impacts can be expected from the railway from Zuunbayan to Tsogttsetsii (Fig. 16-18), which will cut through the northern part of the khulan core range in the South Gobi region and a road that is being discussed to re-route some of the Tavan-Tolgoi traffic via Khatanbulag to the Ailbayan road to reach the Khangii border crossing. Together with the existing linear infrastructure, there is a real risk of subdividing the current range into 5 sections. Each of these sections are currently been used by khulan during different times and/or years (Fig. 17; for monthly maps see: <https://tinyurl.com/yxakmx5c>). It is unknown if or at what densities, any of these

subdivisions could support khulan year round, including in years with extreme weather conditions.

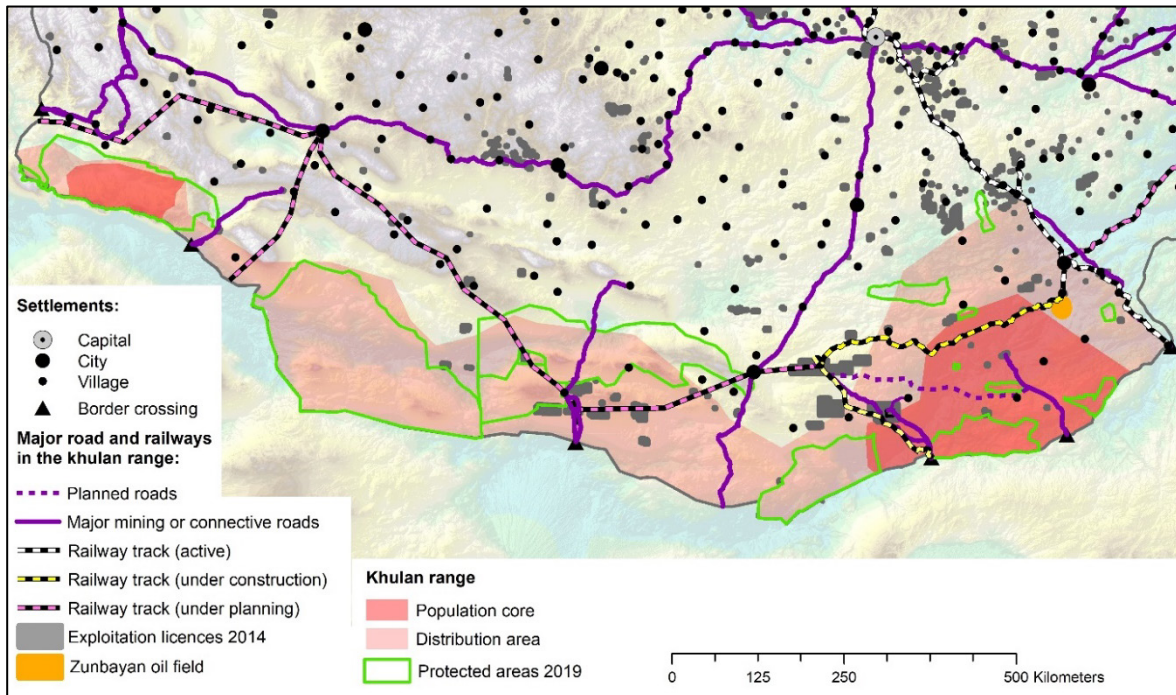


Figure 16: Overview of existing, planned and potential roads and railways under discussion throughout the khulan range in Mongolia.

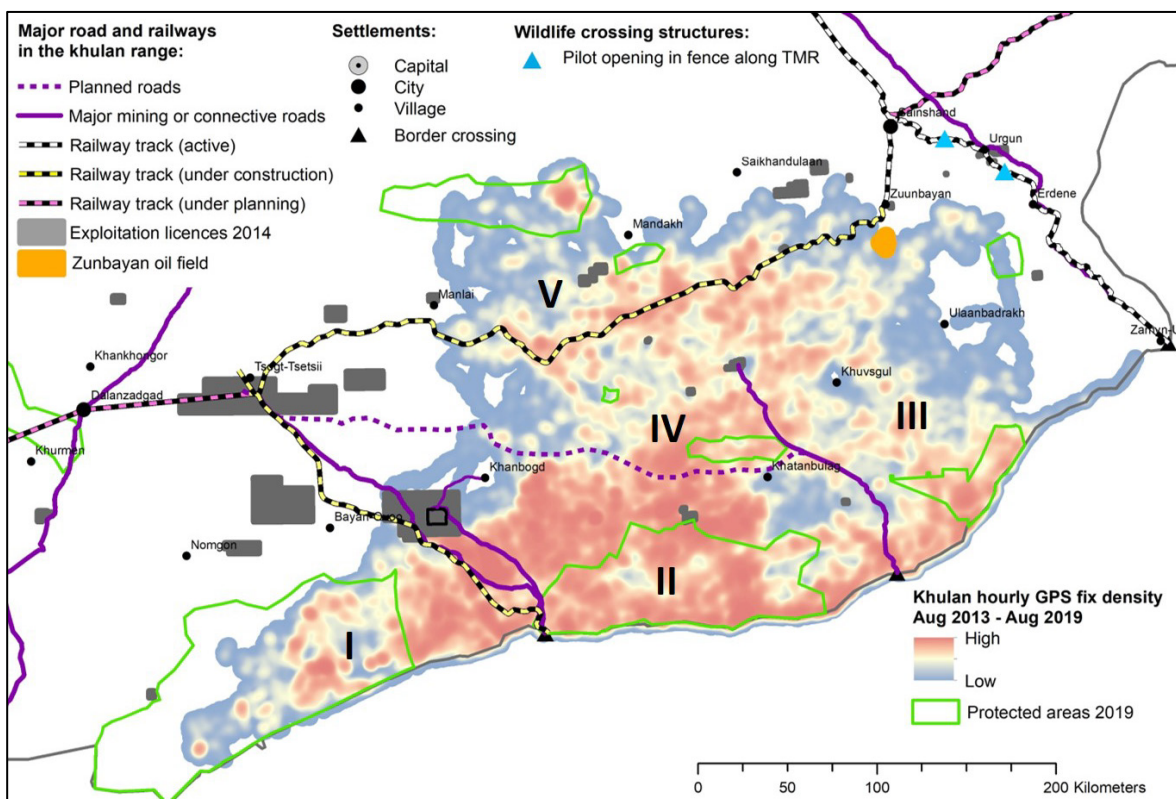


Figure 17: More detailed view of existing, planned and potential roads and railways under discussion in the khulan range of the South Gobi region, which threaten to subdivide this largest remaining subpopulation of khulan into 5 segments.

Table 5: Overview of existing and planned linear infrastructure in khulan range. A=active, UC=under construction, P=planned, UD=under discussion

Name	Type	Status	Surface	Includes wildlife crossings?
<b>South Gobi Region</b>				
Trans Mongolian railway	Railway (fenced)	A	rail	no*
Tavan Tolgoi to Gashuun Sukhait border crossing railway	Railway	UC	rail	no**
Zuunbayan to Tsogttsetsii railway	Railway (fencing discussed***)	UC	rail	??
Tavan Tolgoi to Gashuun Sukhait road	Mining road	A	paved	no
OT to Gashuun Sukhait road	Mining road	A	paved	no
OT to Khanbogd road	Connective road	A	paved	no
Ailbayan to Khangai border crossing road	Mining road	A	partially paved	no
Ulaanbaatar to Zamin Uud road	Connective road (also part of China's Road and Belt Initiative)	A	partially paved	no
OT power station at Tavan Tolgoi	Maintenance road(s)	P	??****	
Tavan Tolgoi-Oyu to Khangai border crossing via Khatanbulag	Mining road	P		no
Orkhon-Gobi	Water pipeline	UD/P?		
Kherlen-Gobi	Water pipeline	UD/P?		
<b>Central Gobi</b>				
Tsogt Tsetii to Shivee Khuren	2 parallel mining roads	A	?	no
Bayanhongor to Gurvantes to Tsogt Tsetsii mine	Connective road	A	?	no
<b>Western Gobi Region</b>				
Altain Khuder Tayan Nuur to Burgastai border crossing	Mining road	A	paved	no

\*Two recent openings in the fence (summer 2019; Fig. 17); \*\*23 culverts/bridges will be installed, which may potentially also be suitable for certain wildlife; \*\*\*there is renewed discussion about the possibility of fencing; if implemented this would create a massive barrier; \*\*\*\*clarification by OT needed



Figure 18: Railway under construction between Zuunbayan and Tsogttsetsii, August 2019. Photo: B. Buuveivbaatar

### 2.6.2.3 Experiences with crossing structures for Asiatic wild ass

The barrier effect of the fenced Trans-Mongolian railway strongly suggests that low and small under passages are not suitable for khulan crossings. However, preliminary evidence from China and India suggests that khulan are willing to use crossing structures if the dimensions are large enough:

- Wild ass along the Qinghai-Tibet railway in China were much more likely to use small bridges rather than culverts (out of 14 small bridges and 11 culverts, kiangs used all bridges, but only 1 culvert) and preferred wider, higher, and shorter crossing structures (Wang et al. 2018).
- The authors further note “Kiangs were photographed near the entrance of other culverts, suggesting an interest in crossing but that culverts were unsuitable. The culvert the kiang successfully crossed is wider and taller than the other culverts. This indicates that the size of this culvert likely represents the smallest size (length, 8 m; width, 3 m; height, 3 m) suitable for kiang.”
- Wild ass in the Viramgam – Halvad corridor along the Gujarat state highway in India mainly crossed the highway close to perennial ponds and often followed natural paths such as riverbeds or dry drainage channels. The animals only crossed culverts with a minimum height of 2.5m and width of 7m, and seemed to avoid those where the ground is not natural (Anonymous 2002).

## 2.6.3 Illegal killing

### 2.6.3.1 National market

The early and mid-2000s saw high poaching rates, especially in the South Gobi Region, with many carcasses strewn across the landscapes and multiple observations of poachers in action (Stubbe et al. 2012, P. Kaczensky pers. obs. 2005). Poaching rates from this earlier period have not been formally assessed. Projected estimates from household interviews suggested that possibly as many as 4,500 khulan may have been taken in 2004 (Wingard and Zahler 2006). Poaching seems to primarily occur during winter, especially in the Dzungarian Gobi (Lkhagvasuren et al. 2017, O. Ganbaatar pers. comm.), but remains of freshly killed khulan, including females with foals, have been found in other parts of the Gobi during summer. There is evidence of khulan being poached by local subsistence hunters as well as by organized groups. A frequent, but to our knowledge unconfirmed claim, is that meat is sold to roadside and border restaurants and sausage factories as a cheap substitute for horse meat (Kuehn et al. 2006).

The human population in the South Gobi region has increased dramatically in recent years and is expected to further increase due to immigration by people seeking employment opportunities in the mining and mining supply sectors. Such increases may result in an increase of wildlife poaching, including khulan, for meat or recreation. Recent carcass surveys are intended to estimate annual poaching rates, but methodological challenges including unknown decay rates and highly clumped carcass distributions have so far made it difficult to provide robust estimates of poaching trends (Batsaikhan 2014; Buuveibaatar et al. 2017b; Strindberg and Buuveibaatar 2019).

An ongoing carcass decay study, and the installation of acoustic monitoring devices (to detect the location, season, and time of gunshots) will hopefully allow a better understanding of where, and how frequently, khulan are poached. These analyses are still ongoing and final conclusions are not yet available.

Additional market surveys are needed to understand the trade chain and predict future demands for khulan and other wildlife products on the national and international markets.

### 2.6.3.2 Spatial variability in poaching risk

A poaching probability surface for the South Gobi Region was derived using a two-step approach (Fig. 17). First, a poaching access surface was produced using the Spatial Point Influence (SPI) tool that relied on human population numbers and locations (the soum and aimag population centers) together with information on speed of travel through the southern Gobi landscape. Second, Generalized Additive Models (GAMs; Hastie and Tibshirani 1990) were used to investigate the relationships between the locations where poached carcasses were found (obtained during the recent 2015-2017 dedicated carcass surveys comprising line transect distance sampling conducted as part of OT's Core Biodiversity Monitoring; for details see Strindberg & Buuveibaatar 2018) and the value of the poaching access layer and other landscape features (distance to roads, distance to waterpoints, habitat type, slope, elevation, and ruggedness). The resulting poaching probability surface was then compared to the dedicated survey data used to derive the model and data collected in the South Gobi Region at water holes or opportunistically by law monitoring/enforcement teams (MAT/MAPU/SMART teams 2016-2018; Fig. 19).

The modelling results match the carcass concentrations quite well and suggest that the areas with the highest poaching probability seem to be along the northern edge of the khulan range (Strindberg and Buuveibaatar 2019). This suggests that poaching is probably done by people coming from adjacent or distant population centres and to a lesser degree by local herders. The poaching probability surface can be used to, 1) inform anti-poaching units, and 2) stratify effort of future khulan carcass surveys to improve precision of the density and abundance estimates of khulan carcasses in order to estimate poaching rates. This said, the expected gain in precision using line transect distance sampling will still make it challenging to achieve good power in detecting non-dramatic changes. Hence, long-term monitoring and triangulation with other



results (i.e., ungulate survey estimates) some of which are available over the shorter term (i.e., law enforcement monitoring results from MAT/MAPU/SMART teams) are needed additionally to provide a more complete understanding of how the poaching rate may be changing over time.

Furthermore, an understanding of the motivation behind khulan poaching (i.e., conflict over pasture, recreation, market hunting), the location of potential markets, and the supply chain need to be better understood to predict poaching trends in space and time.

