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Ecological constraints on and consequences of land use heterogeneity: A case study of the Mongolian Gobi

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ABSTRACT

Mongolian herders are transhumant and therefore follow a specific land use pattern. To understand their movements through a case study, we mapped and superimposed their seasonal camps on a vegetation map and a digital elevation model. We also questioned them about the reasons justifying the locations of their camps, and how they use the surrounding land. It appears that vegetation quality may play a role only in summer, whereas topography is a key driver during 3 seasons. In winter, herders seek shelter against cold winds in rugged places exposed to the south, while in spring and summer, they seek flat places. In spring, to have a clear view of their newborns and in summer, to allow wind to reduce the insect discomfort. Moreover, most of the livestock species stay within a certain distance of the camps depending on the season, but which never exceeds 5.1 km. This leads to a land use pattern where livestock is restrained to specific areas according to the season. Interestingly, during the growing season, when plants are most sensitive to defoliation, most livestock is concentrated on 30.92% of the site surface. Such information is important for range scientists working on grazing impacts at large scales.

1. Introduction

In less than 20 years, livestock numbers in Mongolia almost doubled. There were 26 million sheep, goats, horses, cattle, camels and yaks in 1990 and 44 million in 2009 (National Statistical Office of Mongolia – NSO, 2012). Since 2009, the numbers have decreased slightly, in part as a result of the die-off caused by the harsh 2009/2010 winter, and there are now 36.3 million head (NSO, 2012). This total is still much higher than in the 1990s.

This increase is due to the changes that occurred in 1990 when the country's centralized economy turned into a market economy (Johnson et al., 2006). Many state-provided jobs disappeared, leaving a significant part of the population unemployed, with only limited work opportunities in cities. Thousands of people then had no choice but to return to the countryside in search of a livelihood and to breed animals as their ancestors had done (Reading et al., 2006). This increased the number of herders from 147,500 in 1990 to 327,200 in 2010, with a peak of 421,400 in 2000 (NSO, 2012).

Several sources have expressed concern about the consequences of this increase on the condition of pastures (Johnson et al., 2006; Whitten et al., 2003). UNEP (2002) indicated that 70% of the country's pastures are now degraded, and Reading et al. (2006) described cases of overgrazing around water holes and settlements. Reading, however, indicates that the rest of the country's pastures have retained their natural potential. Unfortunately, these two assessments do not provide ground data to support their diagnoses.

Other sources have described cases of degradation based on field observations at national (Erdenetuya, 2004), regional (Javzandulam et al., 2005) and local (Sankey et al., 2009) scales in terms of a decrease in standing plant biomass. However, a decrease in this parameter is not always irremediable, as has been shown in the center of the country (Sternberg et al., 2011). A diagnosis based on decreased standing biomass should therefore be interpreted cautiously.

A proper evaluation based on health assessment remains in consequence to be carried out to fully understand the impact of the

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recent years' livestock increase. Such methods based on biophysical indicators exist, e.g., the one proposed by the USDA based on 17 indicators (Pellant et al., 2005).

Such assessments should be applied according to a sound spatial sampling strategy, because a country as vast as Mongolia (150 million ha) cannot be regarded as a homogeneous piece of land. This is notably true when studying grazing effects, which are inevitably heterogeneously distributed for three reasons.

The first and most obvious reason is population density. There are more people close to settlements and cities, and herders who want to sell their products and benefit from health and educational services prefer to be close to towns. Degradation is therefore more acute in the proximity of urban centers and roads (Reading et al., 2006; Suttie et al., 2005).

The second reason is that different climatic zones exist in Mongolia. The south of the country is much more arid that the north, which can make the responses of vegetation to grazing more heterogeneous, in accordance with the equilibrium and non-equilibrium theories. The first theory proposes a model that is valid for mesic habitats, where primary production is stable and the condition of vegetation is the result of forage consumption by herbivores (Vetter, 2005). In contrast, the non-equilibrium model applies to environments with low precipitation. It posits that the rainfall variation inherent to arid habitats makes fluctuations in primary production so large that livestock populations cannot track them (Vetter, 2005). The multi-year droughts that occur in such places can moreover cause massive die-offs that prevent livestock numbers from reaching a level that could cause irremediable damage to vegetation (Scoones, 1995). The condition of vegetation and the populations of herbivores are therefore disconnected. In fact, the two models are not exclusive and represent the opposite ends of a continuum, along which real systems exist (Illius and O'Connor, 1999; Vetter, 2005). Concerning Mongolia, it has been shown that the north exhibits more characteristics of the equilibrium model than does the south (Fernandez-Gimenez and Allen-Diaz, 1999; Okayasu et al., 2011). Degradation is therefore more likely to occur in the north.

