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Steppe ungulate count in Great Gobi B Strictly Protected area 2022

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Abstract

The plains of Great Gobi B Strictly Protected Area (subsequently "Great Gobi B") in southwestern Mongolia are home to three endangered wild ungulates, khulan (*Equus hemionus*), takhi (*Equus ferus przewalskii*), and goitered gazelle (*Gazella subgutturosa*). With Mongolia holding the largest populations of these species, their conservation is of global importance. To assess the effectiveness of conservation efforts, robust survey methods are needed to monitor population development.

In late summer 2022 we conducted the 3rd plains ungulate count in Great Gobi B to estimate population size of khulan and goitered gazelle and describe population development since the counts in 2010 and 2015 and tested the method for estimating the growing population of reintroduced Przewalski's horses.

We conducted Distance Sampling point counts at 101 observation points over 6 counting events (at 19:00, 7:00, 9:00, 11:00, 13:00, and 15:00) at each observation point. During each counting event the observers scanned the surroundings using binoculars and registered species, number of animals, time, bearing and distance for each observation. Over the 606 counts, we observed 5,744 khulan, 3,150 gazelles and 922 Przewalski's horses. Using these observations, we created global models (over all observation points and counting events) using the distance analysis framework and selected models with the best fit based on AIC values.

Populations estimates for 2022 were 5,204 (95% CI = 2,121 – 12,771) khulan, 10,980 (95% CI = 7,473 – 16,132) goitered gazelles, and 1,288 (95% CI = 213 – 7,776) Przewalski's horses within the 13,000 km^2 survey area. Population estimates of both khulan and goitered gazelle suggested an increase from 2010 to 2015, while the 2022 estimated is closer to the 2010 estimates for khulan and in between for goitered gazelles. However, confidence intervals, especially for khulan, are large and population development cannot be determined conclusively. The uncertainty in the khulan estimate for 2022 was caused by the combination of a highly clumped distribution due to draught conditions and a large variation in group sizes. Goitered gazelles were more evenly distributed and group sizes less variable.

Estimating Przewalski's horse population resulted in a gross overestimate because of the knowledge rangers had about the location of Przewalski's horse groups from intensive weekly monitoring. The data suggests that they specifically looked for groups, as Przewalski's horses were detected almost equally likely over all distance categories. Confidence intervals were large because the population is still small (numbering just over 400) and distribution was also highly clumped due to the drought condition.

The 2022 population estimates for khulan and goitered gazelles and the comparison with the estimates from 2010 and 2015 should be regarded as preliminary because: 1) The 3 surveys were analysed using slightly different distance analysis frameworks and 2) Distance Sampling does not take the spatial distribution of groups into account and we plan to explore such methods before we will reanalyse the 3 surveys within the same analysis framework.

Keywords:

Distance sampling, Mongolian plains, *Equus hemionus, Gazella subgutturosa, Equus ferus przewalskii,*

Financed by:

Vontobel-Stiftung, International Takhi Group, Inland Norway University of Applied Sciences, Great Gobi B administration, Prague Zoo

Sammendrag

På de mongolske slettene lever det tre truede ville klovdyrarter; asiatisk villesel (*Equus hemionus*), Przewalskihest (*Equus ferus przewalskii*) og struma gaselle (*Gazella subgutturosa*). De største populasjonene av disse artene på verdensbasis lever i Mongolia, og landet har dermed et særskilt ansvar for å ta vare på og forvalte disse artene. For å sikre en kunnskapsbasert og bærekraftig forvalting av populasjonene trengs informasjon om populasjonsutvikling og bestandsstørrelse.

I denne undersøkelsen har vi gjennomført tellinger av viltlevende klovdyrarter i «Great Gobi B» i SV Mongolia for å estimere populasjonsstørrelsen og populasjonsutviklingen av asiatisk villesel og struma gaselle. Det har tidligere blitt gjennomført tellinger i 2010 og 2015, men dette er første gang det blir forsøkt å estimere populasjonsstørrelsen av przewalskihest.

Vi gjennomførte tellinger fra 101 observasjonspunkter fordelt på 3 områder med 24 timers økter på hvert punkt. På hvert observasjonspunkt ble det gjennomført 6 runder med tellinger hvor observatørene skannet området med kikkert og registrerte antall dyr, tidspunkt, kompassretning og avstand.

Vi lagde ulike modeller ved bruk av distance sampling metoden for å estimere populasjonsstørrelsen av asiatisk villesel, przewalskihest og struma gaselle i studieområdet for alle observasjonene samlet, og valgte den modellen med best AIC verdi. I tillegg analyserte vi data fra hver observasjonsrunde separat for å estimere populasjonsstørrelse på de forskjellige tidspunktene for asiatisk villesel og struma gaselle.

I løpet av alle 6 observasjonsrundene telte vi totalt 5 744 asiatiske villesel, 3 150 struma gaseller og 922 przewalskihester. Populasjonsstørrelsen ble estimert til 5 204 (95% KI = 2 121 – 12 771) asiatiske villesel, 10 980 (95% KI = 7 473 – 16 132) struma gaseller og 1288 (95% KI = 213 – 7 776) przewalskihester innenfor studieområdet.

Populasjonene for asiatisk villesel og struma gaselle viste en positiv utvikling mellom 2010 og 2015, men hadde en negativ utvikling fra 2015 til 2022. Usikkerheten i estimatene, spesielt for asiatisk villesel, er høy og det er vanskelig å trekke konklusjoner om populasjonsutvikling ut ifra dataene. 2022 var et uvanlig tørt år, og de asiatiske villeslene samlet seg i en mindre del av studieområdet i nærheten av en vannkilde der beitegrunnlaget var bedre. Denne ujevne fordelingen i studieområdet er mest sannsynlig årsaken til den store usikkerheten i estimatene. Struma gaseller var mere jevnt fordelt i studieområdet, men usikkerheten i dataene var fortsatt høy, dog på et nivå som kan forventes av en stor-skala undersøkelse i et system med lav tetthet. Å estimere przewalskihest populasjonen bød på samme problemer som for asiatiske villesel, men gir enda større usikkerhet på grunn av det lave antallet observasjoner.

Det ble brukt litt ulike analysemetoder innenfor distance metodikken i de 3 undersøkelsene fra 2010, 2015 og 2022, og det ble ikke tatt hensyn til forskjell i størrelsen av studieområdene mellom de ulike årene. For videre arbeid planlegger vi å analysere alle dataene samlet for å oppnå mer pålitelige resultater. Et av problemene med distance metoden er at analysene ikke tar hensyn til den romlige fordelingen av grupper, noe som vi ønsker å utforske ved bruk av andre metoder.

Emneord:

Distance sampling, Mongolia, sletter, *Equus hemionus, Gazella subgutturosa, Equus ferus przewalskii,*

Oppdragsgiver:

Vontobel-Stiftung, International Takhi Group, Høgskolen i Innlandet, Great Gobi B administration, Prague Zoo

Foreword

The Mongolian Gobi is a stronghold for a range of threatened species, including large migratory plains or steppe ungulates such as Asiatic wild ass, or “khulan”, Przewakski’s horse, or “takhi”, wild Bactrian camels, goitered gazelle, and saiga antelope. The Great Gobi B Strictly Protected Area (“Great Gobi B”) in SW Mongolia is a stronghold of the two wild equids species and the goitered gazelle and the management plan of Great Gobi B foresees regular assessments of their conservation status.

Simultaneous point counts from elevated vantage points were first tested in 2010 and have proven a good method to obtain relatively robust population estimates of plains ungulates over the large expanse of Great Gobi B. Because these steppe ungulate counts require significant manpower, logistics, and ultimately funds, they were scheduled to happen only at 5-year intervals.

The second steppe ungulate count was conducted in 2015 and the third one was scheduled for 2020 but had to be postponed due to the COVID-19 pandemic until 2022. Meanwhile the area of the Great Gobi B was increased from 9,000 to 18,000 km^2. In this report, we describe changes to the steppe ungulate count 2022 based on past experiences and the increased size of the protected area, provide preliminary estimates for the khulan and goitered gazelle population, and discuss remaining challenges.

The steppe ungulate count 2022 was conducted in close cooperation with scientific staff of Great Gobi B, namely O. Ganbaatar, N. Altasukh, and ITG Mongolia, namely S. Dalaitseren, and G. Yondon. We are grateful to all participants of the counts who were recruited from protected area rangers & administrative staff, ITG staff, and volunteers from the national university of Mongolia (NUM). Many thanks also to a wonderful supply team who kept everybody well fed and watered.

Special thanks also go to the International Takhi Group (ITG), especially Rebekka Blumer for fundraising and organisational support and Batsukh Jamiyandorj for taking care of travel logistics and much more. Funding was provided by the Vontobel-Stiftung, the International Takhi Group, and Great Gobi B administration. Prague Zoo provided funds for 30 much needed 10x40 binoculars and Fossil Group Europe, Basel, Switzerland sponsored watches which were engraved with the ITG logo and “2022 Steppe Ungulate Count” by Jeweler Schwarcz, Bad Saeckingen, Germany. Inland Norway University of Applied Sciences is funding the PhD position of Thomas Vogler.