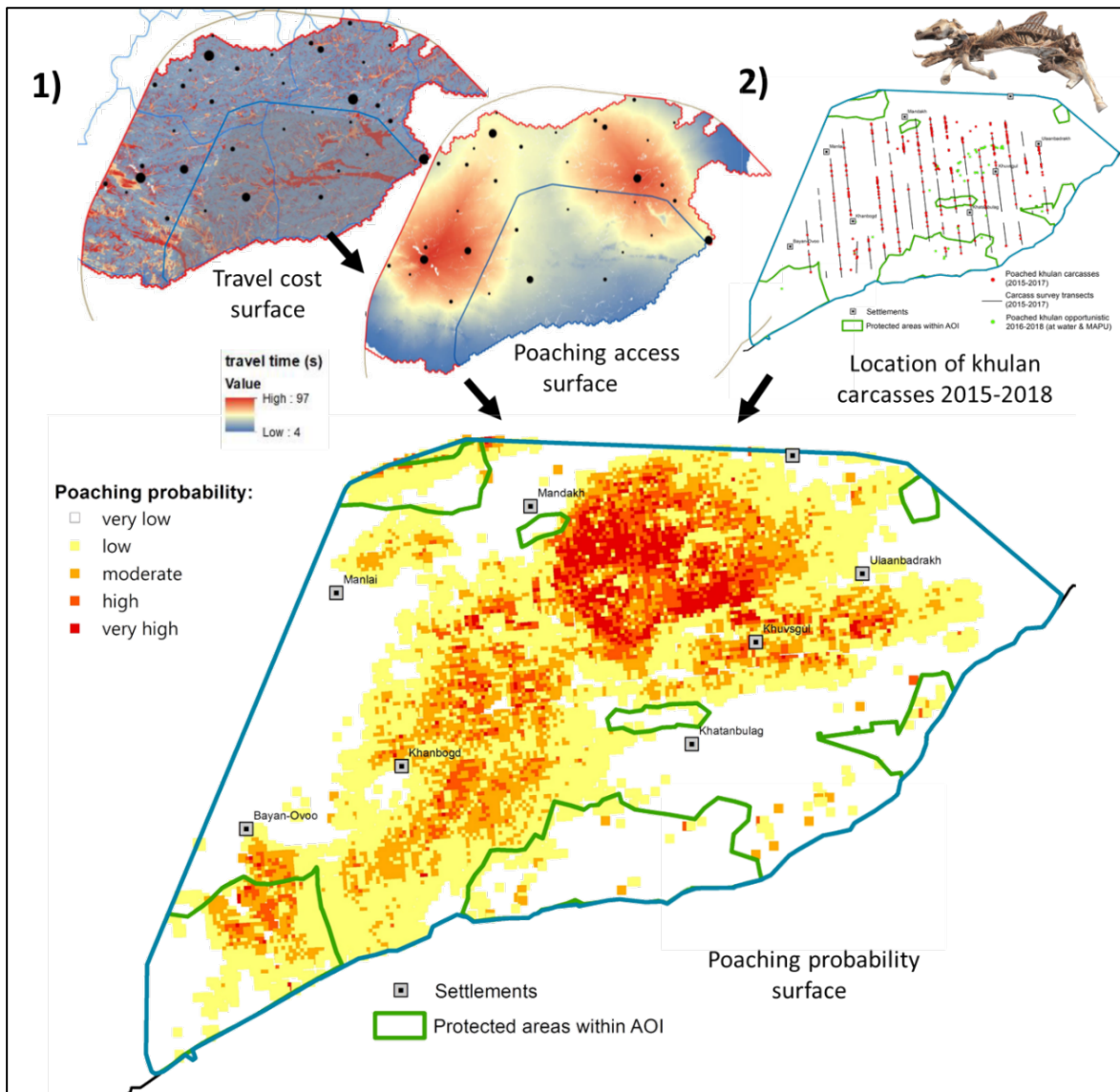


Figure 19: Poaching probability surface based on poaching access probability and landscape features at carcass locations (after: Strindberg and Buuveibaatar 2019).

### 2.6.3.3 International market

The rapidly expanding trade in donkey skins due to a huge demand for traditional Chinese medicine known as “Ejiao” or “Ah-Chiao” is already threatening donkey stocks in Africa and several countries have banned the export of skins (Anonymous 2016, Chebet 2017, Jackson 2017, Powell 2017). This market and trade should be closely monitored to see if the demand for domestic donkey skins in China also includes khulan skins. At the same time, care has to be taken not to draw attention to a potential market for khulan skin.

## 2.6.4 Competition with livestock

In the cold steppes of Central Asia that comprise the khulan range, grazing competition between different herbivores can be expected to be highest during the long and cold non-growing season in winter. During this period, food is not only of low energy content, but is also dry, and once grazed does not regrow before spring (Kerven 2004). Furthermore, with temperatures in the Gobi regularly falling to  $-20^{\circ}\text{C}$  and lower (OT unpubl. weather data), animals need to expend considerable energy to maintaining body temperature.

Khulan are often considered by herders as pasture competitors, particularly if they form large groups. In Mongolia, herders often chase khulan away from their pastures, especially when forage is scarce during droughts or in winter. In the vicinity of herder camps or near guarded livestock flocks, khulan also run the risk of being attacked or chased by dogs (Young et al. 2011). With increasing livestock numbers, khulan will find it increasingly difficult to find undisturbed areas. Frequent disturbances can be expected to be particularly harmful during times when resource needs are high and resource availability is low (i.e., during early lactation or in winter).

Furthermore, livestock grazing reduces the overall available plant biomass and in times of pasture shortage, khulan may be forced into areas with little or no forage, resulting in low reproductive output and eventually high mortality. With livestock numbers still growing, the competition in bad years can be expected to increase strongly.

### 2.6.4.1 Livestock numbers and distribution

Livestock numbers in all of Mongolia, and the 36 Gobi soums, have reached the highest numbers since record-keeping began 1970. In 2018 there were over 66 million heads of livestock in Mongolia as a whole and 6.5 million heads in the Gobi. Cows, horses, sheep and goats have different forage needs based on body size and digestive system, so grazing pressure is often standardized by converting all species to what a sheep requires, referred to as Sheep Forage Units (SFUs; see: Fernandez-Gimenez 1999). The 6.5 million livestock counted in the Gobi soums in 2018, constitute 9.4 million SFUs, of which 1.6 million (17%) are in the western Gobi, 2.8 million (30%) in the Central Gobi and 4.9 million (53%) in the South Gobi region (Appendix Fig. A1).

Large areas without livestock only remain in the extremely dry Trans-Altai Gobi and some adjacent areas. The core khulan population in the Dzungarian Gobi primarily experiences livestock presence in winter, whereas in summer herders move to the foothills and mountain pastures of the Altai range (Kaczensky et al. 2017a; Kaczensky et al. 2006a; Kaczensky et al. 2011a). In contrast, the South Gobi Region lacks large mountain ranges, and khulan have to share the range with herders and their livestock year-round. The only areas largely free of livestock in winter are primarily along the central valley of the khulan range and in a strip along the international border with China. These areas are intensively used by khulan (Fig. 20).

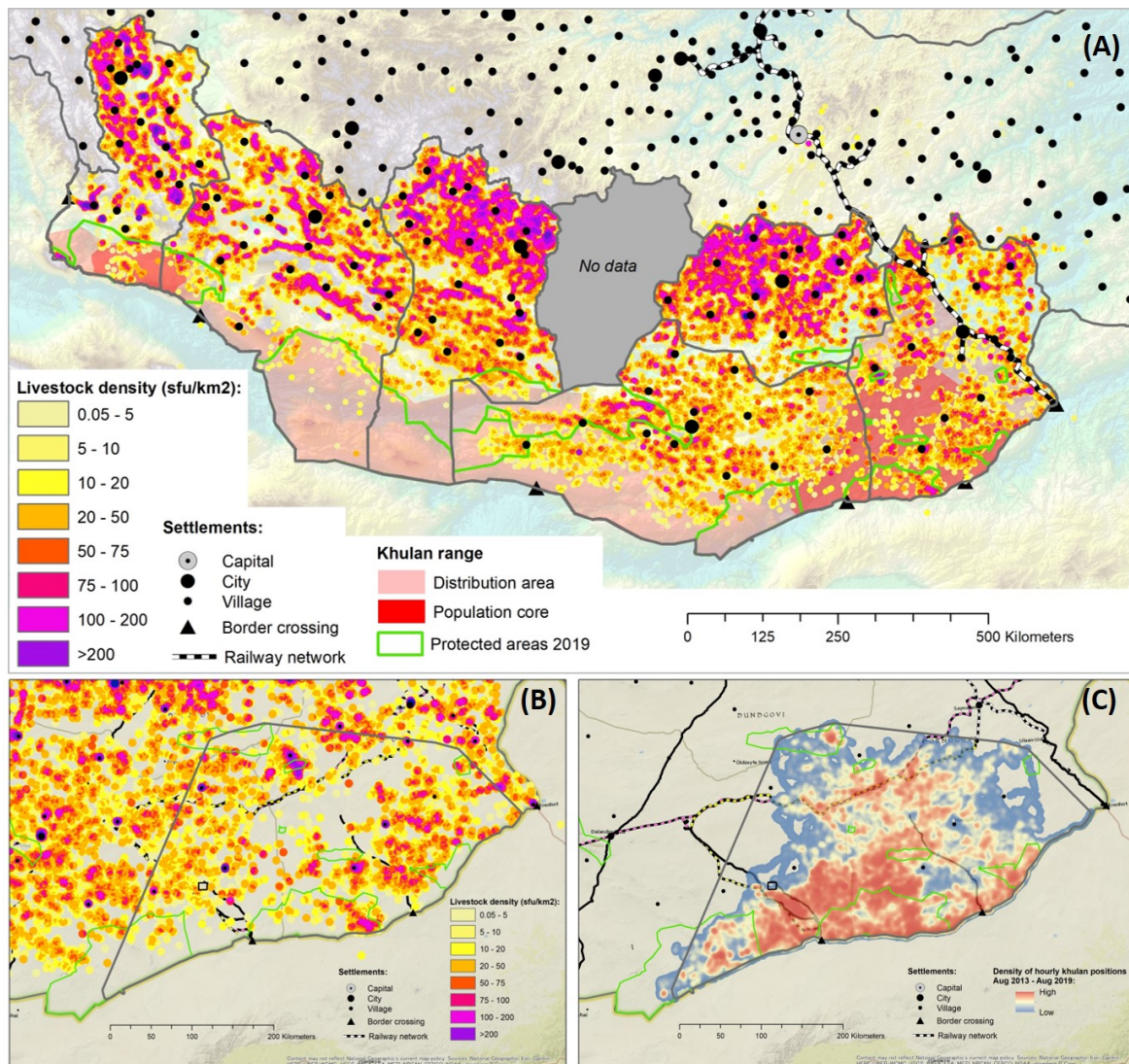


Figure 20: (A) Herder household locations and livestock densities (in Sheep Forage Units (SFUs) in the six Gobi provinces calculated from household based livestock data over a 5km grazing buffer around each camp and summing up densities of overlapping buffers using the household information from 2018), (B) Livestock densities in the South Gobi Region with minimum convex polygon of khulan locations August 2013- August 2019, (C) Khulan use intensity in the South Gobi Region based on GPS locations from 71 khulan monitored from August 2013-August 2019.

#### 2.6.4.2 Loss of preferred habitat

There are currently no continuous metrics to monitor the areas impacted by livestock grazing. The update of the 2010 to the 2018 herder camp map (Mongolian Statistical Service unpubl. data) does not allow for a direct comparison, as it seems likely that there have been methodological changes in the way these layers were produced (Payne and Kaczensky 2019). The area largely ungrazed by livestock in winter currently seems to be 148,000 km<sup>2</sup> (57%) of the total khulan range and 5,421 km<sup>2</sup> (60%) in the Dzungarian core and 26,775 km<sup>2</sup> (48%) in the South Gobi Region core (Figure 4). However, these numbers only represent area size and do not take area *productivity* into account.

Analysis using the household survey map layer (Heiner et al. 2013), which is based on the 2010 herder camp data) and livestock numbers on the bag level for 2013-2015 (Mongolian Statistical Information Service) shows that khulan hourly track locations are more likely than expected to fall in pixels with less than 5 livestock SFU per km<sup>2</sup>, and less likely than expected to fall in pixels with 10 or more livestock SFU per pixel (Fig. 21; Payne and Kaczensky 2017).

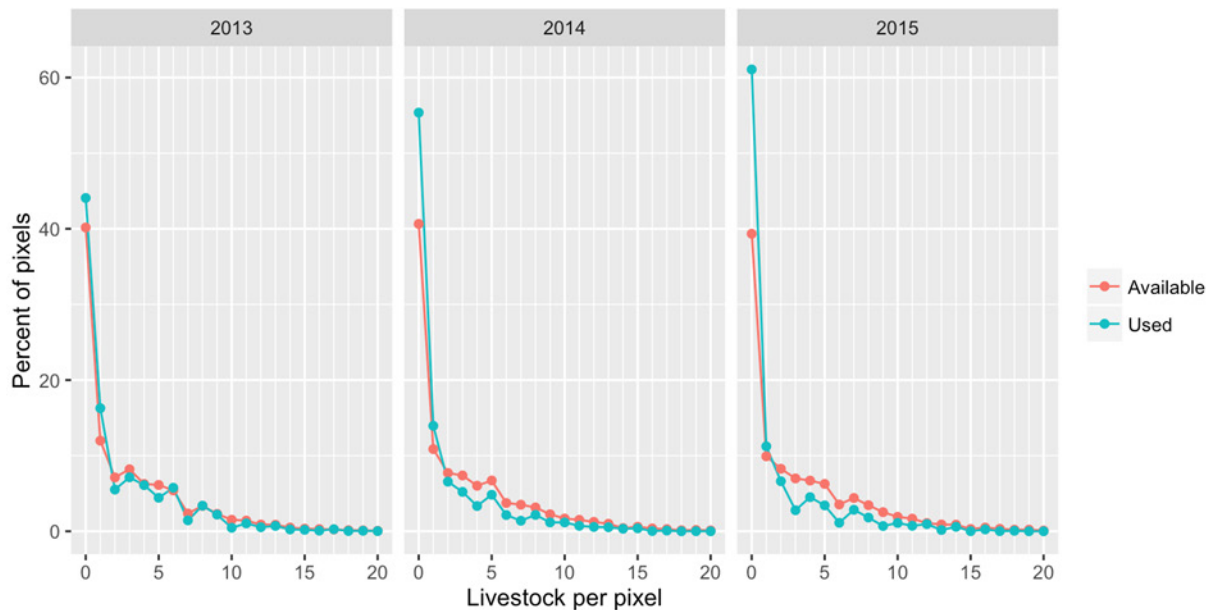


Figure 21: The distribution of livestock densities available in the khulan range (“Available”) compared to the distribution of livestock densities at hourly track locations (“Used”). Note that the “Used” curve crosses from above the “Available” curve to below it between 1 and 2 Sheep Forage Units (SFUs) per pixel (which translates to 5 and 10 SFUs per km<sup>2</sup>). Source: Payne and Kaczensky 2017.

In the South Gobi Region, we calculated that the area of preferred khulan habitat with <5 Sheep Forage Units (SFUs) per km<sup>2</sup> decreased from 54.1% of the khulan range (as defined by the minimum convex polygon of tracked animals) in 2012, to 52.1% in 2013, to 51.5% in 2014, to 49.2% in 2015 as livestock numbers increased steadily during that period in the South Gobi Region (Payne and Kaczensky 2017).

