Appendix S1

Text S1. Locally-collected data on surface water.

To increase accuracy of our estimates of surface water for each study population, we compiled data on springs, streams, small ponds, and man-made water sources (i.e., surface water sources <30 x 30 m, that were undetectable using the Global Surface Water Explorer). These data were recorded primarily by coauthors and data contributors during previous research efforts (Table S1). For study populations at which principal investigators had not collected any local data on surface water (i.e. Grevy's zebra, impala, both elk populations, Mongolian gazelle in eastern Mongolia, white-bearded wildebeest in Kenya-Tanzania Amboseli, and white-bearded wildebeest in Kenya-Tanzania Mara), we used national water databases to extract permanent sources of water including springs and rivers, which were not detected in remotely-sensed surface water layers. Additionally, coauthors and data contributors confirmed if there was any fencing around water sources that would prohibit access by free-ranging ungulates. If fencing existed, the location of fences was digitized and used to mask out locally-collected surface water data. For the white-bearded wildebeest population in Kenya-Tanzania Amboseli, we were not able to obtain information regarding fencing. For the mountain zebra population, where small ephemeral springs existed, locally-collected data on surface water was not available because these data were protected in an effort to protect black rhino (*Diceros bicornis*). However, movements of mountain zebra in this study area were likely less influenced by small water sources compared to larger, more permanent water, which could be detected in remotely sensed water data (pers. comm., Muntifering). For red deer populations in Italy and Norway, and for the roe deer population in Norway, coauthors confirmed that the Global Surface Water dataset provided sufficient detail for surface water. To match the resolution of the remotely-sensed data on surface water, we rasterized a 30 x 30 m grid of locally-collected water data and we merged the layer of locally-collected surface water with the layer on remotely-sensed surface water for each study population. We were not able to detect surface water associated with small, ephemeral water sources created by rainfall, livestock troughs, nor any temporally variable man-made water sources. We were also unable to distinguish between salt and fresh water.

Text S2. Importance of ephemeral sources of water for khulan in southern Mongolia.

In the Dzungarian Gobi and South Gobi Region of Mongolia, khulan (*Equus hemionus hemionus*) typically access water on a daily basis (Kaczensky *et al.* 2010, Nandintsetseg *et al.* 2016, Payne *et al.* 2020). This pattern was undetected in the current study, likely because of the difficulty of detecting small, ephemeral water bodies through the Global Surface Water Explorer (see also Payne *et al.* 2020). Consequently, we believe that the resulting distance to water layer underestimates the true distribution of surface water available to this study population in southern Mongolia (study population 19). Therefore, we urge readers to exercise caution in interpreting the apparent differences in resource selection between the two khulan populations (study populations 18 and 19).

Table S1. Properties of study populations and associated study areas. Number of telemetered individuals (n). Range in number of individuals telemetered in a given year (range of n) for those study populations generating data over multiple years. Years over which GPS relocations were collected and vegetation and surface water characteristics were quantified (study years). MSAVI (Modified Soil-Adjusted Vegetation Index; index of forage biomass) and IRG (Instantaneous Rate of Green-up; index of potential energy intake) were calculated using MODIS terra satellite imagery Version 6.0 (MOD09Q1) with spatial resolution of 250 x 250 meters and temporal resolution of 8 days. Start of growing season and end of growing season are reported as Julian day and averaged across years for study populations that included more than one year of tracking data.