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1. Steppe ungulate monitoring in Great Gobi B Strictly Protected Area

The steppes of Great Gobi B Strictly Protected Area (subsequently referred to as Great Gobi B; IUCN category Ib "wilderness area") in SW Mongolia are home to three endangered wild steppe ungulates, khulan (*Equus hemionus*), Przewalski's horse (*Equus ferus przewalskii*) and goitered gazelle (*Gazella subgutturosa*). The IUCN classifies khulan as *near threatened* (Kaczensky et al., 2020) and the goitered gazelle as *vulnerable* (IUCN SSC Antelope Specialist Group, 2017) with Mongolia holding the largest populations of both species (Buuveibaatar et al., 2017). The Przewalski's horse was previously classified as *extinct in the wild* but reintroduced in Great Gobi B since 1992 and is now classified as *endangered* (King et al., 2015).

Because of the global importance of populations of these three steppe ungulates in Great Gobi B, monitoring of population development is important to assess whether conservation goals for the species are met. Przewalski's horses, who live in relatively stable family groups (referred to as harems), can be individually identified by rangers who most recently counted 423 horses in Great Gobi B (Altansukh Nanjid pers. obs. August 29th, 2022).

Populations of khulan and gazelles are much larger, and groups vary in composition and cannot be individually identified. Bi-monthly monitoring loops using a distance sampling approach (Buckland et al. 2001), provide information on overall distribution, habitat use, and grouping pattern, but fail to produce reliable population estimates (Kaczensky et al., 2015). To overcome the limitations of the line transect counts, a simultaneous point distance sampling survey was successfully implemented in 2010 (Ransom et al., 2012) and repeated and refined in 2015. While the 2010 survey provided a first baseline, the 2015 survey suggested an increase in population size for both khulan and gazelles (Kaczensky et al., 2017).

Great Gobi B now foresees 5-year intervals to assess the population trend of its steppe ungulates. However, the survey planned in 2020 had to be postponed to 2022 due to the COVID-19 pandemic. Furthermore, in 2019 the area of Great Gobi B was increased from 9,000 to 18,000 km^2 and the increase in size had to be reflected in future steppe ungulate counts. In this report we describe changes to the steppe ungulate count in 2022 based on past experiences and the increased size, provide preliminary results for the populations estimates of khulan and goitered gazelles, and discuss remaining challenges. We will also test estimating population size of Przewalski's horses as the population has increased to a level where counting and identifying all individuals is becoming challenging.

2. Material and methods

2.1 Study area

2.1.1 Great Gobi B

Great Gobi B protected area was established in 1975 in the Dzungarian Gobi in SW Mongolia. The protected area originally covered ca. 9000 km^2 but was increased to ca 18,000 km^2 in 2019.

The protected area is located in the provinces Gobi-Altai (34%) and Khovd (66%) and borders China in the south. The dominant habitats are desert steppe and desert habitats. The landscape is dominated by plains >1000m but include mountain ranges along the border with elevations up to 2840 m as well as smaller mountains and rolling hill country. Towards the north Great Gobi B reaches the foothills of the Altai range (Kaczensky et al., 2008).

The climate of Great Gobi B is continental with temperatures ranging from -40°C in winter to +40°C in summer and an annual average temperature of -0.5°C (Geological Institute of Mongolia, 2004). Average annual precipitation is 100mm with most precipitation falling during summer between May and August.

There are no permanent settlements in Great Gobi B and no connective roads. However, the foothills of the border mountains and some of the large oasis complexes in the north and east are used as traditional wintering ranges for local semi-nomadic herders. These herders traditionally spend the fall, winter, and spring in in the Gobi, but use the alpine meadows in the Altai range as summer pastures. The cash economy of herding families is primarily built around cashmere production (Michler et al., 2022).

2.1.2 Environmental conditions in 2022

The summer 2022 was exceptionally dry with only 9.4mm of precipitation from May – June, compared to 52mm and 101mm in 2020 and 2021, respectively. The average temperature during fieldwork (20th – 25th of August) was 14.2°C ranging between 4.9 °C and 24.4°C with average wind speeds of up to 8.6m/s and wind gusts of up to 16.9m/s (Figure 1; Hobo weather station at Takhin Tal administration center). Only minimal precipitation was recorded in some parts of the survey area during fieldwork.

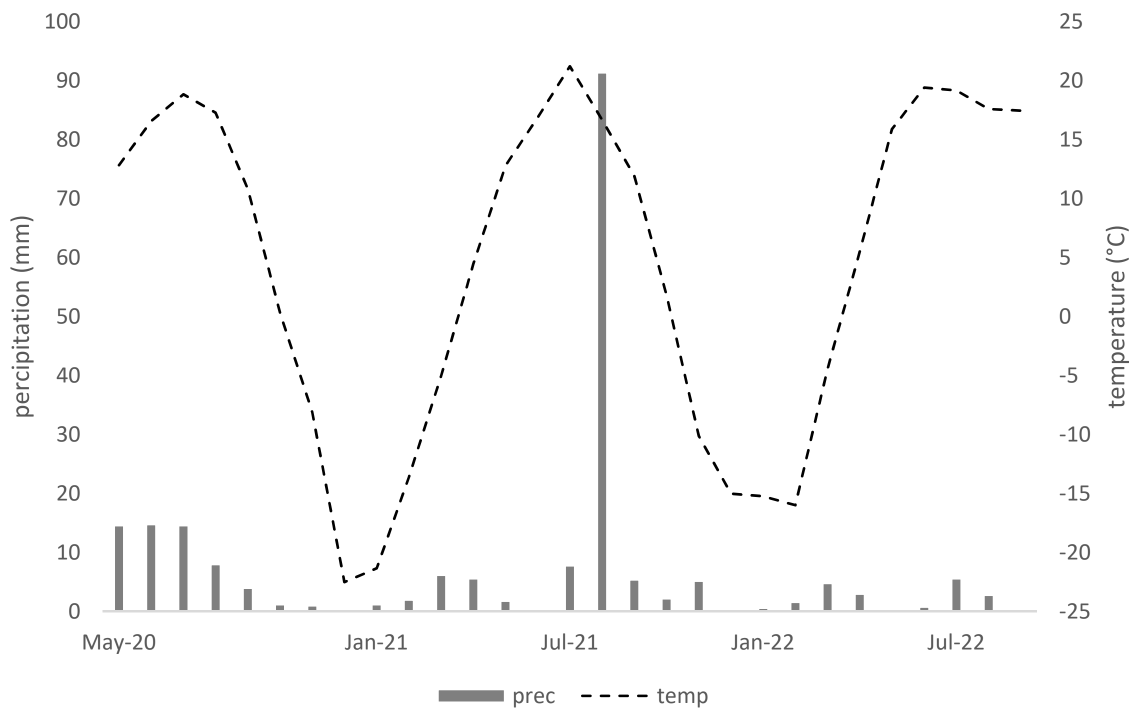


Figure 1: Monthly precipitation in mm (left Y-axis) and average monthly temperature in °C (right Y-axis) from May 2020 to August 2022.

2.2 Methods

2.2.1 Previous steppe ungulate counts In Great Gobi B

Prior to the 2022 steppe ungulate count, similar surveys had been conducted in 2010 and 2015. The general approach was to select suitable vantage points which were more or less evenly distributed within a 10 x 10 km grid over the 11,000 km^2 study area. For the actual count, the study area was divided into an eastern and a western part and counting was carried out over two counting sessions lasting a total of four days.

Observers were driven to their first observation point in the eastern part of the study area in the afternoon. They conducted their first count in the evening when disturbance from driving observers to their vantage points had stopped. Observers then spend the night at the base of their observation point and counted again at 2-hour intervals the next day starting in the early morning and ending in the afternoon. This resulted in a total of six counts per observation point.

Observers were then collected in the late afternoon and transferred to a field camp in the middle of the study area where they spend the night. The next day they were driven to their second observation point in the western part of the study area where counting resumed in the same way.

The first steppe ungulate count in Great Gobi B was conducted from 5 - 8 August 2010 using double observers and a total of 50 observation points. Observers were recruited from rangers, university students plus instructors, and local herders. Population estimates were calculated using distance sampling methods resulting in 5,671 (95% CI = 3611-8907) khulan and 5,909 (95% CI = 3,762–9,279) gazelles over a 11,027 km2 survey area (Kaczensky et al., 2017).

The winter before the count was exceptionally harsh with unusually high amounts of snow (referred to as “dzud”) and low temperatures making forage for wildlife and livestock unavailable. The 2009/10 winter caused a die–off in local livestock and the Przewalski’s horse population. Khulan, on the other hand, largely moved out of the area most affected by the dzud and seemed to have suffered little mortality but had poor recruitment in 2010. The impact on gazelles is largely unknown, but they also had poor reproduction in 2010 (Kaczensky et al., 2011).