Considering that livestock (in SFUs) has increased by another 24% throughout the khulan range since the 2015 data covered by Payne and Kaczensky (2017), it is likely that the area of preferred habitat available has further decreased. An increase in livestock in already-grazed areas probably occurs hand-in-hand with encroachment into previously un-grazed areas, so that we would expect a simultaneous decrease in both: 1) the area which remains ungrazed and 2) the area of preferred habitat with low livestock densities.

### 2.6.4.3 Changes in livestock husbandry methods

#### **Livestock wells and water provisioning to overcome the constraint of water scarcity**

One constraint for livestock grazing in the Gobi is the availability of natural springs and livestock wells. Many of the wells, which were drilled during the Soviet system have fallen into disrepair, resulting in the loss of potential grazing areas for livestock. However, the high mobility of khulan and their high water-use efficiency has likely resulted in areas without wells becoming important retreat areas for khulan (Kaczensky et al. 2006b). Projects aiming at improving the livestock sector and allowing for a more even-spread of livestock to combat local overgrazing have supported the repair of old wells and the drilling of new wells. To our knowledge there is no comprehensive overview of well location and functionality over time. This lack of data currently makes it impossible to calculate how many new areas have become available for livestock in recent years due to improved water supply. Furthermore, with increased motorization and more available capital, some herders have started to invest in water trailers and water tanks. This allows herders to bring water to their herds and also opens up new areas for grazing. Consequently, developments aiming for new water sources should be closely monitored and should be part of the national khulan conversation strategy, since expanding the range for livestock threatens to bring livestock into the heart of the last remaining khulan refuges and further increase pressure on khulan.

### Change in livestock composition

Mongolia has seen a massive change in livestock composition, especially in the Gobi, where goats are favoured due to the high cash returns from cashmere (Fig. 22; see also: The World Bank 2003). Nowadays, the mining industry in the South Gobi Region seems to drive an increasing demand for beef, resulting in an increase in cattle (Kwong 2019). Beef production requires more resources, both in fodder and water, than the production of sheep or goat meat. Hence, an increase in cattle production can be expected to increase pasture competition with khulan and other wild ungulates.

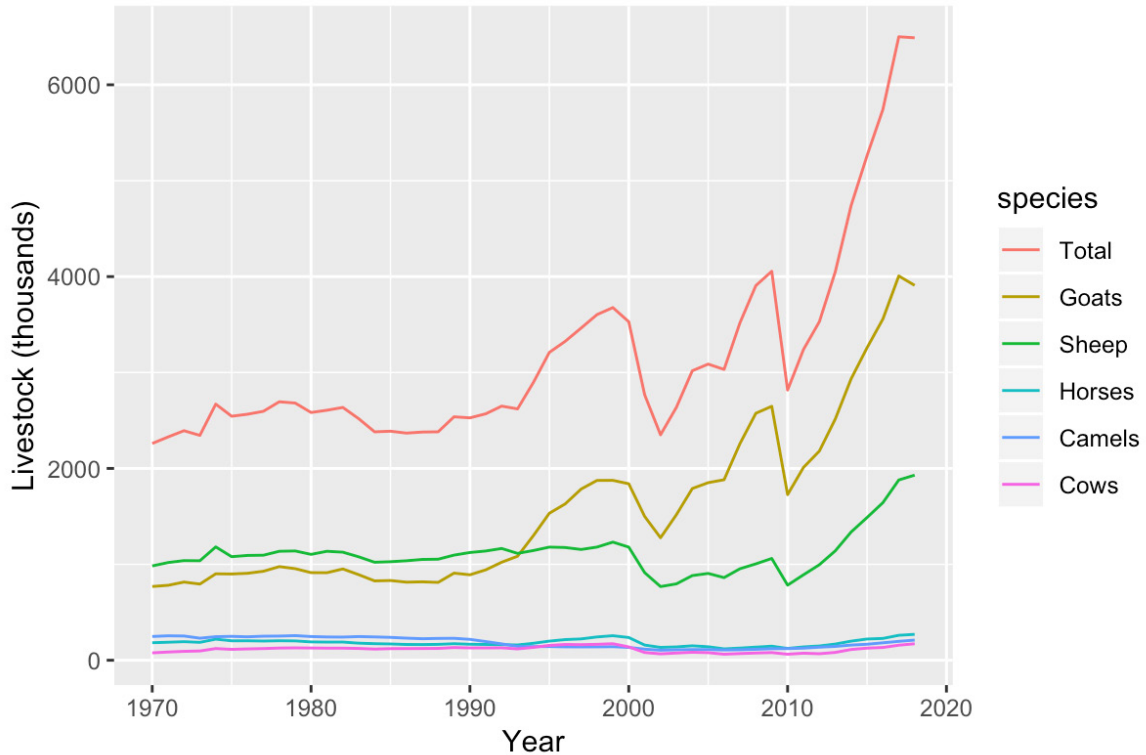


Figure 22: Livestock in the 37 Gobi soums 1970-2018, by species. Source: Mongolian Statistical Information Service

### 2.6.5 Access to water

In the former Central Asian Soviet Republics, where khulan went all-but-extinct by the 1940s, researchers note that khulan may “have been ousted from most places without a shot fired. Water is scarce in the desert and steppes, and wherever man with his domestic animals settled by the rivers and springs, the wild animals were forced into waterless places and doomed to extinction” (Bannikov 1981).

In the South Gobi Region, we used GPS tracking data to identify a set of 53 waterpoints which must be considered as having population-level importance (key waterpoints, Fig. 24; (Payne et al. 2020)). At the same time, there is clear evidence that khulan are negatively impacted by human activities and livestock presence at these waterpoints and in the wider landscape (Buuveibaatar et al. 2016; Kaczensky et al. 2019; Kaczensky et al. 2011b; Wang et al. 2016).

Due to their requirement to access water every 1-2 days, khulan commute between pasture and water mostly covering  $\leq 7.2$  km, but with distances somewhere in the magnitude of 15-20 km still being possible (and even extremes of up to 58km), depending on ambient temperatures and water content of the vegetation (Nandinsetseg et al. 2016, Payne et al. 2020). In the Gobi, water points are rare and distances between them are large (Fig. 23). Hence, if khulan get cut off from water sources due to habitat fragmentation or disturbance, the pastures in the areas surrounding

these water points also become unavailable for them. This not only reduces the overall pasture available to the population, but also forces khulan to concentrate at fewer waterpoints, thereby increasing the risk for parasite and disease transmission (Soilemetzou et al. 2020) and making them more vulnerable to predation and illegal hunting. The increasing livestock numbers also result in stiffer competition for water between wildlife and livestock at natural springs. Furthermore, herder camps that are too close to water points can block access for wildlife due to disturbance and the presence of dogs that may harass or kill wildlife.

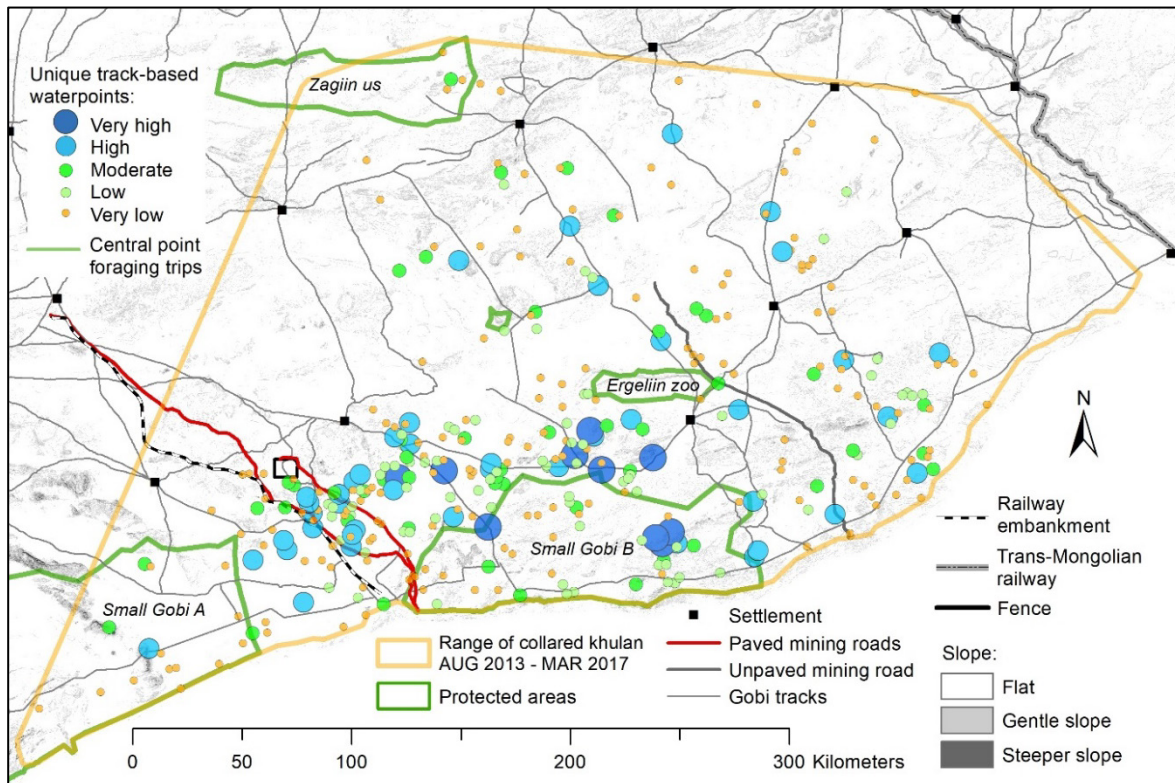


Figure 23: Location of waterpoints used by 41 GPS-satellite tagged khulan from August 2013 to March 2017. The dot sizes and colors indicate different use intensities (number of visits).

Mining operations require huge amounts of water. In the Gobi, these water needs cannot be met by renewable sources, but instead require tapping into fossil aquifers. There are currently unresolved concerns by local herders over potential impacts 1) on shallow, rain fed aquifers (the main source of water for local people, livestock and wildlife), 2) pastures downstream of river diversions, and 3) potential leakage from tailing facilities (JSL Consulting 2017). How these impacts will play out against original predictions of no impacts on local water supply will determine the future of local pastoralists as much as local wildlife.

Locally, test drillings on which the sealing caps are destroyed, result in new waterpoints, while construction of concrete wells in dry river bed locations of subsurface flow, makes it difficult to impossible for khulan to dig (A-C. Souris pers. comm).

### **Absentee herders and ranching**

Mongolian government data on herder households and livestock shows a dramatic increase in livestock but a nearly unchanged, or declining, number of herder households over the last 40 years. That difference indicates that we are witnessing a significant change in livestock ownership patterns, involving an increase in absentee livestock owners, an increase in average herd size, or consolidation of ownership with far reaching consequences for Mongolia's rangelands (Fernández-Giménez et al. 2017; Gerlee et al. 2017).

It is difficult to assess where the livestock sector in Mongolia is heading and researchers have outlined a set of scenarios that have different ecological and cultural consequences. At their extremes those scenarios range from a “Boom-Bust”, “Commercial Techno Ranch”, “Degradation, Restoration & Cultural Revival” to “Extraction Extravaganza” economic models which are positioned at the four extremes along the ecological and cultural resilience axes (Fernández-Giménez et al. 2017). How these, or other potential future scenarios of Mongolia’s herding system and land-use will impact highly mobile ungulates like khulan remains an open question today. (Fig. 24) The answers and outcomes will necessarily depend on Mongolia’s commitment towards the conservation of wide ranging ungulates and maintaining landscape connectivity.

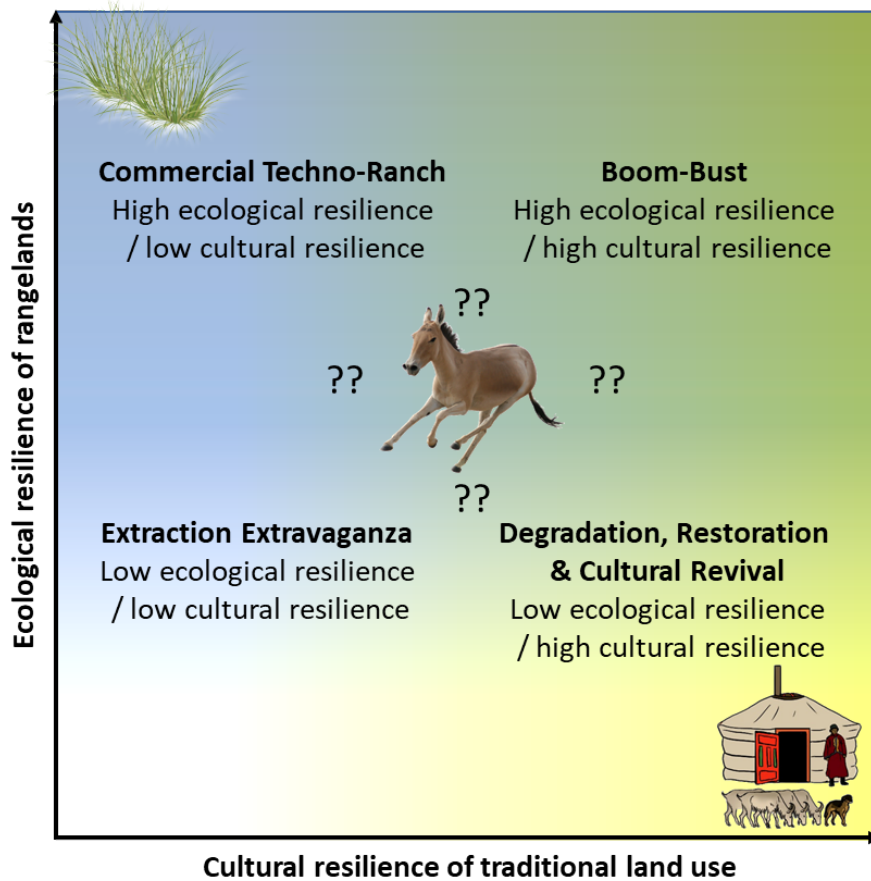


Figure 24: Four possible scenarios with an unknown outcome for the development of Mongolia’s socio-ecological pastural system over the next 10-20 years. The fate of khulan and other wide-ranging ungulates in any of those scenarios will largely depend on conservation strategies which need to be drafted now. After: Fernández-Giménez et al. 2017.