common name	scientific name	country/region	n	range of n	study years	MSAVI mean ± SD in growing season	one growing season?	start of growing season	end of growing season
Equids									
Asiatic wild ass (khulan)*	*Equus hemionus hemionus*	western Mongolia	7	7 – 7	2009-2010	0.05±0.01	yes	89	233
Asiatic wild ass (khulan)#	*E. h. hemionus*	southern Mongolia	9	9 – 9	2013-2015	0.07±0.01	yes	100	252
Asiatic wild ass (onager)	*E. h. onager*	Iran	9	9 – 9	2017-2018	0.07±0.01	yes	61	145
feral burro	*E. asinus*	USA	10	8 – 10	2016-2018	0.11±0.01	yes	75	257
feral horse^	*E. caballus*	USA	22	22	2018	0.09±0.02	yes	81	177
Grevy's zebra**	*E. grevyi*	Kenya	7	1 – 7	2007-2008	0.20±0.03	no	92	334
mountain zebra	*E. zebra*	Namibia	5	4 – 5	2011-2013	0.10±0.04	yes	267	73
plains zebra+	*E. quagga*	Namibia	9	8 – 9	2009-2010	0.16±0.07	yes	277	65
plains zebra	*E. quagga*	Zimbabwe	31	7 – 18	2009-2015	0.31±0.03	yes	260	52
Przewalski's horse	*E. ferus*	central Mongolia	14	14	2018	0.21±0.03	yes	81	233
Przewalski's horse*	*E. ferus*	western Mongolia	5	4 – 5	2013-2014	0.06±0.01	yes	85	252
Ruminants									
African buffalo	*Syncerus caffer*	South Africa	4	3 – 4	2005-2006	0.31±0.05	yes	317	76
elk^	*Cervus canadensis*	USA Wyoming	20	6 – 15	2011-2014	0.09±0.02	yes	71	214
elk	*Cervus canadensis*	USA Colorado	7	4 – 7	2006-2007	0.17±0.06	yes	85	253
goitered gazelle#	*Gazella subgutturosa*	Mongolia	6	6	2014	0.07±0.02	yes	121	273
impala**	*Aepyceros melampus*	Kenya	21	10 – 20	2011-2012	0.28±0.03	no	96	250
Mongolian gazelle#	*Procapra gutturosa*	southern Mongolia	7	7	2014	0.08±0.01	yes	97	217
Mongolian gazelle	*Procapra gutturosa*	eastern Mongolia	5	1 – 5	2015-2018	0.17±0.03	yes	109	255
mule deer^	*Odocoileus hemionus*	USA Wyoming	100	5 – 70	2014-2018	0.15±0.06	yes	81	188
mule deer	*Odocoileus hemionus*	USA Colorado/Wyoming	78	34 – 46	2016-2018	0.19±0.06	yes	75	179
red deer	*C. elaphus*	Germany	22	9 – 21	2009-2011	0.44±0.08	yes	76	204
red deer	*C. elaphus*	Italy	13	7 – 11	2010-2012	0.20±0.08	yes	97	246

red deer	*C. elaphus*	Norway	51	12 – 21	2005-2007	0.29±0.15	yes	110	239
reindeer	*Rangifer tarandus tarandus*	Norway	25	6 – 9	2009-2019	0.26±0.09	yes	154	247
roe deer	*C. capreolus*	Norway	23	4 – 14	2008-2010	0.27±0.12	yes	139	242
saiga*	*Saiga tatarica*	Mongolia	26	7 – 15	2016-2018	0.07±0.05	yes	110	233
springbok+	*Antidorcas marsupialis*	Namibia	10	10 – 10	2009-2010	0.12±0.06	yes	277	65
white-bearded wildebeest	*Connochaetes taurinus*	Kenya-Tanzania Amboseli	9	5 – 9	2010-2012	0.17±0.04	no	294	125
white-bearded wildebeest	*C. taurinus*	Kenya	12	6 – 12	2010-2012	0.23±0.04	no	302	147
white-bearded wildebeest	*C. taurinus*	Kenya-Tanzania Mara	13	6 – 13	2010-2012	0.26±0.05	no	262	125

*, #, **, +, ^ = symbols indicate sympatric populations

Table S1 (continued)