The second steppe ungulate count was carried out from 29 September – 3 October 2015. Based on recommendations from the 2010 count, the number of observation points was increased from 50 to 80 and only single observers were used. Observers were recruited from rangers from Great Gobi B, Great Gobi A, Munkhairhan, Myngan Ugalzat protected areas and a few local people from the nearby villages. Observations were realised at 79 out of 80 points and distance sampling estimates resulted in 9,337 (95% CI = 5,337-16,334) khulan and 13,531 (95% CI = 8,957-20,441) gazelles over the 11,027 km2 study area. The 2015 results suggested an increase in khulan and gazelle population size of 65% and 129%, respectively (Kaczensky et al., 2017).

2.2.2 Steppe ungulate count 2022

To account for the doubling of the size of Great Gobi B and aim for a more robust sampling design, we further increased the number of observations points from 80 observation points used in 2015 to 102 in 2022. The selection of the additional observation points in the enlarged 10x10 km grid was done with the help of topographic maps and aerial images. Only plains and rolling hill country were considered suitable for the survey and there are no observation points in the high mountain ranges furthest east, along the border to China and in the most south-western part of the protected area (Figure 2). Selected points were verified with local staff for their suitability as observation points in respect to visibility (is it really a hill?) and accessibility (can it be reached by vehicle?). Observation points had to be elevated and ideally allow for a largely unobstructed 360^o view. The additional points increased the survey area from ~11,000 km^2 in 2010 and 2015 to ~13,000 km^2 in 2022.

Some adaptation of the pre-selected points was nevertheless necessary during the count. Of the 102 points selected, 2 were not suitable for observations because they were on the plains with no hill nearby, one was dropped and the other one was replaced with a new one. A few additional points had to be slightly shifted for the same reason. New and shifted points were recorded using handheld GPS units. Observation point selection and visualisation was done in ArcGIS Desktop 10.8 or ArcGIS Pro 2.7.3 (ESRI, 2019, 2022).

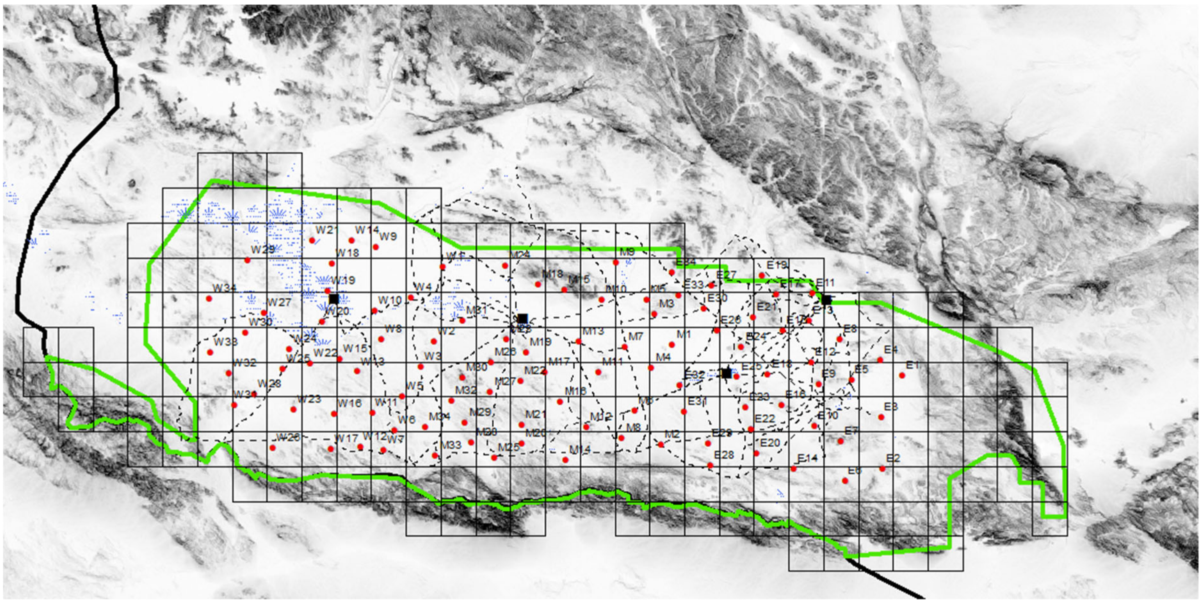


Figure 2: Study area with observation points (red dots) within the 19,000 km2 Great Gobi B study area (light green shape) and the 10x10 km grid for selection of observation points. As the survey was targeting plains ungulates, only observation points in or overseeing plains and rolling hill country were selected. The squares show overnight/supply points for the observer teams at (from east to west): Takhin Tal, Khonin us (only used by 1 team), Takhi us, and Tsagaan Us.

As it is logistically extremely challenging to organise 102 counters, we divided the survey area into 3 parts (eastern, middle and western part) and assembled a team of 35 observers, recruited from Great Gobi B staff (GGB; N=22), Gobi-Altai staff (GA, N=1), a delegation from the National University of Mongolia (NUM; N=6), employees of the International Tahki Group (ITG; N=3), and international researchers (INN; N=3; Table 1, Figure 12). A logistics team responsible for supplies, preparing meals, and transport of kitchen facilities and other equipment supported the observation team.

Table 1: Participants and their affiliation in the 3rd point count in Great Gobi B.

GGB	**GGB**	**NUM**	**GA**
Altansukh Nanjid	Havdrasoli Kakash	Ariunbileg Adiya	Olonbaatar Ganbat
Amarjargal Ganhuyag	Khurelbaatar Ongoodoi	Baasanjav Jargalsaikhan	**INN**
Amgalan Ynjmaa	Munkh-Erdene Davaajav	Davaadorj Enkhbayar	Olivier Devineau
Baast Zentger	Myagmarjav Baadai	Davaasuren Puntsagdulam	Petra Kaczensky
Batbayr Surmaa	Nisehhuu Gaanjuur	Maralgoo Puntsagdulam	Thomas Vogler
Batsuuri Borhuu	Oinbayr Lhachin	Soronzonbold Ochirvaani	**Support team**
Battsogt Sholhoon	Otgonbayar Mend	**ITG**	Erdenebaatar Ulamsain
Bunchindagva Altangerel	Tserendorj Choijiljav	Dalaitseren Sukhbaatar	Odonchimeg Chinbat
Buyantogtokh Dorjbat	Tserentogtoh Pognogor	Lena Michler	Tungalagtuya Sengee
Duurenbayr Urtnasan	Tugsbaatar Janchiv	Yondon Gansukh	Zoljargal Batsuuri
Ganbaatar Oyunsaikhan	Usuhbayr Erdene-ochir		

Observers underwent one full day of training on 19 August and a half day refreshment training on 20 August, which included instructions and practice on: how to count large groups, what is a group, how to conduct the counts using a compass to determine the bearing of observations, and how to estimate distances as well as a short safety briefing.

Estimating distances, the most crucial aspect for the DISTANCE sampling approach, was helped by printing out satellite image views of each observation point with distance rings at 100, 500, 1000, 2000, 3000, and 4000m around the observation point (Figure 4). The use of these maps for orientation and correct identification of the distance bin was trained with all participants from a hill near the administration centre and by putting motorbikes and cars at the distance categories.

Figure 3: Pictures on how to use topographic maps with buffers (top left), how to determine the compass bearing of a group (top middle), how to count croups (top right) and impressions from training (bottom).

We conducted the actual counts during six days from 20 – 25 August. Observers were divided into 6 vehicle teams and 1 motorbike group with 5 motorbikes. For each of the *observation sessions* (= 24h counting period, there are 3 observation sessions, east, middle and west) single observers (except 1 team of 2) were driven to their observation point in the late afternoon. At each point they conducted 6 observations, the first time at 19:00 on the day of arrival and subsequently at 07:00, 09:00, 11:00, 13:00 and 15:00 (= *sampling intervals*) the next day with the night spent close to the observation point in a tent.

Observations started at the indicated time with observers scanning the surrounding with 10x40 binoculars 360° clockwise starting from north. Once an animal or group of animals was spotted, observers used a compass to measure the bearing, a watch to determine time of observation and a map to help estimate the distance of the observation (Figure 3). Observations ended after scanning the surrounding once and after entering all observations into a data sheet. We define all observations registered at the same sampling interval as a *counting event*.

Figure 4: Observation point 12A with distance rings to facilitate distance estimates based on landscape features in the surrounding.