## 2.7 Lessons for regional land-use planning

The low productivity of the Gobi pastures in combination with the unpredictability of resource distribution requires khulan to move long distances. This need for movement is particularly pronounced during regional extreme events – droughts or *dzuds* – which may force a large part of the population to leave an area entirely to avoid mass mortality (Kaczensky et al. 2011a). As a consequence, landscape connectivity is a fundamental prerequisite for the conservation of nomadic species. Because nomadic species need to track resources which are often unpredictable, it is insufficient to protect one or two specific movement corridors. Instead, these species need a landscape which provides them with maximal movement opportunities. Furthermore, during extreme events, khulan may need access through or to areas which they only rarely use in normal years.

The protection of key areas are important and protected areas can provide important refuge areas. However, if landscape connectivity is not maintained, populations of nomadic species can be expected to decline dramatically.

The barrier with the greatest negative impact on khulan movements in the Gobi is currently the fenced Trans-Mongolian railway. Busy transportation routes within the khulan range are rare to date, but higher traffic volumes are predicted and will result in reduced road crossing frequencies. Furthermore, new roads and railways are under construction and being planned. Getting an overview of these projects or access to ESIA documents is very difficult, and makes it hard for local people and conservationists to raise a red flag.

Land-use planning also needs to happen in a multi-sectorial fashion if one wants to align development with sustainable land-use, and conservation for the best possible common outcome. The documented avoidance of livestock by khulan, suggests that land-use planning which aims for an even distribution of livestock can be expected to reduce retreat areas for khulan and increase disturbance and displacement. Hence, to achieve sustainable pasture use by local pastoralists which is compatible with the conservation of khulan and other steppe ungulates, prioritization of certain areas for livestock and others for wildlife, or a rotation system, could be a solution.

Regional land-use planning compatible with khulan conservation should therefore follow a policy which promotes landscape connectivity and heterogeneity. Some key issues include:

- Establish regional Multisectoral Connectivity Steering Group (MCSG) which develops recommendations for minimizing impacts, revises performance standards based on best practise and long-term monitoring, and enforces quality controls for ESIA's with respect to development impacts on landscape connectivity.
- Implement and enforce existing recommendations for migrating/nomadic species in Mongolian legislation.
- Maintain the no-fencing policy for pasture management.
- Maintain khulan retreat areas and avoid developing marginal areas for livestock.
- Establish a legally binding no-fencing policy for linear infrastructure outside settlements and enforce the no-fence requirement.
- Align linear infrastructures to minimize impact and maximize the efficiency of mitigation measures.
- Increase the capacity to require and enforce mitigation of all linear infrastructure with appropriate wildlife crossings following national or where absent, international standards while ensuring that the cost of those crossing and other impact minimization measures are included as part of the development project costs and budgeted for implementation.
- Set reporting standards to enforce transparency and facilitate communication about planned and ongoing infrastructure developments.



- Raise awareness for the need to protect small water sources in the Gobi and develop and enforce specific land-use plans in and around these water sources.
- Demand upfront payments for mitigation measures to ensure that long-term measures are adequately financed. Evaluate the possibility of establishing a Gobi - Steppe Connectivity Fund (see: chapter 3.8) with these mitigation payments to help fund a landscape scale approach to maintaining and restoring connectivity.

## 2.8 Shortcomings of current impact assessment and mitigation practice

A major threat to maintaining habitat connectivity in the Gobi are the means by which infrastructure projects are planned, evaluated, implemented, and monitored.

On one side, Mongolia passed legislation that recognizes the need to avoid and minimize impacts and to implement offsets for residual impacts, signed the Convention on Migratory Species (CMS) and has hosted several workshops within the framework of CMS's Central Mammals Initiative (CMS/CAMI 2015), and has a high level of awareness and understanding in the government and civil society about the need to maintain mobility for livestock and wildlife in the Gobi-Steppe ecosystem.

On the other side, these efforts do not translate into infrastructure design and implementation that is necessary to ensure essential habitat connectivity. There is a need to ensure adequate infrastructure planning that:

- Identifies and ensures protection of critical areas for wildlife movements.
- Reduces the need for new infrastructure by planning for shared infrastructure among projects.
- Minimizes the impacts of all new infrastructure based on identified needs of the species.

### 2.8.1 Environmental and Social Impact Assessments (ESIA)

Environmental and Social Impact Assessments (ESIA) are required for internationally funded development projects and DEIAs are required under Mongolian Law. But these assessments are generally limited in scope to the impact area and a certain buffer around the development (wider impact area). They tend to focus more on direct impacts rather than the indirect impacts in the landscape which may have an even greater impact on wildlife. This is problematic because:

- Khulan move over large distances and with annual or bi-annual ranges in the average size of 30,000 km<sup>2</sup> the impact of a particular development on the khulan population cannot be assessed locally (i.e., any development in the current area of khulan monitoring would have to look at the entire 150,000 km<sup>2</sup> South Gobi Region to assess the impact on habitat connectivity).
- Most impact assessment is primarily concerned with loss of habitat area, but the impact of linear infrastructure is not so much about the area of loss (i.e. a 5m wide and 100 km long road only covers an area of 0.5 km<sup>2</sup>; even assuming an impact area of 500m to each side increases the loss area to 100 km<sup>2</sup>), but much more about the reduction in connectivity (i.e. if the khulan range becomes dissected, access to thousands of square kilometres may be at stake; also see Fig. 15).
- Loss of connectivity is much harder to measure than area loss, and with each new development, the effect on connectivity can be expected to be cumulative at the landscape-scale.

- To understand wildlife movements, detailed baseline studies are needed over multiple seasons to assess impacts and design mitigation measures.
- Currently, there is a low capacity to assess the impact of development projects at the landscape scale due to a lack of coordination between policy sectors and decentralisation of planning to regional (aimag level) or local (soum level) administrations.
- Current practice potentially presents a loop-hole, because new projects are only requested to assess their additional impact on habitat fragmentation, rather than the cumulative effects (i.e. if a new road is built near an existing road, it is possible to argue that the connectivity is already low, and hence the impact of the new road is relatively minor). This logic may lead to a rapid decrease in connectivity with increasing development.
- There are limited efforts to undertake strategic environmental assessments to force project developers to go through a more coordinated planning process that looks at the potential impacts at a landscape scale.
- Currently, neither government planners nor lenders encourage the use of shared infrastructure to reduce the need to develop new infrastructure investment and there is little to no requirement to coordinate and align infrastructure, and no requirement to coordinate and align mitigation measures.

## 2.8.2 Mitigation measures

A mitigation hierarchy (avoidance, mitigation, restoration, off-setting) has been adopted by large international companies including Rio Tinto that are aiming for a No Net Loss or Net Positive Net Impact on Biodiversity (Olsen et al. 2011, Temple et al. 2012). However, implementation of mitigation measures in Mongolia is currently hampered by:

- Placing the burden of proof for successful mitigation measures on conservation science. Since little-to-no experience with mitigation measures exists for Central Asian wildlife species and in Central Asian landscapes, this requirement is currently stalling the construction of wildlife crossings for recently-implemented or ongoing infrastructure projects. But without wildlife crossings, no assessment of their efficiency in a Central Asian context will ever be possible.
- Companies have delayed or backed out of commitments to build wildlife crossing structures. This contradicts the mitigation hierarchy, as there is no doubt that roads with higher traffic volume reduce landscape connectivity. The fragmentation impact of busy transportation corridors has been demonstrated all over the world, as has the efficiency of wildlife under- and overpasses (luell et al. 2003; Olson 2012; Ree et al. 2015; Seidler et al. 2018).
- There is currently little incentive for companies to comply with mitigation commitments, because neither governments nor lenders have forced companies to follow through with the necessary investments. Agreements and financing for such commitments need to be made compulsory for projects to move forward.
- The mitigation hierarchy needs to become compulsory and should be enforced by the government.
- Although international and national standards for wildlife crossing structures exist, the capacity of regulatory bodies to review and enforce implementation of these standards is currently low.
- Experiences with wildlife crossing structures for species native to Mongolia is still scarce and needs to be developed through adaptive management, which requires experimental designs and monitoring.

- The existing standard for building wildlife crossings are a first step in the right direction but need to be refined based on best-practise with similar species in open landscapes and experience gained from adaptive approaches in Mongolia.

### 2.8.3 Monitoring programs

Monitoring programs should be obligatory for all infrastructure and development projects (mining, oil and gas, energy, transport, land conversion) that will have an impact on habitat and ecosystem services. These monitoring programs should be based on early, pre-impact baseline studies.

Currently only some development projects in Mongolia are required to put in place monitoring programs, but most have done little or no effective monitoring of wildlife (OT is an exception). Even the successful monitoring programs fall short for migratory or nomadic ungulates like khulan because of the species' special needs for maintaining landscape connectivity on a landscape scale. These shortfalls encompass:

- The overall lack of baseline data from pre-impact periods.
- The spatial scale of the monitoring programs do not always cover a large enough part of the species' range to be biologically meaningful.
- The lack of coordination between monitoring and mitigation programs by different companies in the same region, results in higher costs for individual programs, and also risks that mitigation measures by one company are jeopardized by the actions of another company.
- The general lack of accepted indicators or frameworks to assess and monitor the impacts of development on migratory or nomadic ungulates in these highly variable environments and over the necessary large spatial scales.
- Our limited understanding of Central Asian species and a lack of incentives for private companies to invest in improving these indicators. However, robust and accurate indicators are needed if monitoring is to be useful.
- The lack of political and financial independence when individual companies hire monitoring consultants, giving the company de facto control of the environmental impact monitoring via annual budget negotiations while putting pressure on conservation groups and researchers to conform to company wishes or lose their funding. This situation also makes long-term planning very difficult and undermines the long-term monitoring programs that would be best suited to detect long-term trends in species populations or other indicators (Dougherty 2019).
- Fiscal constraints resulting from company annual budget decisions that can lead to reduced funding for monitoring. Monitoring of certain activities is either reduced or eliminated over time.

## 2.9 A possible way forward

A possible way forward could be the establishment of a regional Multisectoral Connectivity Steering Group (MCSG) that includes ministries (i.e. environment, transport, mining, finance), scientists and NGOs that oversees the planning for the investment of projects in the Gobi-Steppe ecosystem with respect to maintaining landscape connectivity to safeguard migratory species.

The MCSG would have to be endorsed and financed by the government and given the mandate to develop recommendations for minimizing impacts (i.e. avoidance areas, shared infrastructure, alignment of infrastructure, decisions on reduction and elimination of fencing, etc.) and for revising and assuring compliance with performance standards based on best practise and long-term monitoring.

Assessing impacts on connectivity in the Gobi-Steppe ecosystem would become an obligatory part of EISAs which is overseen and revised by the MCSG. Development plans and impact assessments would be required to address impacts on landscape connectivity and adhere to the mitigation hierarchy focusing on avoidance and minimization of landscape fragmentation. All avoidance and minimization measures (including infrastructure mitigation such as wildlife crossings) would become part of the investment plan for each project and would be covered in the costs of the project.

In addition, a regional Connectivity Fund would be set up to address the long-term residual impacts. It would be a landscape fund which is not focused on any one project. The fund would need to be independent of government and overseen by a board with sufficient technical and financial expertise. Payments into this fund would cover the costs of monitoring residual impacts and managing their offsets (i.e. protection measures, incentives for local communities to share the landscape with khulan etc.) in the long-term future. Results and experiences gained from monitoring impacts and efficiency of mitigation and offset measures would inform the MCSG to revise recommendations and refine standards following adaptive management principles. Experiences and data would be made available in the public domain for future EISAs (see Fig. 25 for a possible scenario).

## Development in accordance with Sustainable Development Goals for the Conservation of Mongolia’s unique migratory landscape

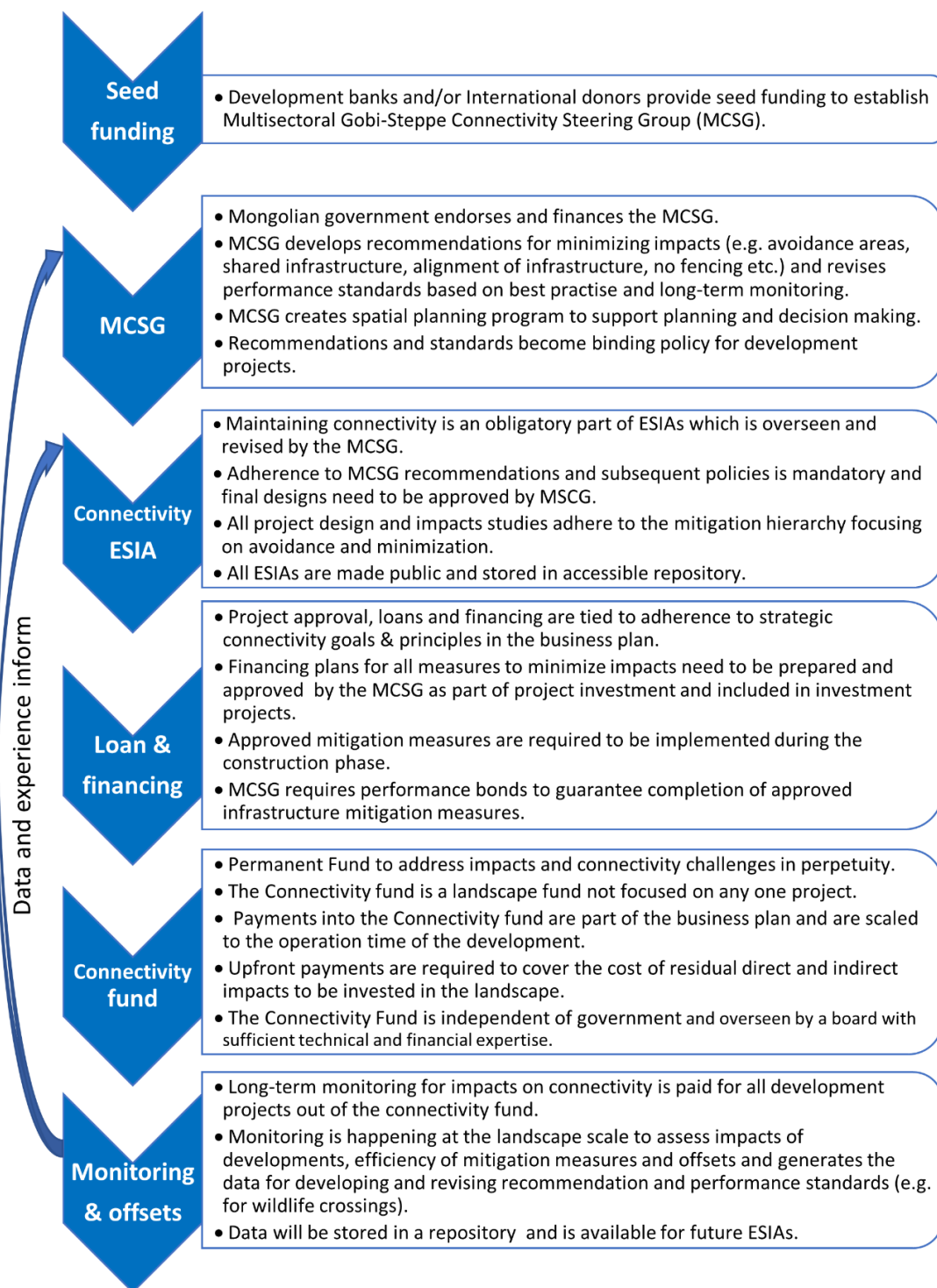


Fig. 25: Flow chart of how land-use planning, ESIA, mitigation, and monitoring impacts and implementing offsets of residual impacts could be organized to maintain landscape connectivity as a basis for sustainable development in Mongolia’s Gobi-Steppe ecosystem.