Finally, we can expect a third level of heterogeneity within grazing systems because land is not used evenly. Herders are transhumant and use different camps according to the seasons (Suttie et al., 2005). They can be located in different altitudinal belts (Zemmrich et al., 2010), or have to fulfill different criteria. For example, they must be protected from the chilling northern winds in winter, whereas they must offer a minimum of exposition in summer to reduce the discomfort brought about by flying insects (Humphrey and Sneath, 1999). The seasonal settlements can therefore be located in areas remote from each other, making the pasture use pattern unevenly distributed over the course of a year. Hence, within a single management unit, we can expect grazing pressure to be heterogeneously distributed across time and space.

In summary, in Mongolia, the effects of grazing are not the same everywhere because of the presence of infrastructures, north/south climate differences and the mobility of the local pastoralists. The risk of overgrazing is in consequence heterogeneously distributed across the country, making a sound spatial sampling strategy essential for an assessment of pasture health. It is necessary to distinguish areas at high and low risks of degradation to determine, after field measurements, the proportion of degraded land.

This paper proposes to contribute to a better understanding of the heterogeneity of grazing effects at the site scale. With this aim, we studied the movements of a community of transhumant herders and tried to understand the reasoning underlying their movements. We mapped their camps and conducted interviews to describe their pasture use. On the basis of this information, we describe how grazing pressure is spread over the site throughout the year and discuss its impact. We also discuss its implications for defining a spatial sampling strategy of pasture condition.

2. Material and methods

2.1. Study area

The herder community inhabits a 2900 km^2 site called Khomyn Tal consisting of one *bag*, the smallest administrative and livestock management unit of Mongolia. It is located in the west of the country in Onts *bag*, Durvuljin district, Zavkhan province in the semi-desert steppe vegetation zone of Mongolia, according to Hilbig's classification (1995) (center coordinates N 47°56′54.82″, E 93°38′29.36″).

Khomyn Tal is a buffer zone for the Khar Us Nuur National Park (Fig. 1). Lakes, including Durgun and Khar Lakes in the west, the Zavkhan River in the east, and large sand dunes toward the south form natural borders to the site. The area is a vast plain consisting of wind and lake deposits whose altitude gradually increases from

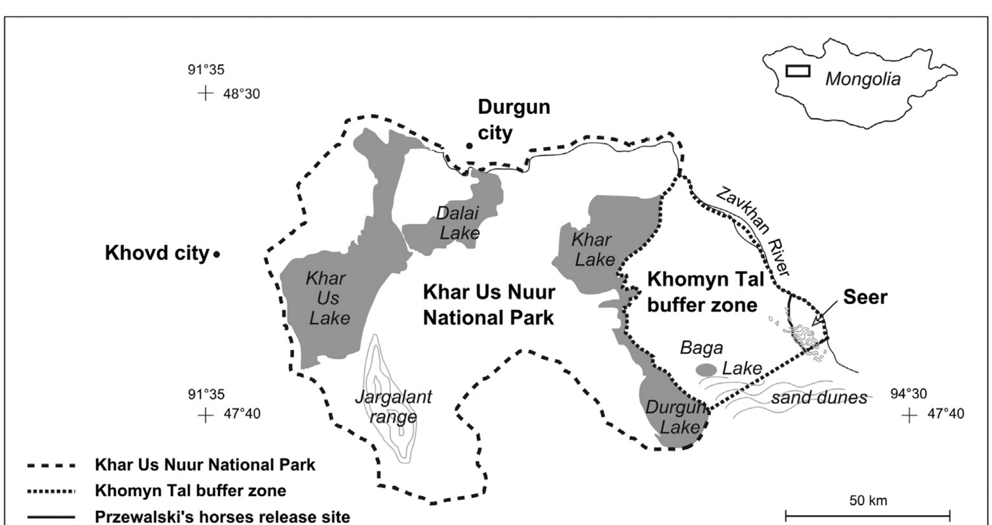

Fig. 1. Khomyn Tal and its surrounding areas.

1200 m a.s.l. in the north to 1300 m a.s.l. in the south (Tsegmid and Vorobev, 1990). A small rocky range that culminates at 1666 m a.s.l. called *Seer* is present in the southeast.

According to the 1970–2000 data of the Durvuljin weather station, located 80 km from Khomyn Tal, the mean precipitation is 95 mm with a coefficient of variation of 0.44. It is therefore above the 0.33 threshold that defines a system behaving mostly according to the non-equilibrium model (Ellis, 1994; Illius and O'Connor, 1999; von Wehrden et al., 2012). However, some surveys showed that livestock and vegetation are not completely uncoupled in this site, notably because of the presence of mesic habitats (Joly et al., 2012).