Table 2: Time schedule of the steppe ungulate count 2022 in Great Gobi B

Date	Activities
18-Aug-22	Arrival participants at the Takhin Tal headquarter of Great Gobi B
19-Aug-22	Full day training including field training
20-Aug-22	Half-day re-fresh training and safety briefing, hand out of supplies, transport to points in the eastern part and 1st counting event at 19:00
21-Aug-22	Main count day of the 1st observation session in the eastern part with counts at 07:00, 09:00, 11:00, 13:00, 15:00. Transport on to Takhi Us ranger camp
22-Aug-22	Transport to points in the middle part and 1st counting event at 19:00
23-Aug-22	Main count day of the 2nd observation session in the middle part with counts at 07:00, 09:00, 11:00, 13:00, 15:00. Transport back to Tahki Us ranger camp
24-Aug-22	Transport to points in the western part and 1st counting event at 19:00
25-Aug-22	Main count day of the 3rd observation session in the western part with counts at 07:00, 09:00, 11:00, 13:00, 15:00. Transport on to Tsagaan Us
26-Aug-22	Transport back to Takhin Tal

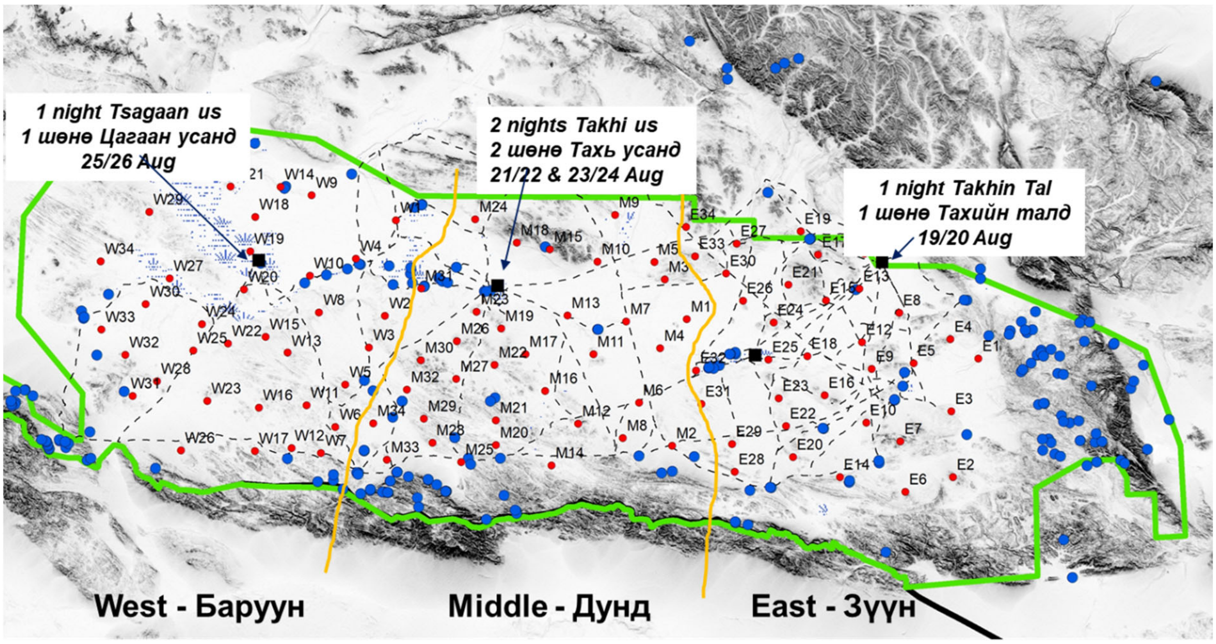


Figure 5: Study area overview with observation points and gathering points divided into eastern, middle and western part.

2.2.3 Distance sampling analysis

For the distance analysis we predetermined the bins as the observation estimate categories (0m-100m, 100m-500m, 500m-1000m, 1000m-2000m, 2000m-3000m, 3000m-4000m and >4000m) but included all observations >4000m in the distance class 4000m-5000m. As the model-fit did not improve by truncating left or right, we used the full dataset in the final models. One of the observed khulan groups was estimated to number around 3000 individuals. This group was only observed once, close to a known water-point and represents the majority of all observed animals. Rather than being a distinct group, we believe this to be the result of aggregation of several groups to get access to water as khulan are known to show a highly dynamic fission-fusion social organisation (Kaczensky et al., 2019). Including that group in the analysis increased uncertainty in the estimates and was therefore excluded from the distance analysis.

In a few cases animal observations were recorded, but the distance category was missing. This concerned only 7 groups of gazelles with a total number of 35. Additionally one observation of gazelles was missing the total number of animals. For the preliminary analysis these observations were dropped as they were unlikely to significantly influence the population estimates.

We created global models (all counting events combined) in which we used the different counting events as effort for khulan, goitered gazelle and takhi. We tested different key functions and adjustment terms to find the model with the best fit based on AIC values.

Additionally, we created specific models for each counting event for the two target species khulan and goitered gazelle. Because the detected group size increased with distance, we included group size as covariate to counteract the size bias. We used the same key function as for the global model but did not use any adjustment terms (this is not possible when using covariates). Because of the low number of observations, we did not create time specific models for takhi.

For this preliminary analysis we assumed a study area of 13,000 km^2 using the convex polygon around all survey points buffered by 4000m. We used the Distance-package in R (R Core Team, 2022) for analysis.

2.2.4 Mapping of observations

We used the observed distance and bearing to calculate and plot the position and group size of khulan (Figure 6), gazelle (Figure 7) and takhi (Figure 8) for each counting event (19:00, 07:00, 09:00, 11:00, 13:00, 15:00) in ArcGIS Pro (ESRI, 2022). Group size was binned in categories of 1, 2-3, 4-10, 11-50, 51-100 and >100 individuals.

3. Results

3.1 All observations

During the 6 counting events the observers counted a total of 5,744 khulan, 3,150 gazelles and 922 takhi. In addition, observers also saw some additional wildlife species, livestock, and signs of human presence (Table 3).

Table 3: All observations of wildlife, domestic animals and anthropogenic structures at all counting events.

Observation event	19:00		07:00		09:00		11:00		13:00		15:00		Total	Total
Species	Groups	Individuals	Groups	Individuals	Groups	Individuals	Groups	Individuals	Groups	Individuals	Groups	Individuals	groups	individuals
Wildlife														
Argali									1	1			1	1
Bearded Vulture	1	1	1	1			1	1					3	3
Fox	4	4			1	1	2	2	1	1			8	8
Goitered gazelle	102	583	112	737	124	761	74	370	54	299	56	400	522	3,150
Hare	1	1	1	1	1	1	1	1					4	4
Ibex			1	13					1	4			2	17
Khulan	44	756	34	688	28	255	23	473	33	413	24	**3159	186	5,744
Takhi	13	197	10	104	6	140	13	122	11	201	9	158	62	922
Takhi/Kulan*									1	1			1	1
Wolf	1	4											1	4
Lifestock														
"Big livestock"*					1	20	1	20					2	40
Camel	14	288	12	279	8	149	10	178	11	159	9	171	64	1,224
Cow	4	147	4	172			1	13	1	40			10	372
Domestic horse	13	290	8	315	6	93	10	177	3	76	2	58	42	1,009
Sheep & goat	1	500					3	1,500	2	900	1	500	7	3,400
Humans and human structures														
Ger***	3	3											3	3
House***	5	7											5	7
Human	1	1											1	1
Motorbike											1	1	1	1

**Unable to identify species with certainty*
***Includes group of ca. 3000 khulan seen at >4000m*
***Fixed structure and hence only counted once, when first seen*

3.2 Observations of khulan, goitered gazelles, and takhi

Khulan were mainly observed in the middle and western part of the survey area during the 2. and 3. observation session and most of the observed animals were in larger groups (Figure 6).