## 2.10 Constraints on alleviating threats to khulan or khulan conservation

In addition to understanding the ecology of khulan and the threats that the species faces, it is important to identify some of the constraints, or obstacles to addressing these threats. The existence of these constraints need to be explicitly addressed when developing conservation actions.

### 2.10.1 Biological constraints.

The key elements here are the **wide-ranging behaviour** of khulan which implies that they need massive areas of connected habitats (in the range of 10's or 100s of thousands of km<sup>2</sup>). Within these areas they also need regular **access to water**. Their overall **low reproductive rates** implies that population recovery from any declines will be slow.

### 2.10.2 Social constraints

The socio-economic changes within the livestock sector are leading to **changes in herder practices**, such as **increasing herd sizes**, construction or rehabilitation of **wells** in currently livestock-free areas all of which are **increasing competition** between livestock and khulan and influencing herder tolerance of khulan. Similarly, an increasingly urbanised public is **losing its knowledge** and awareness of migratory species.

### 2.10.3 Political and administrative constraints

Mongolia has experienced frequent changes in government and administrations in recent years which has not helped the development of a robust legislative and institutional environment to plan and manage the many developments within the khulan range. There is currently **a lack of robust landscape plans** that take cumulative effects of fragmentation into account. There is also **poor enforcement** of existing legislation and / or failure to adhere to international standards in terms of environmental impact assessments, transparency surrounding impact follow-up, and holding developers responsible for their requirements to put mitigation measures in place. Finally, there is **poor availability and access to spatially explicit key socio-economic data like** roads, development licenses, wells, herder camps, etc. which are central for planning and analysis.

### 2.10.4 Economic constraints

The fact that Mongolia's economy is so directly tied to revenue from extraction industries presents multiple potential conflicts of interest with independent and objective impact assessments. There is currently **a lack of independent funding** (i.e. not directly provided by developers) for the research, monitoring and planning that is needed to effectively assess environmental impacts and guide planning. There are also **few direct incentives** for local people to tolerate wildlife in shared landscapes. The proposed Connectivity Fund (2.8.) can help to address the lack of incentives by creating economic benefits for people through improved land management as part of efforts to address residual impacts.

### **2.10.5 Climate change**

The current climate prediction models for Mongolia are associated with a high degree of uncertainty concerning both the timing and amount of precipitation and the interactions between temperature and precipitation on pasture and water dynamics. Of special concern is the problem of predicting the future frequencies of droughts in summer and extreme winter storms (*dzuds*). Of longer-term concern is the uncertainty surrounding the potential future northwards expansion of the desert zone. These uncertainties imply that all land-use planning has to simultaneously prepare for multiple possible future scenarios.

### 3 Conservation planning

#### 3.1 What is conservation planning?

Conservation planning refers to an emerging set of techniques that are designed to improve the integration of science and stakeholder perspectives into the policy making process. The IUCN have developed several approaches, one of which is illustrated below (Fig. 26). The processes consists of a series of steps that involve both experts and stakeholders in the development of a plan. A key element is that the planners continue to monitoring and study of the implementation of the plan so that new experience and knowledge gained from the implementation can be used to revisit the original plan and make necessary adjustments in an adaptive management cycle.

The first sections of this report represents step 2 in a typical conservation planning process (Fig. 26) by summarizing the status and relevant information available on khulan globally and in Mongolia. The content has been generated by the authors and has been circulated among a wider group of experts for comment.

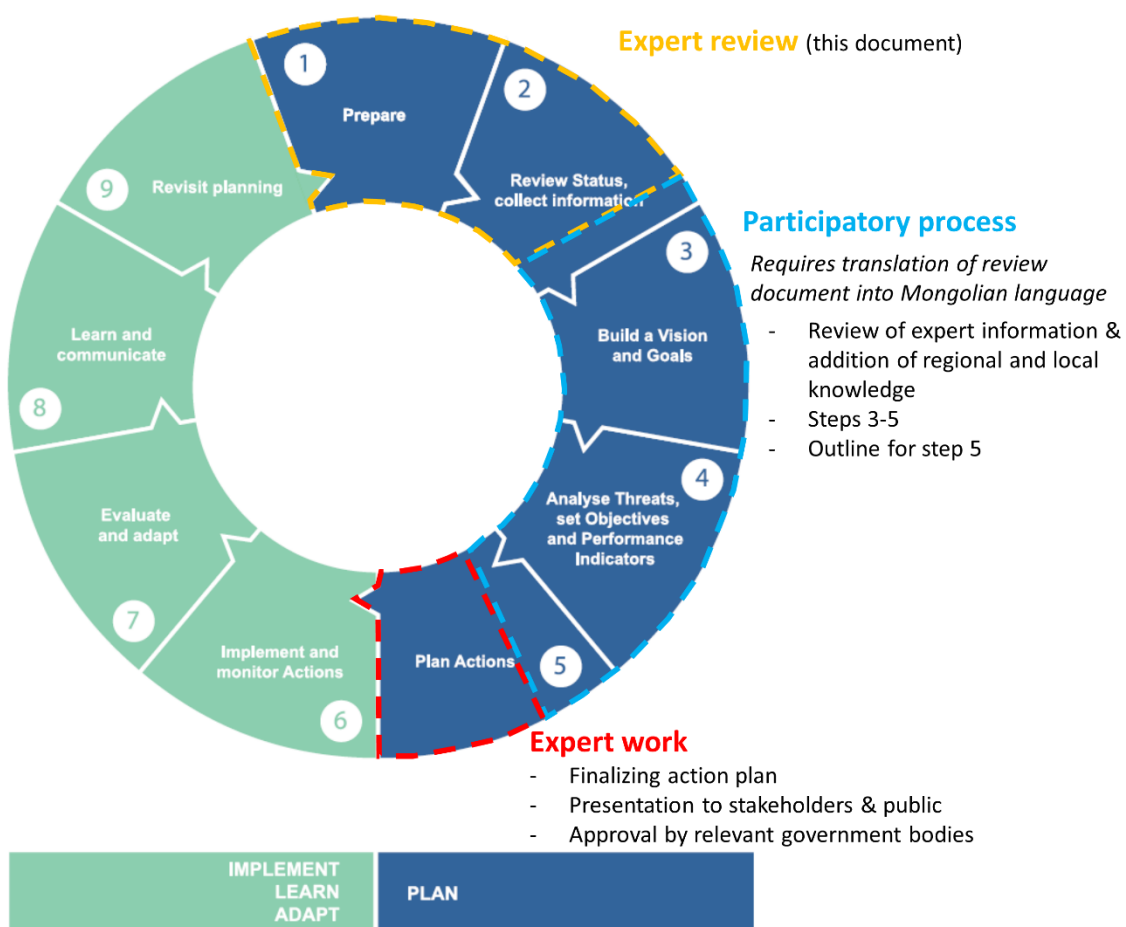


Figure 26: Where we see this document in the context of conservation planning (Khulan Conservation Strategy) for khulan in Mongolia. Source of background image: SSC Species Planning Conservation Cycle (IUCN – SSC Species Conservation Planning Sub-Committee 2017).



## 3.2 Next steps

After this expert-led preparation of background information, a typical conservation planning exercise should then enter a participatory phase. Our goal here is not to provide a detailed step-by-step outline of this process, but rather to lay out some of the key elements that need to be considered:

- (1) The document needs to be translated into Mongolian. This is crucial to initiate the next phase of the planning process, moving from an expert driven to a participatory process.
- (2) Key stakeholders need to be identified and invited to take part in the ongoing process.
- (3) Key stakeholders need to be presented with the translated document.
- (4) Key stakeholders should then be invited to a facilitated workshop that take the process further. It should also be possible for additional stakeholders to contribute input in writing if they are unable to attend workshops.

No two processes are identical, but central elements of most conservation planning processes include those described by Breitenmoser et al. (2015); IUCN/SSC (2008); see also: <http://www.cbsg.org/>):

**Review of the background information:** It is important to discuss the background information document and incorporate different perspectives so that participants approach a common understanding as a starting point for discussions. Important exercises include identifying knowledge gaps, identifying missing perspectives, ranking threats, ranking expected impacts of khulan and khulan conservation on stakeholders, and assessing the effectiveness of current conservation measures.

**A vision:** It is important that visions identify long-term, big-picture objectives that inspire. Typically, vision statements include elements related to the long-term viability and ecological function of the target species or ecosystem, as well as elements relating to its relationship to human well-being and development. It is crucial that visions reflect the ideas of the participants so that they buy-in to the processes that are needed to make the vision become real.

**Objectives:** This is the first step in operationalising a vision. Objectives identify specific states that participants would like to reach. For example, should khulan be assisted in recolonising the Eastern Steppe? How large a khulan population is considered desirable? How much connectivity is desired or needed? How should Environmental Impact Assessments be conducted? Is sufficient attention being paid to the condition of water sources in the Gobi? To be useful, objectives should be concrete and specific.

**Targets:** In order to reach objectives, it is important that each is given one or more measurable targets that allows progress towards each objective to be measured. For example, this could involve a specific number of khulan, a specific area of occupied range, or a specific number of mitigation measures adopted.

**Actions:** These are the operational steps that need to be done to reach the objectives. They need to be very specific, with a clearly identifiable person or agency responsible for conducting each action, a very clear, but realistic, time-scale, a rough estimate of cost, and some idea as to who might pay. It is also often useful to rank the priority of different actions.

### 3.3 Key stakeholders and sectors

From our work with khulan and other migratory ungulates we have identified the following stakeholders which are the most likely to affect khulan conservation and/or are affected by khulan conservation.

- **Herders:** Real and perceived pasture competition, their precarious economic situation, and their presence throughout the khulan range makes herders a key stakeholder group. Local herders are most likely impacted by khulan in both in a negative and positive way.
- **Local farmers:** Farming is rare in the Gobi, but those engaged in agricultural activities can be heavily impacted by khulan raiding their crops and can themselves have a localized strong negative impact on khulan via retaliatory actions.
- **Local hunters:** Can potentially negatively impact khulan by illegal hunting, but could also profit from legal hunting if the protection status is changed to allow a sustainable offtake in the future.
- **Local residents in bags, soums, and aimags:** Residents of towns and cities will interact with khulan to a much lesser extent than local herders or hunters, but may enjoy seeing khulan and profit from non-consumptive use like eco-tourism, although their activities could also cause disturbance.
- **Tourism:** Mongolia's tourism is currently built around cultural tourism (i.e., nomadic herders and horses) and broader "nature-based" tourism (i.e., the wide-open landscapes) with wildlife-viewing playing a more minor role. Khulan are a very charismatic (although a very much unknown) wildlife species which could be "marketed" as an additional attraction for eco-tourism operators.
- **Mining industry:** Mining is expected to negatively affect khulan and may face significant opportunity costs (the costs associated with forgone opportunities to convert land to profitable uses, i.e., Adams et al. 2010) due to the presence of khulan.
- **Other industry (i.e. oil, gas, green energy):** Are expected to have a negative impact on khulan and may face opportunity costs.
- **Transport industry:** Transportation infrastructure is expected to negatively impact khulan through habitat fragmentation, and will face opportunity costs, if they have to mitigate these impacts.
- **Environmental protection:** Protected areas are expected to have a positive impact on khulan and to profit from ecosystem functions provided by khulan, employment opportunities for protected areas staff, and potential economic benefits through tourism.
- **Law enforcement:** Is expected to have a positive impact on khulan.
- **Border security:** Is expected to have a positive impact on khulan through patrolling and the restricted entry policy in the border security zone, but may have a negative effect on khulan through fencing (except where a fence stops poachers).
- **Academia:** Is expected to be positively impacted by khulan (research opportunities) and to positively impact khulan through improved understanding of khulan ecology.
- **Non-governmental organisations:** NGOs are expected to be positively impacted by khulan (employment opportunities) and to positively impact khulan through conservation activities, policy advocacy and awareness raising.