Moreover, the winter is harsh in Khomyn Tal, with daily average temperatures lying below −30 °C for 30–40 days of the year (Tsegmid and Vorobev, 1990).

Approximately 45 families move their traditional Mongolian felt tents (*ger*) from one seasonal camp to another. Except in the case of drought, they return cyclically to the same places, where small structures such as corrals, wells or wooden sheds are present. They breed sheep, goats, horses, cattle and camels.

Khomyn Tal is one of three Mongolian reintroduction sites for the only genuine wild horse, the Przewalski's horse, classified as 'endangered' (IUCN, 2012). Twenty-two individuals were introduced in 2004 and 2005 in a fenced release site, and they had increased to 37 by 2013 (ww.takh.org).

2.2. Mapping of camps and interviews of herders

In 2005, each camp in the study area was visited with a local driver who personally knew each herder. The positions of the camps were recorded with a handheld GPS, and during the visit, herders were asked the locations of their water sources and types (well, river or lake).

To understand the reasoning underlying the camp locations, in 2004 and 2007, 35 herders were asked about the three main criteria justifying their positions. As a measure of the land use around their settlement, we also asked the herders in 2006 about the maximum distance that their livestock can move away from their *ger*, according to livestock species, as well as their usual migration dates.

2.3. Interpretation of the camp mapping and interview results

To investigate the role of forage heterogeneity in nomadic movements, the vegetation type of each seasonal camp was determined on the basis of the 3 main forage types of Khomyn Tal (Joly et al. 2012) (Fig. 2b). In the first type, the surface is dominated by the perennial grass *Psammochloa villosa* mixed with the bush *Artemisia klementzae*. This type covers 50% of the site. The second type, *Stipa*, covers 39% of the site. It is dominated by the grass *Stipa glareosa* mixed with the bushes *Artemisia xerophytica* and *A. klementzae*. The third vegetation type is more mesic because it is located closer to water bodies. It covers 11% of Khomyn Tal, and its main forage plants are the perennial grasses *Calamagrostis epigeios*, *Elymus paboanus* and *Achnaterum splendens* and the sedge *Carex duriuscula*. The distributions of seasonal camps within the vegetation types were compared with the overall Khomyn Tal pattern to see if some vegetation types are preferred in certain seasons. The observed differences were tested using a χ^2 test.

To understand the role played by relief, we compared the locations of the camps with topography parameters. The altitude of each seasonal camp was extracted from the world digital elevation model (DEM) provided by NASA (http://srtm.usgs.gov) using GIS software (ArcGIS 9.1). Slope and aspect (north and south) were calculated for each camp from this DEM using the Spatial Analyst extension of ArcGIS. The differences among average seasonal altitudes and slopes were tested by one-way ANOVA. The observed north/south division of aspect according to season was compared with the average Khomyn Tal aspect division, and the observed differences were tested using a χ^2 test.

The results of the interviews were presented at a workshop with the herders in August 2008, to allow a further interpretation of their answers.

2.4. Land use

To describe land use, we created seasonal buffers around the camps whose locations were collected using GPS. The radiuses used were the seasonal maximum distances livestock can travel from the camp, which were obtained from the interviews. The buffered areas around the camps were merged to produce the zone used by the herder community for each season. Last, we superimposed the 4 seasonal zones to generate the area used over the course of a year.

3. Results

3.1. Camps and water source locations

Most of the herders have four seasonal camps. They are termed *khavarjaa*, *zuslan*, *namarjaa* and *övöljöö*. They correspond to spring, summer, autumn and winter settlements (in Mongolian, *khavar* = spring, *zun* = summer, *namar* = autumn and *övöl* = winter).

Thirty-five camps are in use in winter and spring, 33 in summer and 28 in autumn. The numbers vary according to season because several families often join together to use the same camp. Several *gers* can therefore be present at the same camp.

There is a general movement of the camps from northwest to southeast from spring to winter (Fig. 2). In spring, most camps are located in the west of Khomyn Tal close to the Khar and Durgun Lakes, and in winter, the camps are close to the *Seer* range.

The average dates of migration are May 6 from spring to summer camps, October 7 from summer to autumn, December 3 from autumn to winter and March 7 from winter to spring. Herders therefore stay 2 months in the spring area, 5 months in the summer area, 2 months in the autumn area and 3 months in the winter one. Most of the local growing season is therefore spent in the summer camps. Herders also reported sometimes making short stops at intermediate locations between 2 camps to benefit from grassy places along the way.

In spring, summer and autumn, most of the camps have their own well: 34 out of 35 in spring (97%), 30 out of 33 in summer (91%) and 16 out of 28 in autumn (57%). In the camps without a well, herders use either lake or river water. Only two of the winter camps have wells, but usually in this season, livestock eat snow to get water.