common name	original fix rate	fix rate of uncorrelated steps (hrs. ± min)	length of uncorrelated steps (m) mean ± SD	number of used steps in analysis	body mass (kg)[1]	muzzle width (cm)	sex	distance to water (km) mean ± SD in growing season	maximum distance to water (km) used to scale distance to water layer
Equids									
Asiatic wild ass (khulan)	15 min.	4 (±15)	2053.88±2616.98	5922	230	5.67	4F, 3M	6.18±3.69	31.77
Asiatic wild ass (khulan)	1 hrs.	8 (±15)	3976.00±4048.88	7804	230	5.67	4F, 5M	10.11±6.29	73.60
Asiatic wild ass (onager)	2 hrs.	6 (±15)	2283.50±2060.21	5873	240	5.67	F	4.74±3.06	29.88
feral burro	2 hrs.	4 (±15)	640.61±653.33	24094	180[2]	-	F	1.61±0.93	10.95
feral horse	2 hrs.	4 (±15)	819.69±855.85	12172	430[3]	-	F	4.80±3.48	23.08
Grevy's zebra	1 hrs.	2 (±15)	596.00±648.54	8612	405	5.88	5F, 2M	3.15±1.71	15.04
mountain zebra	3 & 4 hrs.	8 to 9 (±15)	1464.3±1472.32	2849	310	6.48	3F, 2M	19.16±8.02	42.78
plains zebra	1 hrs.	7 (±15)	2931.78±2973.92	4012	247.5	6.50	F	4.42±3.51	26.97
plains zebra	30 min.	3 (±15)	823.69±1005.11	52349	247.5	6.50	F	7.17±5.31	28.75
Przewalski's horse	1 hrs.	3 (±15)	717.3±712.58	15356	250	6.24	F	2.32±1.39	9.99
Przewalski's horse	1 hrs.	4 (±15)	2337.04±2370.76	5058	250	6.24	3F, 2M	7.75±4.33	24.63
Ruminants									
African buffalo	1 hrs.	4 (±15)	910.61±835.04	1929	592.5	9.85	F	6.09±3.11	22.36
elk	2, 3 & 3 hrs.	5 and 6	1196.6±1323.14	32796	255	5.73	F	3.87±2.32	21.37
elk	5 hrs.	10 (±15)	1348.24±1274.29	2988	255	5.73	F	4.06±2.88	16.67
goitered gazelle	2 hrs.	4 (±15)	1201.4±1405.10	5047	25	-	4F, 2M	8.34±4.89	50.00
impala	20 min.	2 (±15)	154.54±162.75	36955	52.75	3.11	F	1.33±0.81	7.20
Mongolian gazelle	8 hrs.	24 (±15)	2698.75±4894.41	375	27.75	3.10	3F, 4M	7.35±4.77	83.25

Mongolian gazelle	1 hrs.	23 (±15)	7455.22.±6277.43	1680	27.75	3.10	F	8.09±6.69	46.61
mule deer	2 hrs.	100 (±15)	6682.91±13385.92	3527	65	3.55	F	2.65±2.34	20.24
mule deer	2 hrs.	46 (±15)	1742.4±3481.92	5002	65	3.55	30F, 48M	2.25±1.50	20.50
red deer	6 hrs.	12 (±15)	729.85±761.21	8044	131.25	-	7F, 15M	0.51±0.37	6.25
red deer	1 & 4 hrs.	4 (±15)	355.73±430.46	9990	131.25	-	9F, 4M	2.47±1.68	10.60
red deer	1 & 2 hrs.	6 (±15)	359.14±574.04	18529	131.25	-	F	0.72±0.63	7.84
reindeer	3 hrs.	9 (±15)	3263.85±2680.61	16853	82.5	5.46	F	0.43±0.38	3.73
roe deer	1 & 6 hrs.	12 (±15)	915.96±1523.91	3495	24	2.68	13F, 10M	0.83±0.78	8.19
saiga	2 & 6 & 13 hrs.	24 to 26	4347.25±4925.79	1964	28.65	2.30	23F, 3M	6.71±5.66	32.60
springbok	1 hrs.	6 (±15)	1356.85±1592.37	5966	36.45	2.04	4F, 6M	3.75±3.06	25.31
white-bearded wildebeest	1 hrs.	6 (±15)	1587.62±2081.97	7636	185	6.32	5F, 4M	6.62±4.35	33.79
white-bearded wildebeest	1 hrs.	3 (±15)	427.73±602.86	18964	185	6.32	7F, 5M	1.76±1.38	11.86
white-bearded wildebeest	1 hrs.	8 (±15)	1342.15±1566.67	10820	185	6.32	9F, 4M	23.56±16.25	67.75