## 4 References

- Adams, V.M., Pressey, R.L., Naidoo, R., 2010. Opportunity costs: Who really pays for conservation? *Biological Conservation* 143, 439-448.
- Adiya, Y., Gunin, P.D., Naranbaatar, G., Tsogtjargal, G., 2016. The present status and problems in the preservation of ungulate animal populations in the arid zones of Mongolia. *Arid Ecosystems* 6, 158-168.
- Anonymous, 2002. Report on wild ass crossing on Viramgam - Halvad corridor. Gujarat State Highways Project Phase IIb. Report E228, volume 8. N.D. Lea International Ltd. and Lea Associate South Asia Pvt. Ltd. Available at: <http://documents1.worldbank.org/curated/en/283141468772510455/pdf/multi0page.pdf>
- Anonymous. 2016. Burkina Faso bans donkey skin exports, affecting Asian trade. BBC News. Available at: <https://www.bbc.com/news/world-africa-37035229>
- Asa, C.S., 2002. Equid Reproductive Biology. Pages 113-117. In: P.D. Moehlman (Eds). IUCN Publication Services Unit, Cambridge, United Kingdom.
- Bannikov, A.G., 1981. The Asian Wild Ass. *Lesnaya Promyshlennost*, Moscow, Russia. [original in Russian, English translation by M. Proutkina, Zoological Society of San Diego].
- Batbayar, N., and G. Purev-Ochir. 2014. Biodiversity and Artisanal and Small-scale Mining in Mongolia - Scoping High Biodiversity Values in soums with active artisanal and small-scale mining (ASM) within ESEC II project sites. Technical Report by the Wildlife Science and Conservation Center of Mongolia. Available at: <https://www.researchgate.net/publication/299411668>
- Batsaikhan, N., 2014. Core Biodiversity Monitoring - Final Report, Appendix D: Research on current situation of poaching khulan - wild ass (*Equus hemionus hemionus*) in Eastern and Galba Gobi of Mongolia. Unpublished annual report 2013 by WCS to Oyu Tolgoi.
- Batsaikhan, N., Buuveibaatar, B., Chimed, B., Enkhtuya, O., Galbrakh, D., Ganbaatar, O., Lkhagvasuren, B., Nandintsetseg, D., Berger, J., Calabrese, J.M., Edwards, A.E., Fagan, W.F., Fuller, T.K., Heiner, M., Ito, T.Y., Kaczensky, P., Leimgruber, P., Lushchekina, A., Milner-Gulland, E.J., Mueller, T., Murray, M.G., Olson, K.A., Reading, R., Schaller, G.B., Stubbe, A., Stubbe, M., Walzer, C., von Wehrden, H., Whitten, T., 2014. Conserving the World's Finest Grassland Amidst Ambitious National Development. *Conservation Biology* 28, 1736-1739.
- Bennett, E.A., Champlot, S., Peters, J., Arbuckle, B.S., Guimaraes, S., Pruvost, M., Bar-David, S., Davis, S.J.M., Gautier, M., Kaczensky, P., Kuehn, R., Mashkour, M., Morales-Muniz, A., Pucher, E., Tournepiche, J.F., Uerpmann, H.P., Balasescu, A., Germonpre, M., Gundem, C.Y., Hemami, M.R., Mouille, P.E., Otzan, A., Uerpmann, M., Walzer, C., Grange, T., Geigl, E.M., 2017. Taming the late Quaternary phylogeography of the Eurasiatic wild ass through ancient and modern DNA. *PLoS ONE* 12, e0174216.
- Bolger, D.T., Newmark, W.D., Morrison, T.A., Doak, D.F., 2008. The need for integrative approaches to understand and conserve migratory ungulates. *Ecol Lett* 11, 63-77.
- Breitenmoser, U., Lanz, T., Vogt, K., Breitenmoser-Würsten, C., 2015. How to save the cat - Cat Conservation Compendium, a practical guideline for strategic and project planning in cat conservation. *Cat News Special Issue* 9, 36 pp.
- Bryson, J.J., Kaczensky, P., 2009. Exploring Knowledge Dissemination as a Selective Force for Aggregation: Preliminary Results from Modelling Wild Asiatic Asses. 10th European Conference on Artificial Life (ECAL), 23-26 September 2009 in Budapest, HUNGARY. Available at: [https://www.academia.edu/2664165/Exploring\\_knowledge\\_dissemination\\_as\\_a\\_selective\\_force\\_for\\_aggregation\\_Preliminary\\_results\\_from\\_modelling\\_wild\\_Asiatic asses](https://www.academia.edu/2664165/Exploring_knowledge_dissemination_as_a_selective_force_for_aggregation_Preliminary_results_from_modelling_wild_Asiatic asses)
- Burnik Šturm, M., Ganbaatar, O., Voigt, C.C., Kaczensky, P., 2017. Sequential stable isotope analysis reveals differences in multi-year dietary history of three sympatric equid species in SW Mongolia. *J Appl Ecol* 54, 1110-1119.

- Buuveibaatar, B., Mueller, T., Strindberg, S., Leimgruber, P., Kaczensky, P., Fuller, T.K., 2016. Human activities negatively impact distribution of ungulates in the Mongolian Gobi. *Biological Conservation* 203, 168-175.
- Buuveibaatar, B., Strindberg, S., Kaczensky, P., Payne, J., Chimeddorj, B., Naranbaatar, G., Amarsaikhan, S., Dashnyam, B., Munkhzul, T., Purevsuren, T., Hosack, D.A., Fuller, T.K., 2017a. Mongolian Gobi supports the world's largest populations of khulan and goitered gazelles. *Oryx* 51, 639-647.
- Buuveibaatar, B., Strindberg, S., Nyamsuren, B., 2017b. Appendix B: Estimating Mongolian khulan (*Equus hemionus*) poaching rates from carcass surveys in the Dornod and Galba areas of the southern Gobi. Unpublished annual report 2016 by WCS to Oyu Tolgoi.
- Buuveibaatar, B., Olson, K., 2019. Appendix F. Foaling rates and first year survival of khulan population in the south Gobi region: An assessment of annual reproductive success. Unpublished annual report 2018 by WCS to Oyu Tolgoi.
- Buzzard, P.J., Bleisch, W.V., Xü, D., Zhang, H., 2008. Evidence for lekking in chiru. *Journal of Zoology* 276, 330-335.
- Chebet, C. 2017. China, one of the countries fuelling global trade for donkey products. *The Standard*. Available at: <https://www.standardmedia.co.ke/business/article/2001249420/china-one-of-the-countries-fuelling-global-trade-for-donkey-products>
- CMS/CAMI, 2015. Implementing Wildlife-Friendly Measures in Infrastructure Planning and Design in Mongolia. Acton Plan based on a workshop from 25-29 August 2015 in Ulaanbaatar, Mongolia supported by Mongolian Ministry of Environment, Green Development and Tourism, German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety, German Federal Agency for Nature Conservation, UNEP, and CMS. Available at: [https://www.cms.int/sites/default/files/document/Technical%20Report\\_Eng.pdf](https://www.cms.int/sites/default/files/document/Technical%20Report_Eng.pdf)
- CMS/CAMI, 2019. Central Asian Mammals Migration and Linear Infrastructure Atlas. CMS Technical Series Publication No. 41. Available at: [https://www.cms.int/sites/default/files/document/cms\\_cami2\\_inf.4\\_cami-migration-and-infrastructure-atlas\\_e.pdf](https://www.cms.int/sites/default/files/document/cms_cami2_inf.4_cami-migration-and-infrastructure-atlas_e.pdf)
- Chu, H., Z. Jiang, Y. Ge, F. Jiang, Y. Tao, and C. Wang. 2008. Population densities and number of khulan and goitred gazelle in Mt. Kalamaili Ungulate Nature Reserve. *Biodiversity Science* 17, 414-422.
- Costantini, D., P. A. Seeber, S. E. Soilemetzidou, W. Azab, J. Bohner, B. Buuveibaatar, G. A. Czirjak, M. L. East, E. M. Greunz, P. Kaczensky, B. Lamglait, J. Melzheimer, K. Uiseb, A. Ortega, N. Osterrieder, D. M. Sandgreen, M. Simon, C. Walzer, and A. D. Greenwood. 2018. Physiological costs of infection: herpesvirus replication is linked to blood oxidative stress in equids. *Sci Rep* 8, 10347.
- Dashkhuu, D., Kim, J.P., Chun, J.A., Lee, W.S., 2015. Long-term trends in daily temperature extremes over Mongolia. *Weather and Climate Extremes* 8, 26-33.
- Dave, C.V., 2010. Understanding conflicts and conservation of Indian wild ass around Little Rann of Kachchh, Gujarat, India. Final technical report submitted to Rufford Small Grant Program, UK. Available at: <https://www.rufford.org/files/47.09.08%20Detailed%20Final%20Report.pdf>
- Dougherty, M.L., 2019. Boom times for technocrats? How environmental consulting companies shape mining governance. *The Extractive Industries and Society* 6, 443-453.
- Esmaili, S., Hemami, M.R., Goheen, J.R., 2019. Human dimensions of wildlife conservation in Iran: Assessment of human-wildlife conflict in restoring a wide-ranging endangered species. *PLoS ONE* 14, e0220702.
- Feh, C., Munkhtuya, B., Enkhbold, S., Sukhbaatar, T., 2001. Ecology and social structure of the Gobi khulan *Equus hemionus* subsp. in the Gobi B National Park, Mongolia. *Biological Conservation* 101, 51-61.

- Fernández-Giménez, M.E., 1999. Reconsidering the Role of Absentee Herd Owners: A View from Mongolia. *Human Ecology* 27, 1-27.
- Fernández-Giménez, M.E., Venable, N.H., Angerer, J., Fassnacht, S.R., Reid, R.S., Jamyansharav, K., 2017. Exploring Linked Ecological and Cultural Tipping Points in Mongolia. *Anthropocene* 17, 46–69.
- Fryxell, J. M., J. Greever, and A. R. E. Sinclair. 1988. Why are Migratory Ungulates So Abundant? *The American Naturalist* 131, 781-798.
- Gerlee, S., Munkhbaatar, D., Munkh-Ireedui, K., 2017. Mongolian pasture management implementation research overview. International Scientific and Practical Conference "WORLD SCIENCE", № 4(20), Vol.1, April 2017.
- Ghasemi, A., Hemami, M.R., Iravani, M., Senn, J., 2012. Seed Dispersal by Persian Wild Ass (*Equus hemionus onager*) in Qatruiyeh National Park, South Central Iran. Page 71 in: P. Kaczensky and J. Ransom (Eds). International Wild Equid Conference - Book of abstracts. Conference in Vienna, Austria from 12-22 September 2012. Research Institute of Wildlife Ecology, University of Veterinary Medicine, Austria.
- Goldberg, E.J., 2018. The Emperor's Ass - Hunting for the Asiatic Onager (*Equus hemionus*) in the 'Abbasid, Byzantine, and Carolingian Worlds. Pages 73-101 in: Tor, D.G. "The 'Abbasid and Carolingian Empires - Comparative Studies in Civilizational Formation", Koninklijke Brill NV, Leiden, The Netherlands and Boston, USA.
- Harris, G., Thirgood, S., Hopcraft, J.G.C., Croomsight, J., Berger, J., 2009. Global decline in aggregated migrations of large terrestrial mammals. *Endangered Species Research* 7, 55-76.
- Hastie, T. and Tibshirani, R. 1990. Generalized Additive Models. Chapman and Hall, New York.
- Heiner, M., Bayarjargal, Y., Kiesecker, J., Galbadrakh, D., Batsaikhan, N., Munkhzul, G., Odonchimeg, I., Enkhutuya, O., Enkhbat, D., von Wehrden, H., Reading, R., Olson, K., Jackson, R., Evans, J., McKenney, B., Oakleaf, J., Sochi, K., 2013. Identifying Conservation Priorities in the Face of Future Development: Applying Development by Design in the Mongolian Gobi. The Nature Conservancy, Ulaanbaatar, Mongolia. Available at: <https://www.nature.org/media/smart-development/development-by-design-gobi-english.pdf>
- Hijioka, Y., E. Lin, J.J. Pereira, R.T. Corlett, X. Cui, G.E. Insarov, R.D. Lasco, E. Lindgren, and A. Surjan, 2014. Asia. Pages 1327-1370 in: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- IPBES, 2018. The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia. Rounsevell, M., Fischer, M., Torre-Marín Rando, A. and Mader, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.
- IUCN/SSC, 2008. Strategic Planning for Species Conservation: A Handbook. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission. Available at: [https://www.iucn.org/downloads/scshandbook\\_2\\_12\\_08\\_compressed.pdf](https://www.iucn.org/downloads/scshandbook_2_12_08_compressed.pdf)
- IUCN – SSC Species Conservation Planning Sub-Committee. 2017. Guidelines for Species Conservation Planning. Version 1.0. Gland, Switzerland: IUCN. Available from: <https://www.iucn.org/content/guidelines-species-conservation-planning-version-10>
- JSL Consulting. 2017. Multi-disciplinary team and independent expert panel joint fact finding: Summary of the Experts' Reports. Oxford, UK: JSL Consulting, Ltd. Available at: [http://www.cao-ombudsman.org/cases/document-links/documents/MDTIEP\\_FINALREPORT\\_ENG\\_January292017\\_000.pdf](http://www.cao-ombudsman.org/cases/document-links/documents/MDTIEP_FINALREPORT_ENG_January292017_000.pdf)

- Iuell, B., Bekker, H.G.J., Cuperus, R., Dufek, J., Fry, G., Hicks, C., Hlavác, V., Keller, V., Rosell, C., Sangwine, T., Tørsløv, N., Wandall, B.I.M., (Eds), 2003. *Wildlife and Traffic: A European Handbook for Identifying Conflicts and Designing Solutions*. COST 341 Habitat Fragmentation due to Transportation Infrastructure, European Co-operation in the Field of Scientific and Technical Research. Available at: [http://www.iene.info/wp-content/uploads/COST341\\_Handbook.pdf](http://www.iene.info/wp-content/uploads/COST341_Handbook.pdf)
- Jackson, A., 2017. Donkey poaching: a growing global threat. *Australian Veterinary Journal* 95, N16.
- Joly, K., Gurarie, E., Sorum, M.S., Kaczensky, P., Cameron, M.D., Jakes, A.F., Borg, B.L., Nandintsetseg, D., Hopcraft, J.G.C., Buuveibaatar, B., Jones, P.F., Mueller, T., Walzer, C., Olson, K.A., Payne, J.C., Yadamsuren, A., Hebblewhite, M., 2019. Longest terrestrial migrations and movements around the world. *Sci Rep* 9, 15333.
- Kaczensky, P., Enkhsaihan, N., Ganbaatar, O., Walzer, C., 2006a. Identification of herder-wild equid conflicts in the Great Gobi B Strictly Protected Area in SW Mongolia. *Exploration into the Biological Resources of Mongolia* 10, 99-116.
- Kaczensky, P., Sheehy, D.P., Walzer, C., Johnson, D.E., Lhkagvasuren, D., Sheehy, C.M., 2006b. Room to Roam? The Threat to Khulan (Wild Ass) from Human Intrusion. *Mongolia Discussion Papers, East Asia and Pacific Environment and Social Development Department*. Washington, D.C. World Bank. Available at: <http://documents1.worldbank.org/curated/en/559701468060257075/pdf/377960MOG0room0to0roam0P09260901PUBLIC1.pdf>
- Kaczensky, P., 2007. Wildlife Value Orientations of Rural Mongolians. *Human Dimensions of Wildlife* 12, 317-329.
- Kaczensky, P., Ganbaatar, O., von Wehrden, H., Walzer, C., 2008. Resource selection by sympatric wild equids in the Mongolian Gobi. *Journal of Applied Ecology* 45, 1662-1769.
- Kaczensky, P., Dresley, V., Vetter, D., Otgonbayar, H., Walzer, C., 2010. Water use of Asiatic wild asses in the Mongolian Gobi. *Exploration into the Biological Resources of Mongolia (Halle/Saale, Germany)* 11, 291-298.
- Kaczensky, P., Ganbataar, O., Altansukh, N., Enkhsaikhan, N., Stauffer, C., Walzer, C., 2011a. The danger of having all your eggs in one basket--winter crash of the re-introduced Przewalski's horses in the Mongolian Gobi. *PLoS ONE* 6, e28057.
- Kaczensky, P., Kuehn, R., Lhagvasuren, B., Pietsch, S., Yang, W., Walzer, C., 2011b. Connectivity of the Asiatic wild ass population in the Mongolian Gobi. *Biol Conserv* 144, 920-929.
- Kaczensky, P., Ganbaatar, O., Altansukh, N., Enkhsaikhan, N., Kramer-Schadt, S., 2015a. Monitoring of khulans and goitered gazelles in the Mongolian Gobi - potential and limitations of ground based line transects. *The Open Ecology Journal* 8, 92-110.
- Kaczensky, P., Lkhagvasuren, B., Pereladova, O., Hemami, M.-R., Bouskila, A., 2015b. *Equus hemionus*. The IUCN Red List of Threatened Species 2015: e.T7951A45171204. Available at: <https://www.iucnredlist.org/species/7951/166520460>
- Kaczensky, P., Hrabar, H., Lukarevski, V., Zimmermann, W., Usukhjargal, D., Ganbaatar, O., Bouskila, A., 2016. Reintroduction of Wild Equids. Pages 196-214 in: Ransom, J.I., and Kaczensky, P. (Eds). *Wild Equids - Ecology, Management, and Conservation*. Johns Hopkins University Press, Baltimore, USA.
- Kaczensky, P., Burnik Šturm, M., Sablin, M.V., Voigt, C.C., Smith, S., Ganbaatar, O., Balint, B., Walzer, C., Spasskaya, N.N., 2017a. Stable isotopes reveal diet shift from pre-extinction to reintroduced Przewalski's horses. *Sci Rep* 7, 5950.
- Kaczensky, P., Ganbaatar, O., Altansukh, N., Strindberg, S., 2017b. Simultaneous Point Count for Steppe Ungulates in Great Gobi B SPA in October 2015 – Preliminary Results. Progress Report Great Gobi B Strictly Protected Area. Available from: [shorturl.at/ksFU3](http://shorturl.at/ksFU3)