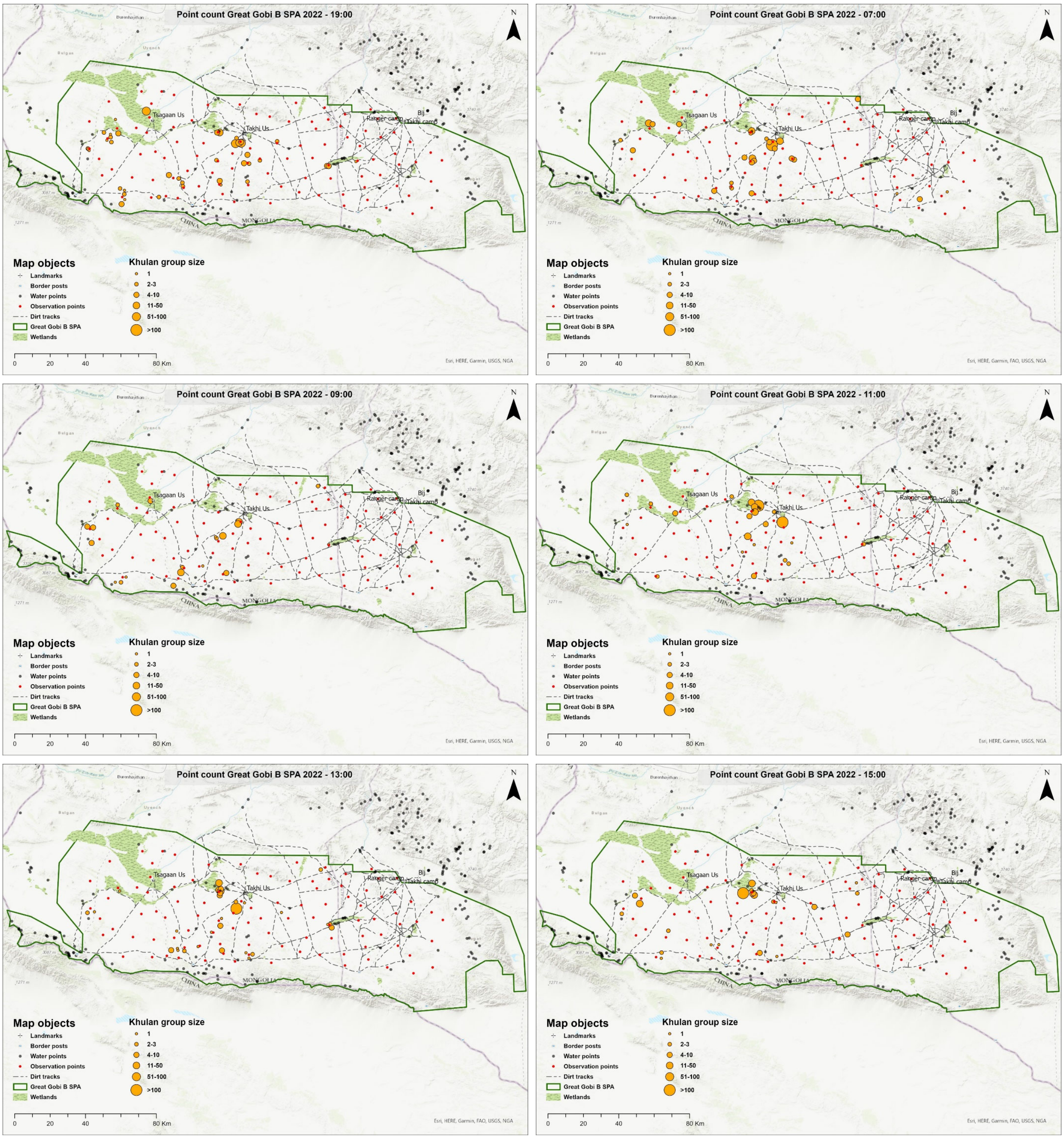


Figure 6: Khulan observations and group size at different counting intervals.

Gazelles were observed throughout the entire study area (east, middle and west), mainly in smaller groups (Figure 7).

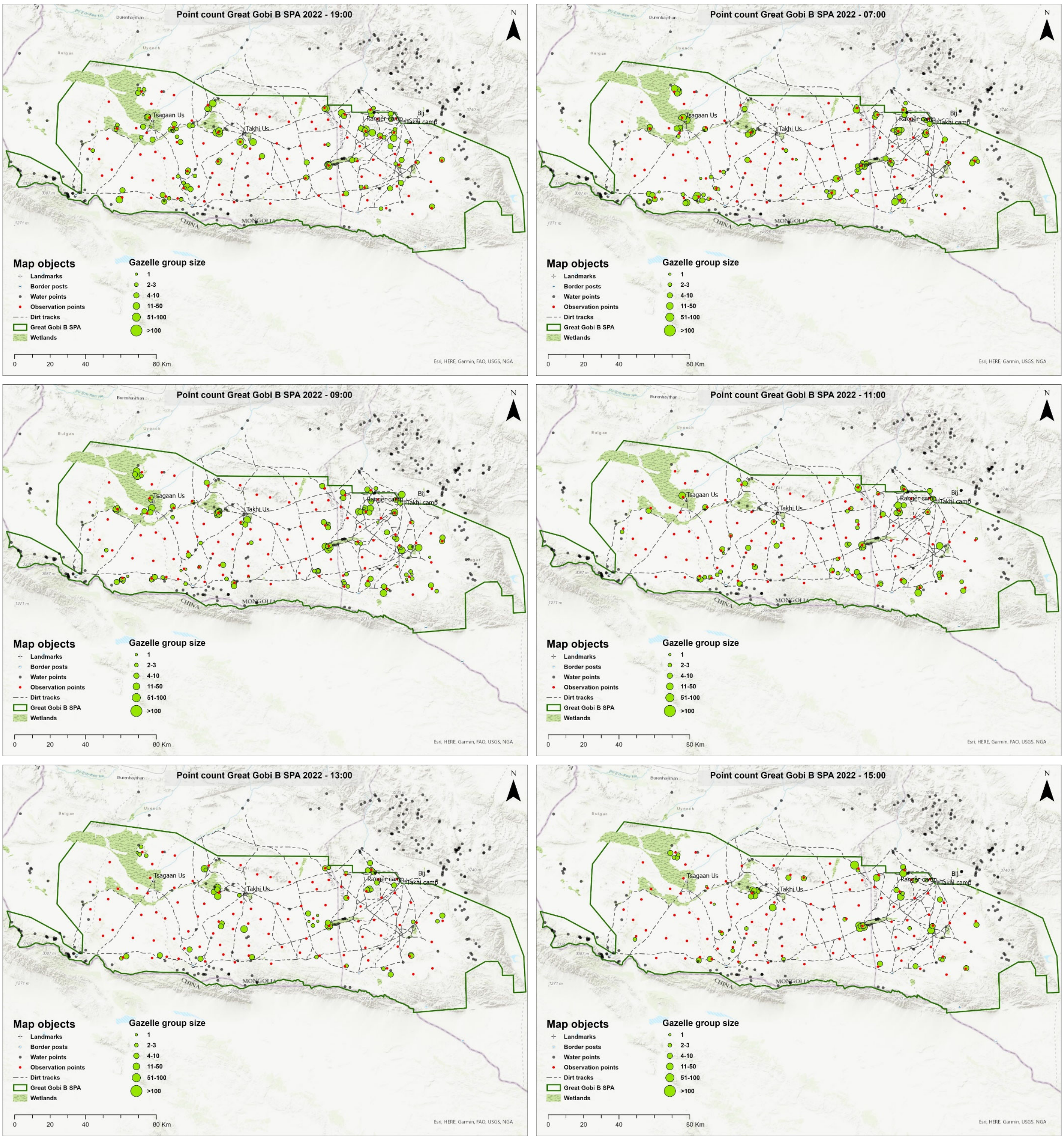


Figure 7: Gazelle observations and group size at different counting intervals

Takhi were observed mainly in the middle and eastern part of the area with observations close to Takhin Tal. No takhi were observed west of Tsagaan Us (Figure 8). 20% (N=185) of animals and 26% of groups (N=16) were observed >4000m from the observation point.

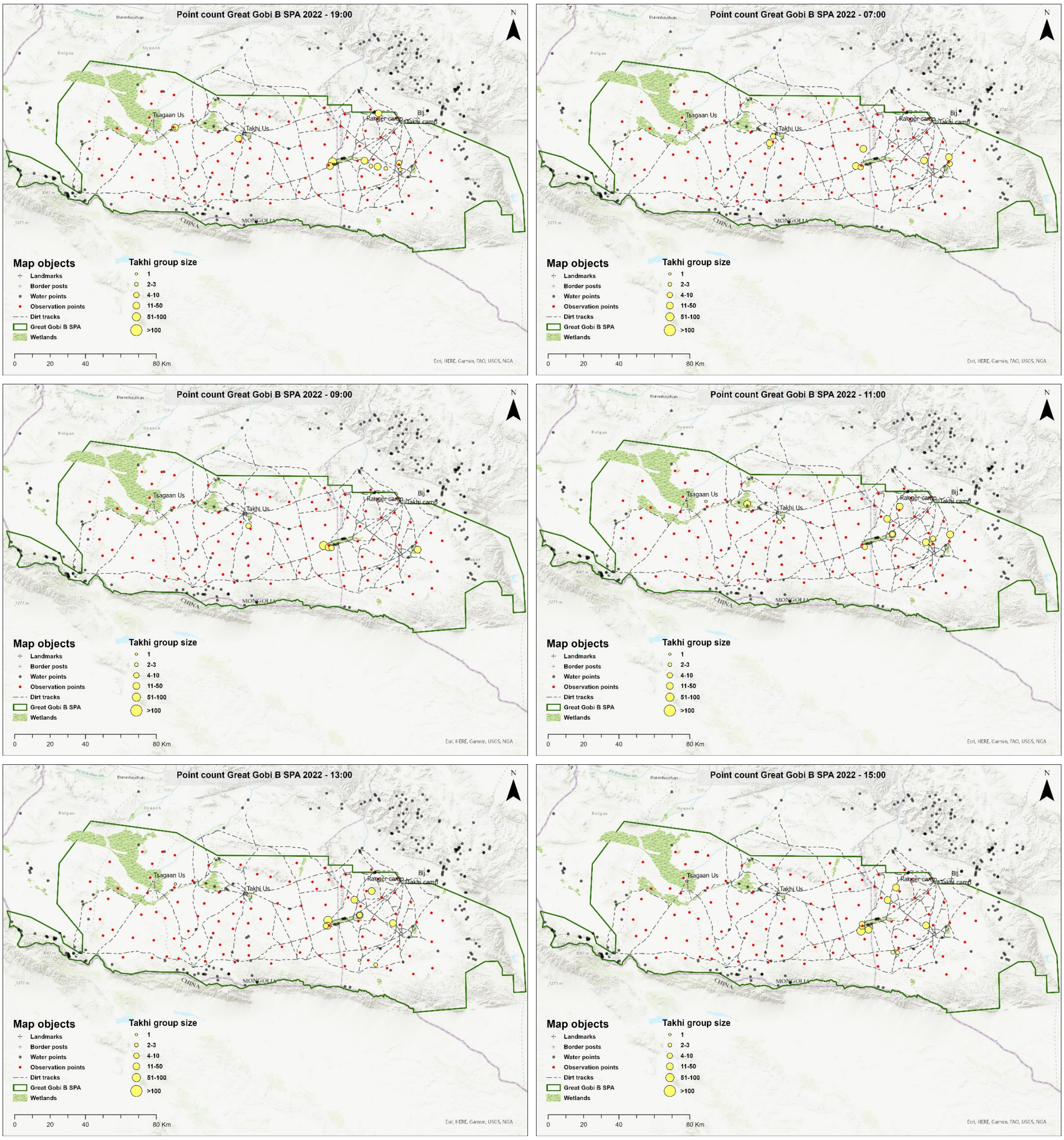


Figure 8: Takhi observations and group size at different counting intervals.