Most of the wells are located in the west of Khomyn Tal at a mean altitude of 1155 m, whereas the average altitude of the study area is 1188 m (Fig. 3). Most of them are hand-dug.

3.2. Criteria justifying camps' locations according to the interviews

During the interviews, respondents gave between 0 and 3 criteria to explain the positions of their camps. Vegetation and water are the first criteria to be cited in spring, summer and autumn, and they rank 3rd and 4th in winter (Table 1). Relief is cited more than 10% of the time in spring, summer and winter and is the first criteria for winter. The other criteria cited more than 10% of the time are shelter in winter and spring and temperature in autumn.

During the 2008 workshop, some explanations were provided by the herders regarding these criteria. Regarding vegetation, they

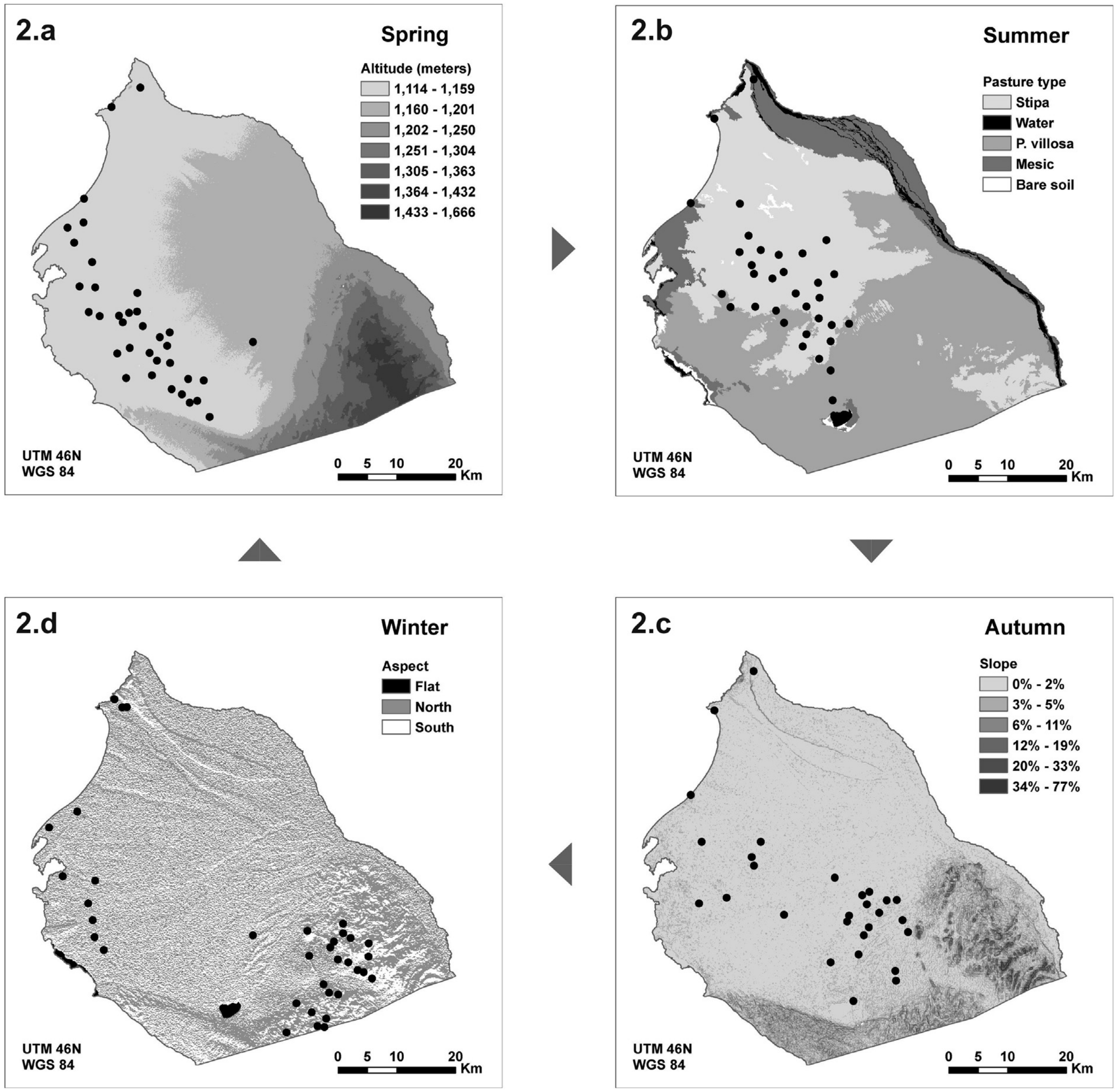

Fig. 2. Locations of seasonal camps on background maps used to study the ecological constraints in Khomyn Tal.

said the amount of grass is used as the criterion rather than its quality. Differences among plant species are not important enough to justify aiming to use a specific forage type. Regarding relief, it is important in three seasons but for different reasons. In winter, relief is needed to stop cold winds but in summer it is used to diminish the nuisance of biting insects. Flat places are therefore preferred in summer. Flatness is also preferred in spring because it is the lambing season, and the camps' surroundings must be visible to allow intervention in case of predator attack (wolves) on newborns. The shelters mentioned in spring refer to equipment handmade during the collectivist epoch to protect livestock from the wind, and in winter, they refer to the *Seer* hills that also stop winds.