- Kaczensky, P., Kovtun, E., Habibrakhmanov, R., Hemami, M.-R., Khaleghi, A., Linnell, J.D.C., Rustamov, E., Sklyarenko, S., Walzer, C., Zuther, S., Kuehn, R., 2018a. First population-level genetic analysis of free-ranging Asiatic wild ass populations in Central Asia - implications for conservation. *Conservation Genetics* 19, 1169–1184.
- Kaczensky, P., Linnell, J.D.C., Zuther, S., Salemgareyev, A., Doldin, R., 2018b. Reintroduction of kulan into the central steppe of Kazakhstan: Field Report for 2017. NINA Report 1459. Available at: <https://brage.nina.no/nina-xmlui/handle/11250/2494076>
- Kaczensky, P., Khaliun, S., Payne, J., Boldgiv, B., Buuveibaatar, B., Walzer, C., 2019. Through the eye of a Gobi khulan – Application of camera collars for ecological research of far-ranging species in remote and highly variable ecosystems. *PLoS ONE* 14, e0217772.
- Kaczensky, P., J. Payne, O. Ganbaatar, N. Altansukh, and C. Walzer. 2020 in Press. Water use by khulan in the Dzungarian Gobi in SW Mongolia. *Exploration into the Biological Resources of Mongolia* (Halle/Saale, Germany) 14.
- Kerven, C., 2004. The influence of cold temperatures and snowstorms on rangelands and livestock in northern Asia. Pages 41-55 in S. Vetter (Ed): *Rangelands at equilibrium and non-equilibrium*. Programme for Land and Agrarian Studies (PLAAS), Cape Town, South Africa.
- Kuehn, R., Kaczensky, P., Lkhagvasuren, D., Pietsch, S., Walzer, C., 2006. Differentiation of Meat Samples from Domestic Horses (*Equus caballus*) and Asiatic Wild Asses (*Equus hemionus*) Using a Species-Specific Restriction Site in the Mitochondrial Cytochrome b Region. *Mongolian Journal of Biological Sciences* 4, 57-62.
- Kwong, E., 2019. Mongolia's Long Road To Mining Wealth. NCPRI online 31 July 2019. Available at: <https://www.northcountrypublicradio.org/news/npr/741798613/mongolia-s-long-road-to-mining-wealth>
- Linnell, J.D., Trouwborst, A., Boitani, L., Kaczensky, P., Huber, D., Reljic, S., Kusak, J., Majic, A., Skrbinek, T., Potocnik, H., Hayward, M.W., Milner-Gulland, E.J., Buuveibaatar, B., Olson, K.A., Badamjav, L., Bischof, R., Zuther, S., Breitenmoser, U., 2016. Border Security Fencing and Wildlife: The End of the Transboundary Paradigm in Eurasia? *PLoS Biol* 14, e1002483.
- Lkhagvasuren, B., 2007. Population assessment of khulan (*Equus hemionus*) in Mongolia. *Exploration into the Biological Resources of Mongolia* (Halle/Saale, Germany) 10, 45-48.
- Lkhagvasuren, B., Chimeddorj, B., Sanjmyatav, D., 2011. Barriers to migration - case study in Mongolia: Analysing the Effects of Infrastructure on Migratory Terrestrial Mammals in Mongolia. Report for CMS. Available at: [https://www.cms.int/sites/default/files/publication/Inf\\_23\\_Migration\\_Barriers\\_WWF\\_Mongolia\\_E.pdf](https://www.cms.int/sites/default/files/publication/Inf_23_Migration_Barriers_WWF_Mongolia_E.pdf)
- Lkhagvasuren, D., Ansorge, H., Samiya, R., Schafberg, R., Stubbe, A., Stubbe, M., 2013. Age determination of the Mongolian wild ass (*Equus hemionus* Pallas, 1775) by the dentition patterns and annual lines in the tooth cementum. *Journal of Species Research* 2, 85-90.
- Lkhagvasuren, D., 2015. Some Population Characteristics of the Asiatic Wild Ass (*Equus hemionus* Pallas, 1775) in Mongolia. PhD thesis at the School of Arts and Sciences, National University of Mongolia.
- Lkhagvasuren, D., Batsaikhan, N., Fagan, W.F., Ghandakly, E.C., Kaczensky, P., Müller, T., Samiya, R., Schafberg, R., Stubbe, A., Stubbe, M., Ansorge, H., 2017. First assessment of the population structure of the Asiatic wild ass in Mongolia. *European Journal of Wildlife Research* 64: <https://doi.org/10.1007/s10344-017-1162-x>
- Moehlman, P., 2002. *Equids: Zebras, Asses and Horses*. IUCN Publication Services Unit, Cambridge, UK.
- Mongolian Agency for Standardization and Metrology, 2015. Standard of Mongolia - Passage for wild animals along auto and rail roads in steppe and Gobi region. General requirements. Report by the Mongolian Agency for Standardization and Metrology, Ulaanbaatar, Mongolia.
- Munkherdene, G., and D. Sneath. 2018. Enclosing the Gold-Mining Commons of Mongolia: The Vanishing Ninja and the Development Project as Resource. *Current Anthropology* 59, 814-838.

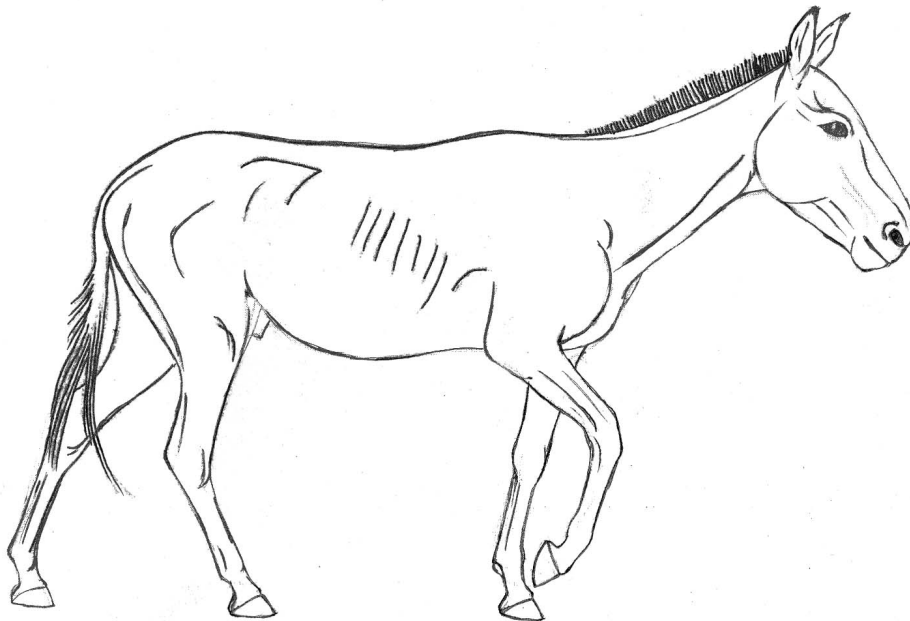
- Nandintsetseg, B., Shinoda, M., 2013. Assessment of drought frequency, duration, and severity and its impact on pasture production in Mongolia. *National Hazards* 66, 995–1008.
- Nandintsetseg, D., Kaczensky, P., Ganbaatar, O., Leimgruber, P., Mueller, T., 2016. Spatiotemporal habitat dynamics of ungulates in unpredictable environments: The khulan (*Equus hemionus*) in the Mongolian Gobi desert as a case study. *Biological Conservation* 204, 313–321.
- Nandintsetseg, D., Bracis, C., Leimgruber, P., Kaczensky, P., Bayarbaatar, B., Badamjav, L., Buyanaa, C., Shiilegdamba, E., Horning, N., Ito, T., Olson, K., Payne, J., Walzer, C., Shinoda, M., Stabach, J., Songer, M., Mueller, T., 2019. Variability in Nomadism: Environmental Gradients Modulate the Movement Behaviors of Dryland Ungulates. *Ecosphere* 10, e02924.
- Neumann-Denzau, G., and H. Denzau. 2007. Remarks on the social system of the Mongolian wild ass (*Equus hemionus hemionus*). *Exploration into the Biological Resources of Mongolia (Halle/Saale)* 10:177-187.
- Norton-Griffiths, M., Frederick, H., Slaymaker, D.M., Payne, J., 2015. Aerial Census of Wildlife and Livestock in the Oyu Tolgoi Area of the Gobi Desert, Mongolia May - July 2013. Unpublished report to Oyu Tolgoi LLC, Ulaanbaatar, Mongolia.
- Nutt, H.L., 1873. Donkey Hunting on the Runn of Kutch. *Oriental Sporting Magazine* 6, 276-280.
- Olsen, N., J. Bishop, and S. Anstee. 2011. Exploring ecosystem valuation to move towards net positive impact on biodiversity in the mining sector. IUCN and Rio Tinto Technical Series No.1, Gland, Switzerland: IUCN. Available at: <https://www.iucn.org/ja/content/exploring-ecosystem-valuation-move-towards-net-positive-impact-biodiversity-mining-sector-0>
- Olson, K., 2012. Wildlife Crossing Options Along Existing And Planned Mongolian Railway Corridors. Mongolian discussion papers, East Asian and Pacific Sustainable Development Department. Washington D.C., World Bank.
- Olson, K.A., van der Ree, R., 2015. Railways, roads and fences across Kazakhstan and Mongolia threaten the survival of wide-ranging wildlife. Pages 472-478 in R. van der Ree, D.J. Smith, C. Grilo (Eds) *Handbook of Road Ecology*, John Wiley & Sons, Ltd., Chichester, UK.
- Oyu Tolgoi. 2012. Environment and Social Impact Assessment (ESIA). Section C: Impact Assessment, Chapter C6: Biodiversity and Ecosystem Services.
- Painer, J., Kaczensky, P., Ganbaatar, O., Huber, K., Walzer, C., 2010. Comparative parasitological examination on sympatric equids in the Great Gobi “B” Strictly Protected Area, Mongolia. *European Journal of Wildlife Research* 57, 225-232.
- Payne, J., Kaczensky, P., 2017. Annual Report 2016. Appendix A: Khulan movement monitoring by satellite collaring. Unpublished annual report 2016 by WCS to Oyu Tolgoi.
- Payne, J., Kaczensky, P., 2018. Annual Report 2017. Monitoring mining-related impacts on khulan in the SE Gobi - Annual report 2017. Unpublished annual Report 2017 by WCS to Oyu Tolgoi.
- Payne, J.C., Buuveibaatar, B., Bowler, D.E., Olson, K.A., Walzer, C., Kaczensky, P., 2020. Hidden treasure in the Gobi: understanding how water limits range use of khulan in the Mongolian Gobi. *Scientific Report*, 10, 2989.
- Payne, J., Kaczensky, P. 2020. Update on khulan monitoring through August 2019. Technical Report to WCS. Unpublished annual Report 2019 by WCS to Oyu Tolgoi.
- Peled, T., 2010. Reintroductions as an ecosystem restoration tool: A case study of reintroduced ungulates as vectors for seed-dispersal. Master thesis submitted Ben-Gurion University of the Negev The Jacob Blaustein Institutes for Desert Research The Albert Katz International School for Desert Studies. Available at: <https://www.yumpu.com/en/document/read/16937297/ben-gurion-university-of-the-negev>
- Powell, A. 2017. Chinese Demand Threatens South Africa’s Donkeys. VOA News. Available at: <https://www.voanews.com/africa/chinese-demand-threatens-south-africas-donkeys>
- Ransom, J. I., P. Kaczensky, B. C. Lubow, O. Ganbaatar, and N. Altansukh. 2012. A collaborative approach for estimating terrestrial wildlife abundance. *Biol Conserv* 153:219-226.