Table S1 (continued)

common name	percent tree cover[4] mean ± SD	percent dense forest[5]	biome[6]	population number on Figure 2	example references
Equids					
Asiatic wild ass (khulan)	0	0	Deserts and Xeric Shrublands	18	Kaczensky et al. 2008; Nandintsetseg et al. 2019
Asiatic wild ass (khulan)	0	0	Deserts and Xeric Shrublands	19	Payne et al. 2020; Nandintsetseg et al. 2019
Asiatic wild ass (onager)	0	0	Deserts and Xeric Shrublands	20	Esmaeili 2020
feral burro	0.00±0.11	0	Deserts and Xeric Shrublands	14	
feral horse	0.00±0.02	0	Deserts and Xeric Shrublands	29	Hennig et al. 2018
Grevy's zebra	0.74±1.94	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	28	Sundaresan et al. 2007
mountain zebra	0±0.09	0	Deserts and Xeric Shrublands	27	Muntifering et al. 2019
plains zebra	1.28±2.20	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	21	
plains zebra	10.88±3.99	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	22	Chamaillé-Jammes et al. 2016; Courbin et al. 2019
Przewalski's horse	0.00±0.18	0	Temperate Grasslands, Savannas and Shrublands	23	
Przewalski's horse	0	0	Deserts and Xeric Shrublands	24	Kaczensky et al. 2008
Ruminants					
African buffalo	8.32±4.31	0	Temperate Grasslands, Savannas and Shrublands	30	Cross et al. 2004
elk	0.01±0.48	0	Deserts and Xeric Shrublands	25	Merkle et al. 2016; Cole et al. 2015
elk	7.35±19.42	0.15	Temperate Conifer Forests	26	Schoenecker 2012
goitered gazelle	0	0	Deserts and Xeric Shrublands	2	Nandintsetseg et al. 2019
impala	0.74±1.90	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	7	

Mongolian gazelle	0	0	Deserts and Xeric Shrublands	3	Ito et al. 2006, 2013, 2018; Imai et al. 2017, 2019, 2020
Mongolian gazelle	0.00±0.03	0	Temperate Grasslands, Savannas and Shrublands	4	Nandintsetseg et al. 2019
mule deer	5.43±17.54	0.12	Deserts and Xeric Shrublands / Temperate Conifer Forests	8	Sawyer et al. 2017
mule deer	12.94±25.74	1.19	Deserts and Xeric Shrublands / Temperate Conifer Forests	9	Monteith et al. 2018
red deer	15.93±29.66	8.18	Temperate Broadleaf and Mixed Forests	12	Richter et al. 2020
red deer	20.86±33.55	12.32	Temperate Conifer Forests	13	
red deer	30.43±37.33	12.60	Boreal Forests	11	Godvik et al. 2009
reindeer	5.30±14.37	0.06	Tundra	10	Gundersen et al. 2021
roe deer	22.62±30.98	6.08	Boreal Forests	1	Mysterud et al. 2012; Cagnacci et al. 2011; Morellet et al. 2013
saiga	0.01±0.51	0	Deserts and Xeric Shrublands	5	Nandintsetseg et al. 2019
springbok	0.53±1.52	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	6	
white-bearded wildebeest	0.51±2.08	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	15	Stabach et al. 2016
white-bearded wildebeest	2.39±3.00	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	16	Stabach et al. 2016
white-bearded wildebeest	10.52±8.67	0	Tropical and Subtropical Grasslands, Savannas and Shrublands	17	Stabach et al. 2016

1 Wilson and Mittermeier 2011
2 Schoenecker personal communication.
3 Godfrey and Berger 1987
4 Hansen et al. 2013
5 Friedl and Sulla-Menashe 2015
6 Olson et al. 2001

Table S2. Sources used to generate locally-collected data on surface water for 11 populations of equids and 19 populations of ruminants across the globe. Numbers after each populations' name are associated with Figure 2 in the manuscript.