3.3. *Relief and vegetation of seasonal camps*

The *Psammochloa villosa* vegetation type is the most dominant in terms of surface cover, the *Stipa* type is second and the mesic type is the smallest. This same ranking is found for the distributions of the seasonal camps in spring, autumn and winter, and the minor differences between the distributions of camps among vegetation types and the distributions of the types across Khomyn Tal are not significant. The summer camps are primarily located in the *Stipa* type and the difference is statistically significant (Table 2).

Average seasonal altitude gradually increases from 1143 m in spring to 1255 m in winter. The differences observed among the seasons are significant (Table 2).

Slope also gradually increases from 1.2% in spring to 5.05% in winter. This pattern of increase is also significant (Table 2).

The mean aspect of Khomyn Tal is slightly biased toward the north; 52.04% of the area is oriented north and 47.96% south. The spring and summer aspects are close to this ratio — slightly more camps are oriented toward the north, and the differences from the overall north/south bias of Khomyn Tal are not significant. In autumn and winter, approximately twice as many camps are oriented toward the south, and the difference is statistically significant in winter (Table 2).

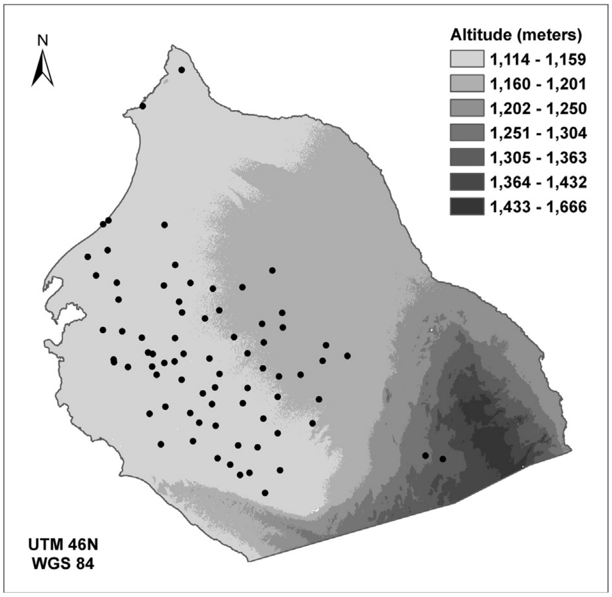

Fig. 3. Wells on altitude map.

3.4. Land use

Livestock movements around the *ger* are different according to the species. Sheep, goats and cattle are closely watched. They graze in the land surrounding the camps during the day and are brought back every night to the *ger*. In contrast, most of the camels and domestic horses are free-roaming with only a couple of individuals kept at the camp. Camels are usually used as draft animals and horses as a means of transportation and for herding livestock. For horses, there is a turnover. They are kept at the camp for a certain time but are regularly replaced by free-roaming individuals.

In the interviews, when herders responded about the maximum distances that sheep, goats and cattle can move away from the *ger*, they did not distinguish among the 3 species. The shortest distance between a grazing site and *ger* is, on average, in the spring (2.2 km), when newborns are present and have to be watched to prevent predator attack. The second shortest average grazing distance is in winter, also a risky season in terms of predators (3.3 km). Summer and autumn are less risky, so herders let their animals go further, 5.1 and 4.8 km respectively, on an average.

The maps generated from the locations of camps and the reported maximum distances that sheep, goats and cattle can go (Fig. 4) enabled us to calculate the percentage of land unused by the 3 species. In spring they leave 87.00% of the study site available (253,396 ha), in summer 69.08% (201,193 ha), in autumn 67.15% (195,576 ha) and in winter 80.58% (234,688 ha). When the four seasonal utilization maps are superimposed, 43.15% (125,664 ha) of Khomyn Tal remains free of sheep, goats and cattle throughout the year (Fig. 5).

4. Discussion

4.1. Land use pattern

We obtained information about camp movements from both interviews and GIS data. Putting both data sets in perspective makes it possible to understand the environmental constraints and their impact on land use.