- Ransom, J.I., Kaczensky, P., 2016. Wild Equids - Ecology, Management, and Conservation. Johns Hopkins University Press, Baltimore, USA.
- Ransom, J.I., Lagos, L., Hrabar, H., Nowzari, H., Usukhjargal, D., Spasskaya, N., 2016. Wild and Feral Equid Population Dynamics. Pages 68-83 in: Ransom, J.I., and Kaczensky, P. (Eds). Wild Equids - Ecology, Management, and Conservation. Johns Hopkins University Press, Baltimore, USA.
- Reading, R. P., H. M. Mix, B. Lhagvasuren, C. Feh, D. P. Kane, S. Dulamtseren, and S. Enkhbold. 2001. Status and distribution of khulan (*Equus hemionus*) in Mongolia. Journal of Zoology, London 254, 381-389.
- Ree, R.v.d., Smith, D.J., Grilo, C., 2015. Handbook of Road Ecology. Wiley Blackwell, Hoboken, New Jersey, United States.
- Rubenstein, D.I., Sundaresan, S., Fischhoff, I., Tantipathananandh, C., Berger-Wolf, T.Y., 2015. Similar but Different: Dynamic Social Network Analysis Highlights Fundamental Differences between the Fission-Fusion Societies of Two Equid Species, the Onager and Grevy's Zebra. PLoS ONE 10, e0138645.
- Saltz, D., Rubenstein, D.I., 1995. Population Dynamics of a Reintroduced Asiatic Wild Ass (*Equus hemionus*) Herd. Ecological Application 5, 327-335.
- Schoenecker, K.A., King, S.R.B., Nordquist, M.K., Nandintsetseg, D., Cao, Q., 2016. Habitat and Diet of Equids. Pages 41-55 in: Ransom, J.I., and Kaczensky, P. (Eds). Wild Equids - Ecology, Management, and Conservation. Johns Hopkins University Press, Baltimore, USA.
- Schook, M.W., Wildt, D.E., Weiss, R.B., Wolfe, B.A., Archibald, K.E., Pukazhenth, B.S., 2013. Fundamental studies of the reproductive biology of the endangered persian onager (*Equus hemionus onager*) result in first wild equid offspring from artificial insemination. Biol Reprod 89, 41.
- Seidler, R.G., Green, D.S., Beckmann, J.P., 2018. Highways, crossing structures and risk: Behaviors of Greater Yellowstone pronghorn elucidate efficacy of road mitigation. Global Ecology and Conservation 15, e00416.
- Soilemetzidou, E.S., Bruin, E.d., Czirják, G.Á., Buuveibaatar, B., Kaczensky, P., Koopmans, M., Walzer, C., Greenwood, A.D., 2020. Bearing the brunt: Mongolian khulan (*Equus hemionus hemionus*) are exposed to multiple influenza A strains. Vet Microbiol 242:108605
- Strindberg, S., Buuveibaatar, B. 2018. Khulan Mortality Monitoring: Estimating Mongolian khulan (*Equus hemionus*) poaching rates from carcass surveys in the Dornod and Galba areas of the southern Gobi. Unpublished annual report 2017 by WCS to Oyu Tolgoi.
- Strindberg, S., Buuveibaatar, B., 2019. Appendix G. Khulan Mortality Monitoring: Estimating Mongolian khulan (*Equus hemionus*) poaching rates from carcass surveys in the Dornod and Galba areas of the southern Gobi. Unpublished annual report 2018 by WCS to Oyu Tolgoi.
- Stubbe, A., Stubbe, M., Batsaikhan, N., Samjaa, R., 2012. Long term ecology of Asiatic wild ass (*Equus h. hemionus* Pallas) in Central Asia. Exploration into the Biological Resources of Mongolia (Halle/Saale) 12, 61-76.
- Sugimoto, T., Ito, T.Y., Taniguchi, T., Lkhagvasuren, B., Oyunsuren, T., Sakamoto, Y., Yamanaka, N., 2018. Diet of sympatric wild and domestic ungulates in southern Mongolia by DNA barcoding analysis. Journal of Mammalogy 99, 450-458.
- Sukhchuluun, G., Tegshjargal, N., Tsogzolboo, T., 2013. Rare ungulates distribution, density, and affecting factors in western part of Umnugobi province. Proceedings of the Institute of Biology 29, 84-92.
- Sundaresan, S.R., Fischhoff, I.R., Dushoff, J., Rubenstein, D.I., 2007. Network metrics reveal differences in social organization between two fission-fusion species, Grevy's zebra and onager. Oecologia 151, 140-149.

- Teitelbaum, C.S., Mueller, T., 2019. Beyond Migration: Causes and Consequences of Nomadic Animal Movements. *Trends Ecol Evol* 34, 569-581.
- Temple, H. J., S. Anstee, J. Ekstrom, J. D. Pilgrim, J. Rabenantoandro, J.-B. Ramanamanjato, F. Randriatafika, and M. Vincelette. 2012. Forecasting the path towards a Net Positive Impact on biodiversity for Rio Tinto QMM. IUCN and Rio Tinto Technical Series No.2, Gland, Switzerland: IUCN. Available at: <https://portals.iucn.org/library/efiles/documents/2012-049.pdf>
- The World Bank, 2003. From goats to coats: institutional reform in Mongolia's cashmere sector. Report 26240-MOG. Poverty Reduction and Economic Management Unit, East Asia and Pacific Region, Washington, D.C. Available at: <http://documents1.worldbank.org/curated/en/892921468123890417/pdf/262400ENGLISH0rev0MG0Cashmere01PUBLIC1.pdf>
- Tucker, M.A., Böhning-Gaese, K., Fagan, W.F., Fryxell, J.M., Van Moorter, B., Alberts, S.C., Ali, A.H., Allen, A.M., Attias, N., Avgar, T., Bartlam-Brooks, H., Bayarbaatar, B., Belant, J.L., Bertassoni, A., Beyer, D., Bidner, L., van Beest, F.M., Blake, S., Blaum, N., Bracis, C., Brown, D., de Bruyn, P.J.N., Cagnacci, F., Calabrese, J.M., Camilo-Alves, C., Chamaillé-Jammes, S., Chiaradia, A., Davidson, S.C., Dennis, T., DeStefano, S., Diefenbach, D., Douglas-Hamilton, I., Fennessy, J., Fichtel, C., Fiedler, W., Fischer, C., Fischhoff, I., Fleming, C.H., Ford, A.T., Fritz, S.A., Gehr, B., Goheen, J.R., Gurarie, E., Hebblewhite, M., Heurich, M., Hewison, A.J.M., Hof, C., Hurme, E., Isbell, L.A., Janssen, R., Jeltsch, F., Kaczensky, P., Kane, A., Kappeler, P.M., Kauffman, M., Kays, R., Kimuyu, D., Koch, F., Kranstauber, B., LaPoint, S., Leimgruber, P., Linnell, J.D.C., López-López, P., Markham, A.C., Mattisson, J., Medici, E.P., Mellone, U., Merrill, E., de Miranda Mourão, G., Morato, R.G., Morellet, N., Morrison, T.A., Díaz-Muñoz, S.L., Mysterud, A., Nandintsetseg, D., Nathan, R., Niamir, A., Odden, J., O'Hara, R.B., Oliveira-Santos, L.G.R., Olson, K.A., Patterson, B.D., Cunha de Paula, R., Pedrotti, L., Reineking, B., Rimmler, M., Rogers, T.L., Rolandsen, C.M., Rosenberry, C.S., Rubenstein, D.I., Safi, K., Saïd, S., Sapir, N., Sawyer, H., Schmidt, N.M., Selva, N., Sergiel, A., Shiilegdamba, E., Silva, J.P., Singh, N., Solberg, E.J., Spiegel, O., Strand, O., Sundaresan, S., Ullmann, W., Voigt, U., Wall, J., Wattles, D., Wikelski, M., Wilmers, C.C., Wilson, J.W., Wittemyer, G., Zięba, F., Zwijacz-Kozica, T., Mueller, T., 2018. Moving in the Anthropocene: Global reductions in terrestrial mammalian movements. *Science* 359, 466.
- Tuinhof, A. and Buyanhisnig, N. 2010. Groundwater Assessment of the Southern Gobi Region. Mongolia Discussion Papers, East Asia and Pacific Sustainable Development Department. Washington, D.C.: World Bank. Available at: <https://openknowledge.worldbank.org/bitstream/handle/10986/27855/627890REPLACEM07018020110Box361493B.pdf?sequence=1&isAllowed=y>
- Volf, J., 2010. Sixty years of kulan, *Equus hemionus kulan* (Groves et Mazák, 1967) breeding at Prague Zoo. *Equus*, 30-55.
- Wang, M.Y., Ruckstuhl, K.E., Xu, W.X., Blank, D., Yang, W.K., 2016. Human Activity Dampens the Benefits of Group Size on Vigilance in Khulan (*Equus hemionus*) in Western China. *PLoS ONE* 11, e0146725.
- Wang, Y., Guan, L., Chen, J., Kong, Y., 2018. Influences on mammals frequency of use of small bridges and culverts along the Qinghai–Tibet railway, China. *Ecological Research* 33, 879-887.
- Warner, S., 2014. Road-kills of Asiatic Wild Ass in the Central Negev – possible causes and means to prevent them. Unpublished report, Hebrew University of Jerusalem, Israel, 11pp. [in Hebrew].
- Wilcove, D.S., Wikelski, M., 2008. Going, going, gone: is animal migration disappearing. *PLoS Biol* 6, e188.
- Wingard, J.R., Zahler, P., 2006. Silent Steppe: The Illegal Wildlife Trade Crisis. Mongolia Discussion Papers, East Asia and Pacific Environment and Social Development Department. Washington D.C.: World Bank. Available at: <https://library.wcs.org/doi/ctl/view/mid/33065/pubid/DMX974800000.aspx>

- Xu, W., Xia, C., Yang, W., Blank, D.A., Qiao, J., Liu, W., 2012. Seasonal diet of Khulan (Equidae) in Northern Xinjiang, China. *Italian Journal of Zoology* 79, 92-99.
- Young, J.K., Olson, K.A., Reading, R.P., Amgalanbaatar, S., Berger, J., 2011. Is Wildlife Going to the Dogs? Impacts of Feral and Free-roaming Dogs on Wildlife Populations. *BioScience* 61, 125-132.
- Zhang, Y., Cao, Q.S., Rubenstein, D.I., Zang, S., Songer, M., Leimgruber, P., Chu, H., Cao, J., Li, K., Hu, D., 2015. Water Use Patterns of Sympatric Przewalski's Horse and Khulan: Interspecific Comparison Reveals Niche Differences. *PLoS ONE* 10, e0132094.
- Zhirnov, L.V., Ilyirsky, V.O., 1986. The Great Gobi park - A refuge for rare animals of the central Asian deserts. Centre for International Projects, GKNT, Moscow, Russia.



## 5 Appendix

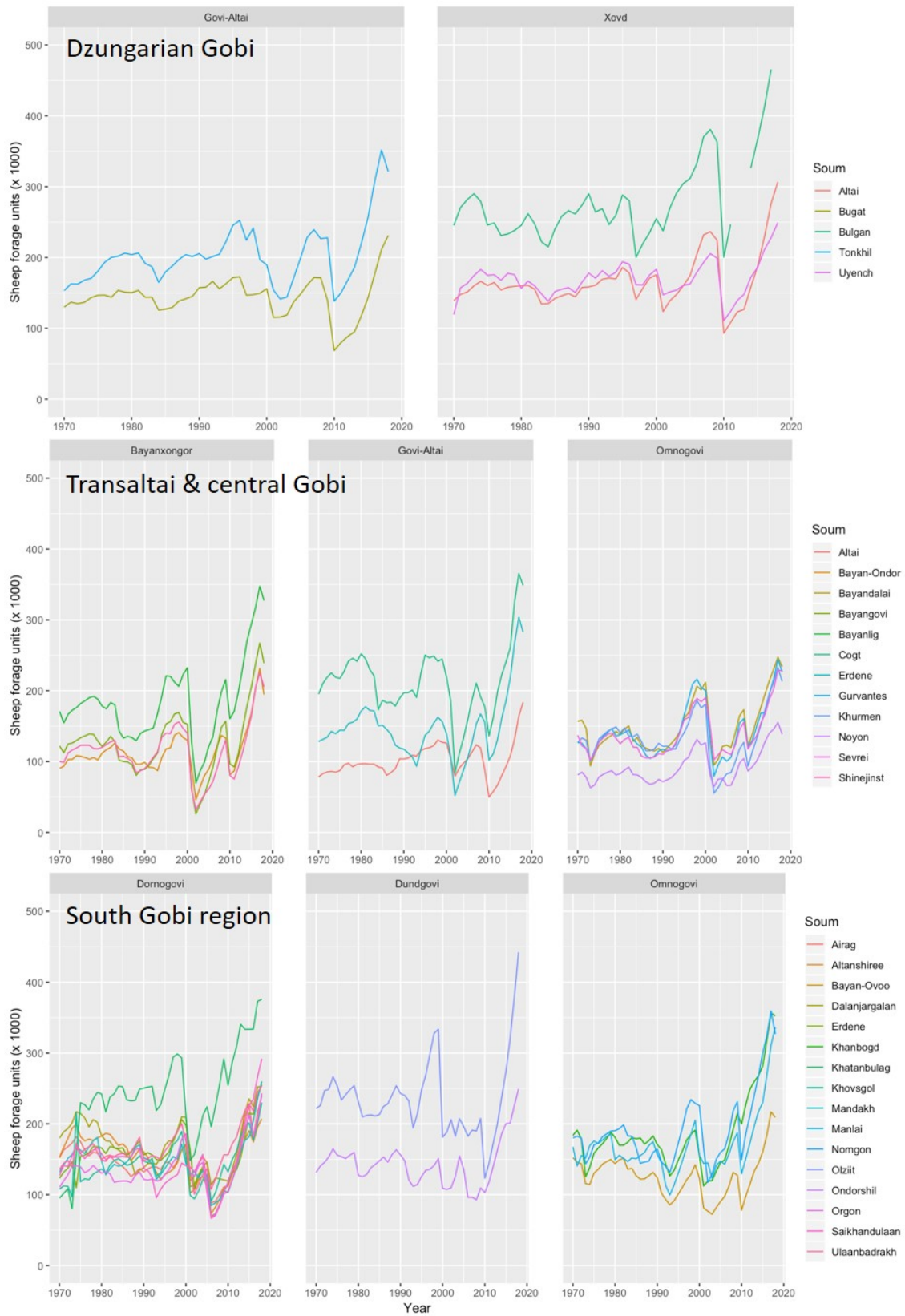


Figure A1: Livestock numbers expressed as Sheep Forage Units (SFUs where: 1 goat = 0.9 sheep, 1 camels = 5 sheep, 1 cattle = 6 sheep, and 1 horses = 7 sheep; see: Fernandez-Gimenez 1999).







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