Table 4: Observations of khulan, goitered gazelles, and takhi during the different counting events and distance parameters for khulan and goitered gazelles.

	Survey time (hours)					
	19:00	**07:00**	**09:00**	**11:00**	**13:00**	**15:00**
Effort (N observation points)	101	100	101	100	100	100
Khulan						
All observations						
Total observed	756	688	255	473	413	3159
Number of groups	44	34	28	23	33	24
Mean group size	17.2	20.2	9.4	20.6	12.5	131.6
minimum group size	1	1	1	1	1	1
Maximum group size	280	350	80	160	160	3000
Distance parameters						
Expected group size	15	23.3	7.2	10.0	5.9	4.9
Standard error of mean	15.6	6.7	3.9	5.2	2.3	2.5
Encounter rate	0.44	0.34	0.27	0.23	0.33	0.23
Effective detection radius (m)	1908					
Goitered gazelles						
All observations						
Total observed	583	737	761	370	299	400
Number of groups	102	112	124	74	54	56
Mean group size	5.7	6.6	6.1	5.0	5.5	7.3
minimum group size	1	1	1	1	1	1
Maximum group size	20	70	70	18	27	60
Distance parameters						
Expected group size	5.7	7.2	5.0	4.2	6.7	6.5
Standard error of mean	0.7	2.1	0.7	0.4	1.6	2.1
Encounter rate	1.02	1.11	1.18	0.73	0.54	0.56
Effective detection radius (m)	1386					
Takhi						
All observations						
Total observed	197	104	140	122	201	158
Number of groups	13	10	6	13	10	9
Mean group size	15.2	10.4	23.3	9.4	20.1	17.6
minimum group size	1	1	1	1	1	3
Maximum group size	75	18	100	20	100	80

3.3 Population estimates of khulan

The best fitting model according to AIC values used a half-normal key function with a cosine adjustment term of order 2. Because there were no observations in the category 0m-100m, we used 6 bins of 0m-500m, 1000m-2000m, 2000m-3000m, 3000m-4000m and 4000m-5000m (>4000m) in the model (Figure 9). The population size in the study area was estimated to 5,204 (95% CI = 2,121 – 12,771) khulan with a population density of 0.40 khulan/km^2 (95% CI = 0.16 – 0.98) in the 13,000 km^2 survey area. Including the group of 3000 animals in the model resulted in a population estimate of 10,850 (95%CI = 3,339-35,255).

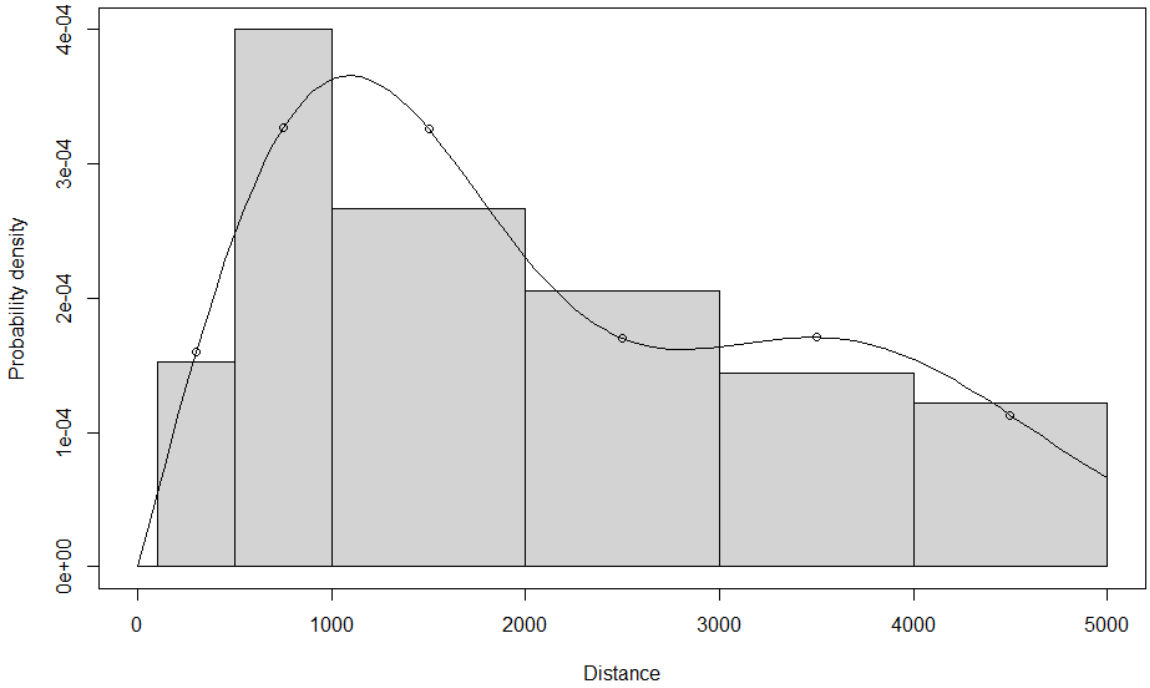


Figure 9: Detection probability function and model fit for khulan.

A half normal key function was used in the time specific models and no adjustment terms were used. Estimated population size varied between 561 – 6052 animals with the highest estimates during the first two sampling intervals in the evening and early in the morning (Table 5). The number of observations per sampling interval varied between 23 – 44 groups (Table 4).

Table 5: Distance estimates for khulan for the different counting events within the survey area (N = number of animals, D = density of animals, DS = density of groups).

	Estimate	%CV	df	95% Confidence Interval	
Stratum 19:00					
DS	0.0311	29.0	140.9	0.0177	0.0545
D	0.4656	116	64.1	0.0740	2.9301
N	6052	116	64.1	962	38091
Stratum 07:00					
DS	0.0144	31.3	127.2	0.0079	0.0264
D	0.1777	65.7	92.9	0.0541	0.5839
N	2310	65.7	92.9	703	7591
Stratum 09:00					
DS	0.0151	33.2	117.2	0.0080	0.0287
D	0.1090	66.0	47.8	0.0325	0.3653
N	1417	66.0	47.8	422	4749
Stratum 11:00					
DS	0.0083	37.1	68.8	0.0040	0.0171
D	0.0833	64.4	119.4	0.0260	0.2673
N	1083	64.4	119.4	338	3475
Stratum 13:00					
DS	0.0197	32.1	126.3	0.0106	0.0367
D	0.1158	50.9	129.2	0.0448	0.2993
N	1505	50.9	129.2	583	3891
Stratum 15:00					
DS	0.0088	36.8	94.2	0.0043	0.0179
D	0.0432	67.4	91.7	0.0129	0.1456
N	561	67.4	91.7	166	1892
Global over all strata					
DS	0.0263	24.38	159.3	0.0164	0.0423
D	0.4003	47.8	112.7	0.1631	0.9824
N	5204	47.8	112.7	2121	12771

3.4 Population estimates of goitered gazelle

The best fitting model according to AIC values used a half-normal key function with cosine adjustment terms of order 2 and 3. We used the 7 original bins of 0m-100m, 500m-1000m, 1000m-2000m, 2000m-3000m, 3000m-4000m and 4000m-5000m (>4000m) in the model (Figure 10). The population size in the study area was estimated to 10,980 (95% CI = 7,473 – 16,132) with a population density of 0.84 gazelle/km^2 (95% CI = 0.57 – 1.24). Gazelles were more or less evenly distributed throughout the 13,000 km^2 survey area which resulted in a lower uncertainty than for the khulan estimates.