For herders, access to grass is essential. The interviews confirmed this by ranking vegetation as first for the criteria justifying camp locations in spring, summer and autumn and it is also ranked third in winter. According to the workshop discussions regarding vegetation, quantity matters more than quality. The superimposition of camp locations with the vegetation map confirms this lack of qualitative consideration in spring, autumn and winter. For summer, there is, however, a clear bias toward the *Stipa* type, which can be explained by two hypotheses. The first possibility is that the *Stipa* vegetation type is the best for livestock to gain weight during the fattening season. This hypothesis is supported by the nutritious value of *Stipa glareosa*, which appears to be the highest of the 3 pasture types' main grasses. During the growing season, it has a protein content of 13.86%, whereas *Psammochloa villosa* protein content is only 9.99% (data unpublished) and that of *Calamagrostis epigeios*, the main forage grass of the mesic vegetation type, is 5.4–8.5% (Jigjidsuren and Johnson, 2003). Although these percentages are not sufficient to identify the *Stipa glareosa* type as the most nutritious, notably because digestibility and standing biomass should also be studied, they make this first hypothesis worthy of further investigation. If it can be verified that the *Stipa* type is the most nutritious, it could imply that the statement of the herders that quantity matters more than quality is a general one that masks seasonal nuances.

The alternative hypothesis is that the bias toward the *Stipa* vegetation type is incidental. The summer camps could be concentrated in areas of this type simply because they are between the spring and winter areas, on the main transhumance axis. This would mean that the forage characteristics of summer camps do not play any role, which would appear to be counterintuitive for a place used by pastoralists. For this reason, our preference is for the first hypothesis.

Access to water is also of critical importance for herders. This is consistent with the interviews, which ranked water as the 2nd priority in spring, summer and autumn. Most of the camps in these seasons have wells, and in winter, livestock obtain water by eating snow. This favorable distribution of wells can be explained by the

Table 1
Main criteria for choosing seasonal camps declared during herder interviews.

Spring	N[a]	%	Summer	N[a]	%	Autumn	N[a]	%	Winter	N[a]	%
Vegetation	21	28.0	Vegetation	25	41.0	Vegetation	25	48.1	Relief	22	30.6
Water	20	26.7	Water	21	34.4	Water	13	25.0	Shelter	15	20.8
Shelter	16	21.3	Relief	8	13.1	Temperature	6	11.5	Vegetation	14	19.4
Relief	10	13.3	Salt	5	8.2	Salt	4	7.7	Water	13	18.1
Salt	3	4.0	Minerals	1	1.6	Minerals	2	3.8	Snow	2	2.8
No sand	2	2.7	Shelter	1	1.6	Argol[b]	1	1.9	Salt	2	2.8
Forage	1	1.3				Relief	1	1.9	No sand	2	2.8
Minerals	1	1.3							Forage	1	1.4
Hay	1	1.3							Temperature	1	1.4

[a] Overall number of times the criteria were cited in replies by herders.
[b] Animal dung used as combustible.

Table 2
Vegetation and relief parameters of the seasonal camps of Khomyn Tal.

Vegetation parameters	Overall Khomyn Tal	Spring (35 camps)	Summer (33 camps)	Autumn (28 camps)	Winter (35 camps)
	Surface (%)	Nb of camps	Nb of camps	Nb of camps	Nb of camps
Stipa glareosa sand steppe	39%	8	27	6	8
Psammochloa villosa sand steppe	50%	22	4	19	21
Mesic types	11%	5	2	3	6
χ^2 test of difference between overall site and season		$\chi^2 = 3.858555$ $p < 0.145255$	$\chi^2 = 25.62752$ $p < 0.000003$	$\chi^2 = 4.063897$ $p < 0.131082$	$\chi^2 = 4.212443$ $p < 0.121699$
Relief parameters	**Khomyn Tal**	**Spring**	**Summer**	**Autumn**	**Winter**
Mean altitude (meter)** (Fisher's $F = 35.042664$)	1188	1143	1155	1161	1255
Mean slope (%)** (Fisher's $F = 27.905105$)	2.34	1.20	1.27	1.55	5.05
Distribution of aspect[a]	**Khomyn Tal**	**Spring**	**Summer**	**Autumn**	**Winter**
N	52.04%	19	17	10	11
S	47.96%	15	15	18	22
χ^2 test of difference between overall site and season		$\chi^2 = 0.2015836$ $p < 0.653446$	$\chi^2 = 0.0152171$ $p < 0.901824$	$\chi^2 = 2.988457$ $p < 0.083861$	$\chi^2 = 4.624676$ $p < 0.031516$