study population	country/region	local water data exists	local water data incorporated?	reference for local water data	fenced water existed?	fenced water excluded?
Asiatic wild ass (khulan) (18)	western Mongolia	yes	yes	Kaczensky unpublished report	no	
Asiatic wild ass (khulan) (19)	southern Mongolia	yes	yes	Kaczensky unpublished report	no	
Asiatic wild ass (onager) (20)	Iran	yes	yes	Esmaeili unpublished report	no	
feral burro (14)	USA	yes	yes	Schoenecker unpublished report	no	
feral horse (29)	USA	yes	yes	Hennig unpublished report; USGS (2018)	yes	yes
Grevy's zebra (28)	Kenya	yes	yes	Fischhoff unpublished report; ICPAC 2017a; ICPAC 2017b	yes	yes
mountain zebra (27)	Namibia	yes	no	Muntifering unpublished report	no	
plains zebra (21)	Namibia	yes	yes	Etosha Ecological Institute, pers. comm. with Abrahams	no	
plains zebra (22)	Zimbabwe	yes	yes	Chamaillé-Jammes et al. 2016	no	
Przewalski's horse (23)	central Mongolia	yes	yes	Dejid unpublished report	no	
Przewalski's horse (24)	western Mongolia	yes	yes	Kaczensky unpublished report	no	
African buffalo (30)	South Africa	yes	yes	Skukuza GIS Lab, Kruger National Park, pers. comm. with Esmaeili	no	
elk (25)	USA Wyoming	yes	yes	USGS (2018)	yes	yes
elk (26)	USA Colorado	yes	yes	Schoenecker unpublished report	no	
goitered gazelle (2)	Mongolia	yes	yes	Kaczensky unpublished report; Buuveibaatar unpublished report	no	
impala (7)	Kenya	yes	yes	ICPAC 2017a; ICPAC 2017b	yes	yes
Mongolian gazelle (3)	southern Mongolia	yes	yes	Kaczensky unpublished report; Buuveibaatar unpublished report	no	
Mongolian gazelle (4)	eastern Mongolia	yes	yes	International Steering Committee for Global Mapping (2010)	no	
mule deer (8)	USA Wyoming	yes	yes	USGS (2018)	yes	yes
mule deer (9)	USA Colorado/Wyoming	yes	yes	USGS (2018)	yes	yes
red deer (12)	Germany	yes	yes	Signer unpublished report	no	
red deer (13)	Italy	yes	no	pers. comm. with Cagnacci	no	
red deer (11)	Norway	no	no	pers. comm. with Mysterud	no	
Reindeer (10)	Norway	yes	yes	Norwegian Institute of Bioeconomy Research (2016)	no	
roe deer (1)	Norway	no	no	pers. comm. with Mysterud	no	
saiga (5)	Mongolia	yes	yes	Buuveibaatar unpublished report	no	
springbok (6)	Namibia	yes	yes	Etosha Ecological Institute, pers. comm. with Abrahams	no	
white-bearded wildebeest (15)	Kenya-Tanzania Amboseli	yes	yes	ICPAC 2017a; ICPAC 2017b	unknown	

white-bearded wildebeest (16)	Kenya	yes	yes	Reid et al. (2008)	yes	yes
white-bearded wildebeest (17)	Kenya-Tanzania Mara	yes	yes	ICPAC 2017a; ICPAC 2017b; ICPAC 2017c	no	

Table S3. Pearson's correlation coefficients between MSAVI, IRG, and surface water used in step-selection models for 11 populations of equids and 19 populations of ruminants across the globe. Numbers after each populations' name are associated with Figure 2 in the manuscript.

Asiatic wild ass (khulan), western Mongolia (18)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.345	1.00	
Water	-0.048	0.063	1.00
Asiatic wild ass (khulan), southern Mongolia (19)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.093	1.00	
Water	0.030	-0.016	1.00
Asiatic wild ass (onager), Iran (20)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.152	1.00	
Water	-0.003	-0.046	1.00
feral burro, USA (14)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.108	1.00	
Water	-0.144	0.047	1.00
feral horse, USA (29)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.281	1.00	
Water	-0.099	0.159	1.000
Grevy's zebra, Kenya (28)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.107	1.00	
Water	-0.174	-0.179	1.00
mountain zebra, Namibia (27)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.042	1.000	
Water	0.243	0.152	1.000
plains zebra, Namibia (21)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.201	1.00	
Water	0.127	0.147	1.00
plains zebra, Zimbabwe (22)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.118	1.00	
Water	-0.060	-0.008	1.00
Przewalski's horse, central Mongolia (23)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.043	1.00	
Water	0.025	-0.002	1.00
Przewalski's horse, western Mongolia (24)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.134	1.00	
Water	0.012	-0.006	1.00
African buffalo, South Africa (30)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.305	1.00	
Water	0.343	-0.277	1.00
elk, USA Wyoming (25)	MSAVI	IRG	Water