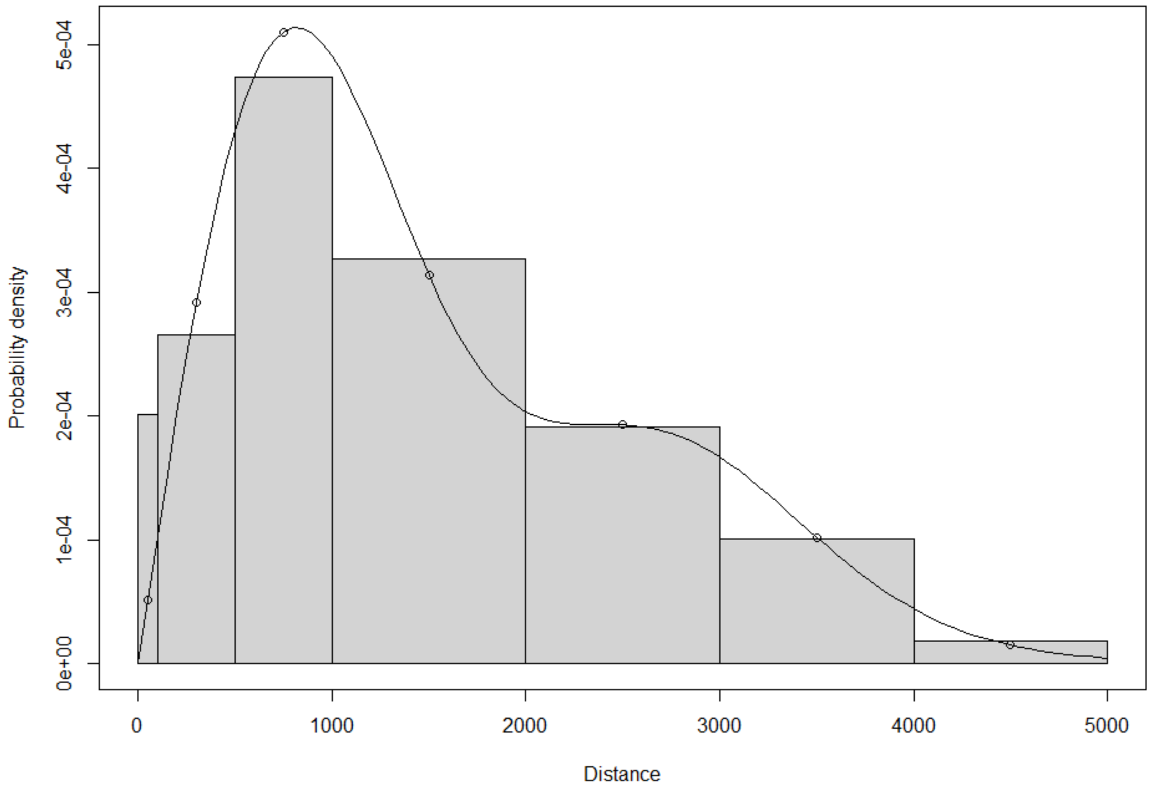


Figure 10: Detection probability function and model fit for goitered gazelle.

A half normal key function was used in the time specific models and no adjustment terms were used. Estimated population size varied between 3165 – 10,472 animals with the highest estimates during the first two morning sampling intervals(Table 4, Table 6). The number of observations per sampling interval varied between 54 – 124 groups (Table 6)

Table 6: Distance estimates for gazelles for the different counting events within the survey area (N = number of animals, D = density of animals, DS = density of groups).

	Estimate	%CV	df	95% Confidence Interval	
Stratum 19:00					
DS	0.0857	16.5	157.9	0.0620	0.1185
D	0.4859	20.5	168.0	0.3254	0.7256
N	6316	20.5	168.0	4230	9432
Stratum 07:00					
DS	0.1116	20.2	149.0	0.0752	0.1657
D	0.8055	36.7	203.9	0.3995	1.6241
N	10472	36.7	203.9	5194	21114
Stratum 09:00					
DS	0.1052	15.9	166.7	0.0770	0.1436
D	0.5260	21.4	185.2	0.3463	0.7988
N	6838	21.4	185.2	4502	10385
Stratum 11:00					
DS	0.0657	19.5	153.4	0.0449	0.0961
D	0.2762	21.2	162.0	0.1827	0.4176
N	3591	21.2	162.0	2375	5429
Stratum 13:00					
DS	0.0365	27.5	150.4	0.0214	0.0622
D	0.2435	40.4	149.6	0.1130	0.5247
N	3165	40.4	149.6	1469	6821
Stratum 15:00					
DS	0.0649	25.1	151.0	0.0398	0.1059
D	0.4214	47.3	116.7	0.1730	1.0265
N	5478	47.3	116.7	2249	13344
Global over all strata					
DS	0.1372	15.4	176.3	0.1014	0.1857
D	0.8446	19.6	139.9	0.5748	1.2410
N	10980	19.6	139.9	7473	16133

3.5 Population estimates of Przewalski's horse

Model fit was poor, with the best fitting model according to AIC values being a hazard-rate key function with a cosine adjustment term of order 2. We used the 7 original bins of 0m-100m, 100m-500m, 1000m-2000m, 2000m-3000m, 3000m-4000m and 4000m-5000m (>4000m) in the model (Figure 11). The population size in the study area was estimated to 1,288 (95% CI = 213 – 7,776) with a population density of 0.10 takhi/km^2 (95% CI = 0.02 – 0.60) in the 13,000 km^2 survey area.

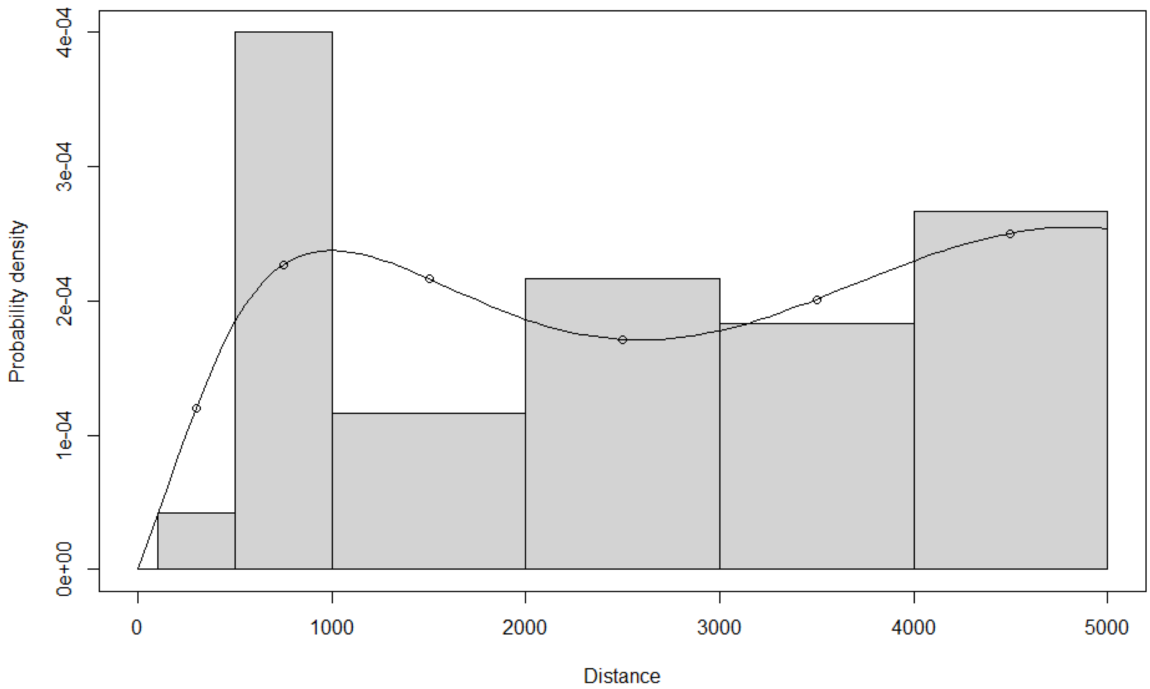
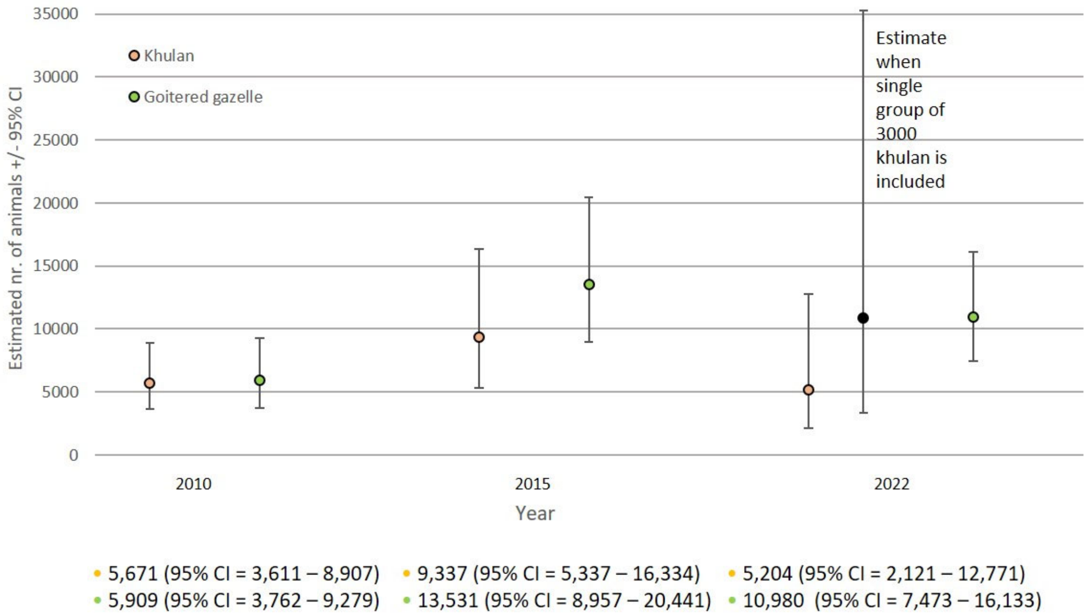


Figure 11: Detection probability function and model fit for takhi.