**: p-value < 0.01.
[a] Some camps on flat places (slope = 0) were removed from the calculation.

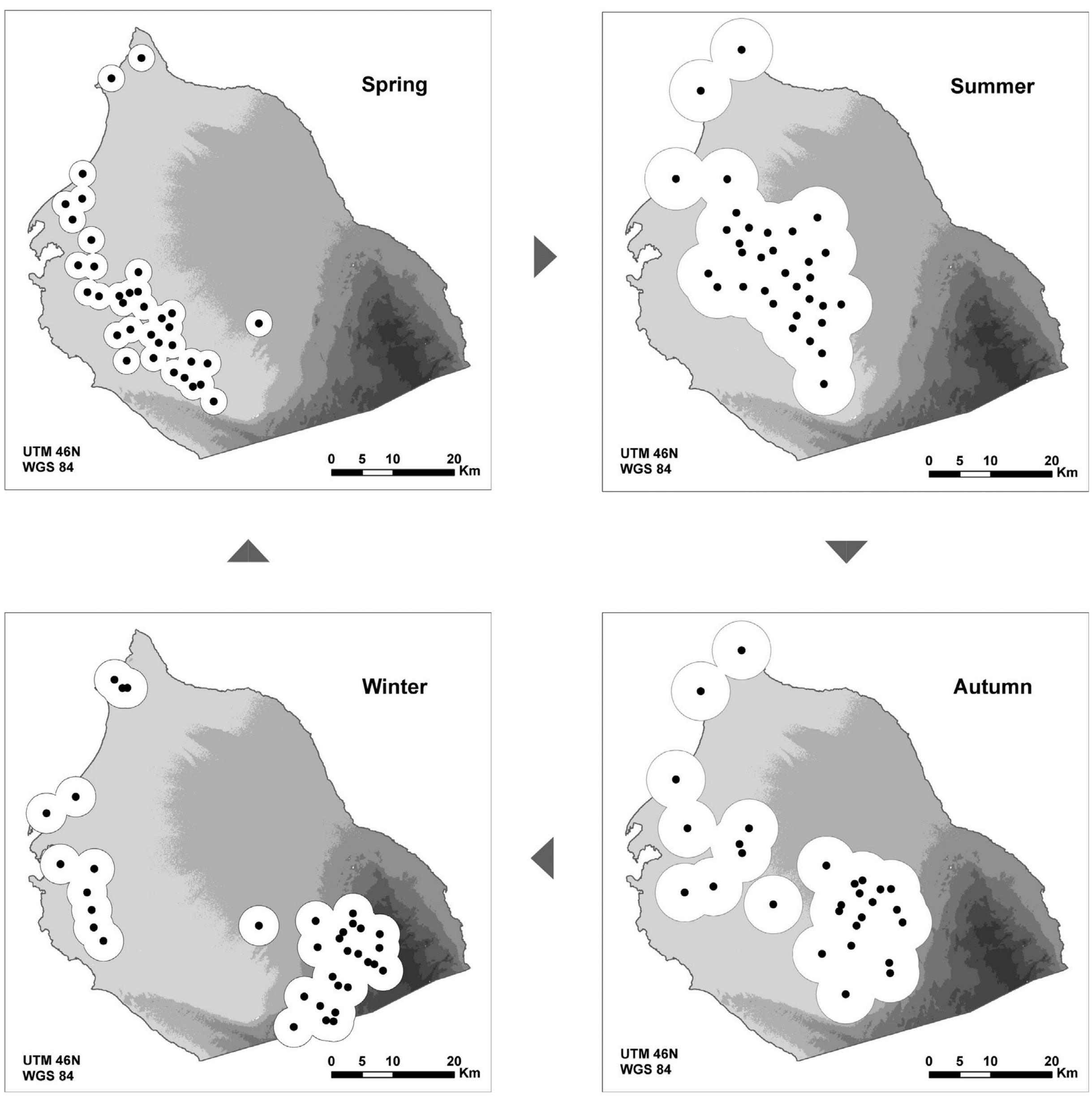

Fig. 4. Locations of camps (black dots) and the surrounding land used by sheep, goats and cattle.

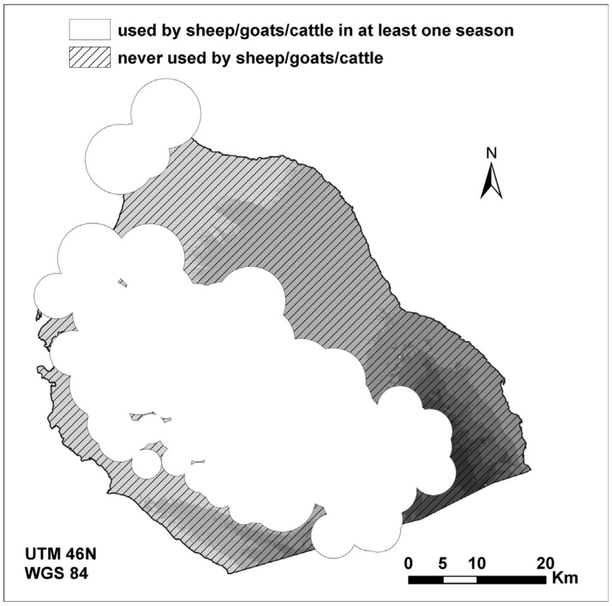

Fig. 5. Superimposition of seasonal areas indicating the areas used in the course of a year by sheep, goats and cattle (horses and camels are free-roaming).