MSAVI	1.00		
IRG	-0.163	1.00	
water	-0.002	0.036	1.00
elk, USA Colorado (26)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.187	1.00	
water	-0.086	0.022	1.00
goitered gazelle, Mongolia (2)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.068	1.00	
water	-0.053	-0.255	1.00
impala, Kenya (7)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.016	1.00	
water	0.073	-0.08	1.00
Mongolian gazelle, southern Mongolia (3)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.099	1.00	
water	0.551	0.135	1.00
Mongolian gazelle, eastern Mongolia (4)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.274	1.00	
water	0.003	0.122	1.00
mule deer, USA Wyoming (8)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.159	1.00	
water	-0.022	0.028	1.00
mule deer, USA Colorado/Wyoming (9)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.342	1.00	
water	0.019	0.001	1.00
Red deer, Germany (12)			
MSAVI	1.00		
IRG	-0.188	1.00	
Water	-0.017	0.005	1.00
Red deer, Italy (13)			
MSAVI	1.00		
IRG	0.005	1.00	
Water	0.006	0.059	1.00
Red deer, Norway (11)			
MSAVI	1.00		
IRG	0.010	1.00	
Water	-0.027	-0.033	1.00
Reindeer, Norway (10)			
MSAVI	1.00		
IRG	0.022	1.00	
Water	0.001	-0.004	1.00
Roe deer, Norway (1)			
MSAVI	1.00		
IRG	-0.125	1.00	
Water	0.018	-0.026	1.00
saiga, Mongolia (5)	MSAVI	IRG	Water
MSAVI	1.00		

IRG	0.036	1.00	
Water	0.014	0.041	1.00
springbok, Namibia (6)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	0.143	1.00	
Water	-0.079	-0.045	1.00
white-bearded wildebeest, Kenya-Tanzania Amboseli (15)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.034	1.00	
Water	-0.009	0.072	1.00
white-bearded wildebeest, Kenya (16)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.021	1.00	
Water	0.023	-0.083	1.00
white-bearded wildebeest, Kenya-Tanzania Mara (17)	MSAVI	IRG	Water
MSAVI	1.00		
IRG	-0.051	1.00	
Water	0.062	0.224	1.00

Table S4. Parameter estimates and robust standard errors (SE) for the step-selection models. Variables for which 95% confidence intervals did not encompass zero are denoted by asterisks. For ease of interpretation, we switched the direction of parameter estimates for surface water in all of the analyses and presentations. Therefore, positive and negative values show selection and avoidance, respectively, for all three variables. Numbers after each populations' name are associated with Figure 2 in the manuscript.

parameter	**estimate**	**SE**	**z value**	***p***
Asiatic wild ass (khulan), western Mongolia (18)				
MSAVI	-0.030	0.071	-0.421	0.673
IRG	-0.094	0.079	-1.189	0.235
water	0.313	0.129	-2.423	0.015*
Asiatic wild ass (khulan), southern Mongolia (19)				
MSAVI	0.039	0.066	0.590	0.555
IRG	-0.002	0.050	-0.036	0.971
water	0.129	0.073	-1.756	0.079
Asiatic wild ass (onager), Iran (20)				
MSAVI	0.334	0.084	3.963	<0.001*
IRG	0.001	0.076	0.016	0.987
water	1.950	0.651	-2.997	0.003*
feral burro, USA (14)				
MSAVI	0.004	0.106	0.039	0.969
IRG	-0.082	0.093	-0.875	0.381
water	1.203	0.182	-6.596	<0.001*
feral horse, USA (29)				
MSAVI	0.035	0.030	1.147	0.252
IRG	0.005	0.034	0.142	0.887
water	0.370	0.202	-1.834	0.067
Grevy's zebra, Kenya (28)				
MSAVI	-0.065	0.039	-1.642	0.101
IRG	0.005	0.040	0.121	0.904
water	-0.005	0.089	0.057	0.954
mountain zebra, Namibia (27)				
MSAVI	0.129	0.037	3.460	0.001*
IRG	-0.092	0.071	-1.303	0.192
water	0.053	0.034	-1.569	0.117
plains zebra, Namibia (21)				
MSAVI	-0.063	0.086	-0.732	0.464
IRG	-0.052	0.075	-0.689	0.491
water	0.325	0.264	-1.231	0.218
plains zebra, Zimbabwe (22)				
MSAVI	-0.046	0.021	-2.179	0.029*
IRG	-0.001	0.039	-0.017	0.987
water	0.371	0.093	-3.974	<0.001*
Przewalski's horse, central Mongolia (23)				
MSAVI	0.042	0.025	1.718	0.086
IRG	-0.034	0.043	-0.795	0.427