4. Discussion

4.1 Population estimates comparared to previous estimates

The population estimates for khulan showed an increase of 65% between the counts of 2010 and 2015. The 2022 estimates, on the other hand, are closer to the 2010 results (**Feil! Fant ikke referansekilden.**). However, the confidence intervals for the estimates for the last two counts are much larger and uncertainty of the estimates is higher than for the 2010 estimate.



Figur 12: Population estimates +/- 95% CI of khulan (orange marker) and gazelles (green marker) for all 3 steppe ungulate counts in 2010, 2015 and 2022 and khulan estimate of 2022 including the group of 3000 animals (black marker).

The number of gazelles increased by 129% between the point counts of 2010 and 2015. The 2022 estimates show a slight decrease but remains well within confidence intervals of the previous counts. Even though the precision of the gazelle estimates is better than for the khulan, confidence intervals are still relatively large, which is an unavoidable consequence when dealing with low densities of animals over a large spatial extend.

4.2 Validity of the results

The results presented in this report are preleminary and should be treated as such. The main focus of this study was the total number of animals within Great Gobi B rather then densities. However, the study area increcesed from 2010 - 2022 and this is not taken into account when reporting absolute numbers. Direct comparison between the three steppe ungulate counts is problematic as so far, they have been run within three slightly different analysis frameworks, rather than using all three in the same framework. Doing the latter is planned and may allow for a more direct comparison.

4.3 Challenges for khulan, goitered gazelle and takhi population estimates in 2022

Khulan observations included one group of around 3,000 individuals. Including this group in the distance analysis resulted in a higher population estimate but also huge confidence intervals (**Feil! Fant ikke referansekilden.**) and we chose to exclude that observation from the analysis. Because the large group isn't included in the estimates, one could argue that 3,000 khulan should be added to the overall estimate. This would result in an estimate of 8,204 khulan and brings the 2022 estimates closer to the 2015 estimates. However, there are several considerations which makes including or simply adding this group problematic.

Firstly, estimating the size of large groups is difficult, especially when seen at >4000m and a short field test comparing ground estimates versus counts on drone images suggest that groups may be overestimated.

Secondly, the group was seen only once and near the large Yolkum oasis complex where a lot of khulan groups converged to access water because of the drought. Khulan are highly mobile and have a fission-fusion social system, meaning that there are no stable harem groups, but rather animals join and leave groups and smaller groups fuse and dissolve as well, depending on resource availability. It seems unlikely that such a large group would have gone undetected by all other observers and we rather believe it was the result of several smaller groups joining, potentially seen by other observers.

However, we also cannot exclude for certain, that such a group formed and was only visible from one observation point at one time period. Yolkum oasis is large with few vantage points, none of which allows to oversee the entire area. Hence, the khulan population may be somewhat higher than the 2022 estimate suggests.

The summer of 2022 had been unusually dry, with almost no precipitation during the summer months. Consequently, the pasture was extremely poor especially in the eastern part. Khulan were almost absent there and occurred very clumped in the western part of the survey area. This uneven distribution of khulan is problematic as it results in many observation points having no khulan observations. In combination with the large variation in khulan group sizes, this results in large confidence intervals. This raises the question if distance sampling – which does not take the spatial distribution of animal groups into account - is the best tool to analyse the 2022 point count. We will therefore explore further analysis methods which are making use of the spatial distribution of the animal observations (Torney et al., 2022).

Gazelles were more evenly distributed throughout the study area and variation in group size was smaller than for khulan. Together with a higher number of observations, this results in much smaller confidence intervals around the population estimate. While the confidence intervals might still seem large, they are within the uncertainty one has to expect for large scale surveys in low-density systems (Buuveibaatar et al., 2017).

The highest numbers of gazelle observations were recorded during the first counting event in the evening, at 19:00, as well as the two first counting events of the day, at 07:00 and 09:00 (Table 4). We assume this to be an effect of 1) lower activity of gazelles during mid-day because they lay down while ruminating, often using vegetation for shade. The silhouette of an animal that is laying down is much smaller than an animal standing and grazing (moving) and therefore harder to spot.

This is the first time we included takhi in the distance analysis because the number of takhi harems was too small in previous years. While takhi numbers were small it was relatively easy to individually recognize individuals. However, with the now rapidly increasing takhi population which is becoming very shy direct observations at close range and individual identification becomes increasingly challenging and future monitoring will have to change from counting individuals in clearly identifiable harems to obtaining population estimates. We therefore included takhi to test the distance sampling approach.

However, the population estimates have the following constrains: 1) with currently only 31 groups (harems) and a total number of 423 takhi, the population is still small and hence probability of seeing takhi is relative low, 2) takhi like khulan were also very clumped and primarily restricted to the eastern part and the area around Takhi us, 3) rangers know where takhi groups roam from weekly monitoring and were specifically looking for them which resulted in poor model fit of the detection probability function (almost equal probability of detection, regardless of distance). Since we defined the distance category of >4000m as 4000m–5000m for the analysis but included observations beyond 5000m the density is inflated. This results into a gross 3-fold overestimation of the takhi population (low accuracy) while the clumping results in large confidence intervals (low precision). Nevertheless, the overall approach is promising, and should work for takhi once the population is larger and less intensively monitored.

4.4 Efford and logistics

We were able to carry out the survey without any major problems. Smaller issues like several punctured tires and a car that ran out of gas were adressed in the field without any effect on the survey schedule. The final set of 101 observation points all seemed suitable and should be re-used in future surveys. The extended coverage of the study area by mobile network providers facilitated communication.

4.4.1 Satellite maps for improving distance estimates

Estimating distances is not easy and likely subject to individual variation, despite prior training. In the 2010 count we used customized simple rangefinders with khulan silhouettes to help distance estimates of observers, several of which were recruited from students (Ransom, 2011). In 2015, we used almost exclusively rangers, which are generally more experienced in estimating distances. In 2022, we provided observers with satellite images showing the landscape in relation to the different distance bins, to facilitate distances estimates and reduce inter-observer variation. Observers did say that the maps were a useful tool for estimating the distance bins, particularly if there were distinct landmarks present (e.g., hills, dry riverbeds).

4.4.2 Other changes

During the 2015 survey observers were somewhat scarcely equipped to handle harsh weather conditions while in the field and provisions, especially water, were not sufficient. Which is why each observer was provided with a tent and sleeping bag, larger food rations and a 5l water bottle for every observation session. Further, the survey was carried out one month earlier to avoid challenging weather conditions.

Carrying out the survey during 2 observation sessions, like in 2015, would have required 51 observers. Instead, we used 34 observers during 3 observation sessions. While this prolonged the survey time, it required fewer vehicles, equipment and observers, which was easier to organise in this remote setting.

We chose to collect the data sheets after every observation session, check them for errors and missing information and started to digitise the data in the field using laptops and a portable generator. This was done so we could discuss problems directly with the observers while they were still present, which allowed for corrections and resulted in minimal data gaps.

Figure 12: Survey team including observers and support team in front of Takhin Tal field station.

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Høgskolen i Innlandet

The plains of Great Gobi B Strictly Protected Area (subsequently "Great Gobi B") in south-western Mongolia are home to three endangered wild ungulates, khulan (*Equus hemionus)*, takhi (*Equus ferus przewalskii*), and goitered gazelle (*Gazella subgutturosa*). With Mongolia holding the largest populations of these species, their conservation is of global importance. To assess the effectiveness of conservation efforts, robust survey methods are needed to monitor population development.

In late summer 2022 we conducted the 3rd plains ungulate count in Great Gobi B to estimate population size of khulan and goitered gazelle and describe population development since the counts in 2010 and 2015 and tested the method for estimating the growing population of reintroduced Przewalski's horses.

We conducted Distance Sampling point counts at 101 observation points over 6 counting events (at 19:00, 7:00, 9:00, 11:00, 13:00, and 15:00) at each observation point. During each counting event the observers scanned the surroundings using binoculars and registered species, number of animals, time, bearing and distance for each observation. Over the 606 counts, we observed 5,744 khulan, 3,150 gazelles and 922 Przewalski's horses. Using these observations, we created global models (over all observation points and counting events) using the distance analysis framework and selected models with the best fit based on AIC values.

Populations estimates for 2022 were 5,204 (95% CI = 2,121 – 12,771) khulan, 10,980 (95% CI = 7,473 – 16,132) goitered gazelles, and 1,288 (95% CI = 213 – 7,776) Przewalski's horses within the 13,000 km2 survey area. Population estimates of both khulan and goitered gazelle suggested an increase from 2010 to 2015, while the 2022 estimated is closer to the 2010 estimates for khulan and in between for goitered gazelles. However, confidence intervals, especially for khulan, are large and population development cannot be determined conclusively. The uncertainty in the khulan estimate for 2022 was caused by the combination of a highly clumped distribution due to draught conditions and a large variation in group sizes. Goitered gazelles were more evenly distributed and group sizes less variable.