substrate of Khomyn Tal, made up of wind and lake deposits that can be easily dug. The site is, in addition, located between a river and lakes, so the water table is probably near the surface in the lower part of the site. This is confirmed by the superimposition of the camps with the DEM, which indicates that apart from winter, all camps are located below the average site altitude.

Suttie et al. (2005) indicate that topography plays a significant role in the movements of Mongolian pastoralists. This is also consistent with our findings. During the workshop, herders explained that in spring and summer flatness is preferred, whereas in winter, rugged areas are preferred to block the wind. This is confirmed by the superimposition of campsites with the DEM, which indicates that the slope is significantly higher in the winter camps than in the other seasonal areas, and that exposition to the south is privileged.[3] Hence, our superimposition clarifies what herders meant by ranking relief first in winter: it needs to block winds but also to expose camps to the sun during the harshest season of the year.

In summary, the spatial coverage of the different vegetation types may only play a role in summer and access to water is a minor concern because in winter livestock can eat snow and most of other seasonal camps are equipped with a well. This high rate of equipment in spring, summer and autumn seems to be due the altitude distribution, which attributes a potential indirect role to topography in access to water at that time. In contrast, topography has a clear and direct role in the prevention of predator attacks, in the prevention of insect nuisance through flatness, and in mitigating winter's harshness. For all of these reasons, we consider topography to be the most important driver of the transhumance pattern in this area.

This finding is interesting because topography is stable in time and, in consequence, we can hypothesise that the transhumance pattern will remain stable through time (at least as long as the broad socio-economic context remains similar to the actual one). It is therefore worth discussing its effects on the local pastures.

4.2. Impact of grazing and implications for the definition of sampling strategies

Grazing can degrade vegetation in several ways, including trampling and erosion, if soil is exposed to wind and precipitation. Direct defoliation through grazing can also have a detrimental effect on plant physiology, in particular during the growing season when plants are photosynthetic. When the leaves are dry, most of the plants' energy reserves are stored in the roots or seeds and no longer in the foliage (Huss, 1996). Grazing at that time therefore has little incidence.

In Khomyn Tal, most of the growing season is spent in the summer camps occupied from early May to early October. Sheep, goats and cattle stay nearby according to our mapping, and we think that the horses also stay at close proximity as they drink regularly at their owner's well (herders personal communication and own observations). Moreover, wherever the camels roam, their impact is negligible since their numbers are very low (0.77% of the livestock heads in Mongolia (NSO, 2012) and 1.88% in our study site (*bag* governor personal communication). The bulk of the grazing thus occurs close to the camps.

We can consequently expect the local pastures to be mainly impacted from a physiological point of view in the areas used in summer, which represent 30.92% of Khomyn Tal. A sound assessment should therefore be focused there.

This shows that mapping of the seasonal camps coupled with the use of buffers makes it possible to prioritize the importance of the different areas for monitoring, and reduces the sampling effort to less than one third of the surface. Of course, the condition of the pastures in the concerned area cannot be totally homogeneous, notably because grazing intensity decreases with the distance from the settlements (Sasaki et al., 2008), but this approach offers a good compromise between the surface to sample and the need to take into account the herders' habits.

The same reasoning is valid for all Mongolian grazing systems and any spatial survey should take the heterogeneity of land use resulting from herders' movements into account. If, in other regions, the herders also spend the growing season in their summer camps, it is essential to study the surrounding areas. If degradation occurs, it will be visible there first and those areas could therefore play the role of early warning indicators of overgrazing. They should however not be considered representative of the studied systems, and sample plots in other seasonal zones should also be surveyed. The picture of the physiological condition of the studied regions would then be complete.

Hence, by classifying the country according to its different climate zones and population densities, and defining sampling zones according to seasonal use areas, we can put in place a reliable stratified sampling strategy for Mongolia. Consistently assessing the impact of the last years' increases in livestock numbers would then be possible.

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[3] One might think that there is only limited significance in the differences for this aspect since mean slope is only 5%. However, in winter, the herders settle their camps in the foothills, which means the slopes of the campsites are higher in the surrounding areas.

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