Water	0.986	0.191	-5.175	<0.001*
Przewalski's horse, western Mongolia (24)				
MSAVI	-0.286	0.250	-1.143	0.253
IRG	0.178	0.119	1.492	0.136
Water	1.374	0.185	-7.427	<0.001*
African buffalo, South Africa (30)				
MSAVI	0.022	0.082	0.265	0.791
IRG	-0.143	0.055	-2.605	0.009*
Water	0.375	0.233	-1.611	0.107
elk, USA Wyoming (25)				
MSAVI	0.008	0.054	0.152	0.880
IRG	0.099	0.048	2.042	0.041*
Water	-0.035	0.076	0.470	0.639
elk, USA Colorado (26)				
MSAVI	0.450	0.215	2.093	0.036*
IRG	-0.076	0.141	-0.540	0.589
Water	-0.201	0.126	1.594	0.111
goitered gazelle, Mongolia (2)				
MSAVI	-0.124	0.058	-2.136	0.033*
IRG	-0.070	0.047	-1.495	0.135
Water	-0.004	0.051	0.079	0.937
impala, Kenya (7)				
MSAVI	-0.043	0.016	-2.645	0.008*
IRG	0.009	0.019	0.511	0.609
Water	0.015	0.033	-0.453	0.651
Mongolian gazelle, southern Mongolia (3)				
MSAVI	-0.186	0.084	-2.216	0.027*
IRG	0.302	0.123	2.462	0.014*
Water	0.078	0.451	-0.172	0.863
Mongolian gazelle, eastern Mongolia (4)				
MSAVI	0.122	0.028	4.402	<0.001*
IRG	0.127	0.050	2.530	0.011*
Water	-0.289	0.123	2.347	0.019*
mule deer, USA Wyoming (8)				
MSAVI	0.001	0.047	-0.006	0.995
IRG	0.251	0.063	4.014	<0.001*
Water	-0.069	0.083	0.831	0.406
mule deer, USA Colorado/Wyoming (9)				
MSAVI	-0.110	0.043	-2.541	0.011*
IRG	0.137	0.035	3.908	<0.001*
Water	-0.339	0.256	1.326	0.185
red deer, Germany (12)				
MSAVI	0.176	0.077	2.286	0.022*
IRG	0.071	0.091	0.782	0.434
water	-0.836	0.219	3.814	<0.001*
red deer, Italy (13)				
MSAVI	0.120	0.064	1.883	0.060
IRG	0.106	0.060	1.761	0.078

water	0.002	0.036	-0.043	0.966
red deer, Norway (11)				
MSAVI	0.163	0.026	6.191	<0.001*
IRG	0.012	0.032	0.383	0.702
water	-0.385	0.088	4.351	<0.001*
reindeer, Norway (10)				
MSAVI	0.052	0.039	1.319	0.187
IRG	0.080	0.034	2.391	0.017*
water	-2.005	0.077	26.126	<0.001*
roe deer, Norway (1)				
MSAVI	0.049	0.084	0.582	0.560
IRG	-0.040	0.068	-0.589	0.556
water	0.588	0.442	-1.331	0.183
saiga, Mongolia (5)				
MSAVI	0.066	0.062	1.068	0.286
IRG	0.172	0.089	1.939	0.052*
water	-0.610	0.133	4.583	<0.001*
springbok, Namibia (6)				
MSAVI	-0.045	0.021	-2.199	0.028*
IRG	-0.008	0.068	-0.116	0.908
water	0.111	0.135	-0.822	0.411
white-bearded wildebeest, Kenya-Tanzania Amboseli (15)				
MSAVI	0.054	0.037	1.470	0.142
IRG	0.063	0.061	1.028	0.304
water	0.301	0.121	-2.482	0.013*
white-bearded wildebeest, Kenya (16)				
MSAVI	0.045	0.023	1.951	0.051*
IRG	0.057	0.036	1.606	0.108
water	0.145	0.131	-1.109	0.267
white-bearded wildebeest, Kenya-Tanzania Mara (17)				
MSAVI	0.024	0.030	0.778	0.436
IRG	-0.028	0.038	-0.724	0.469
water	-0.017	0.032	0.512	0.608

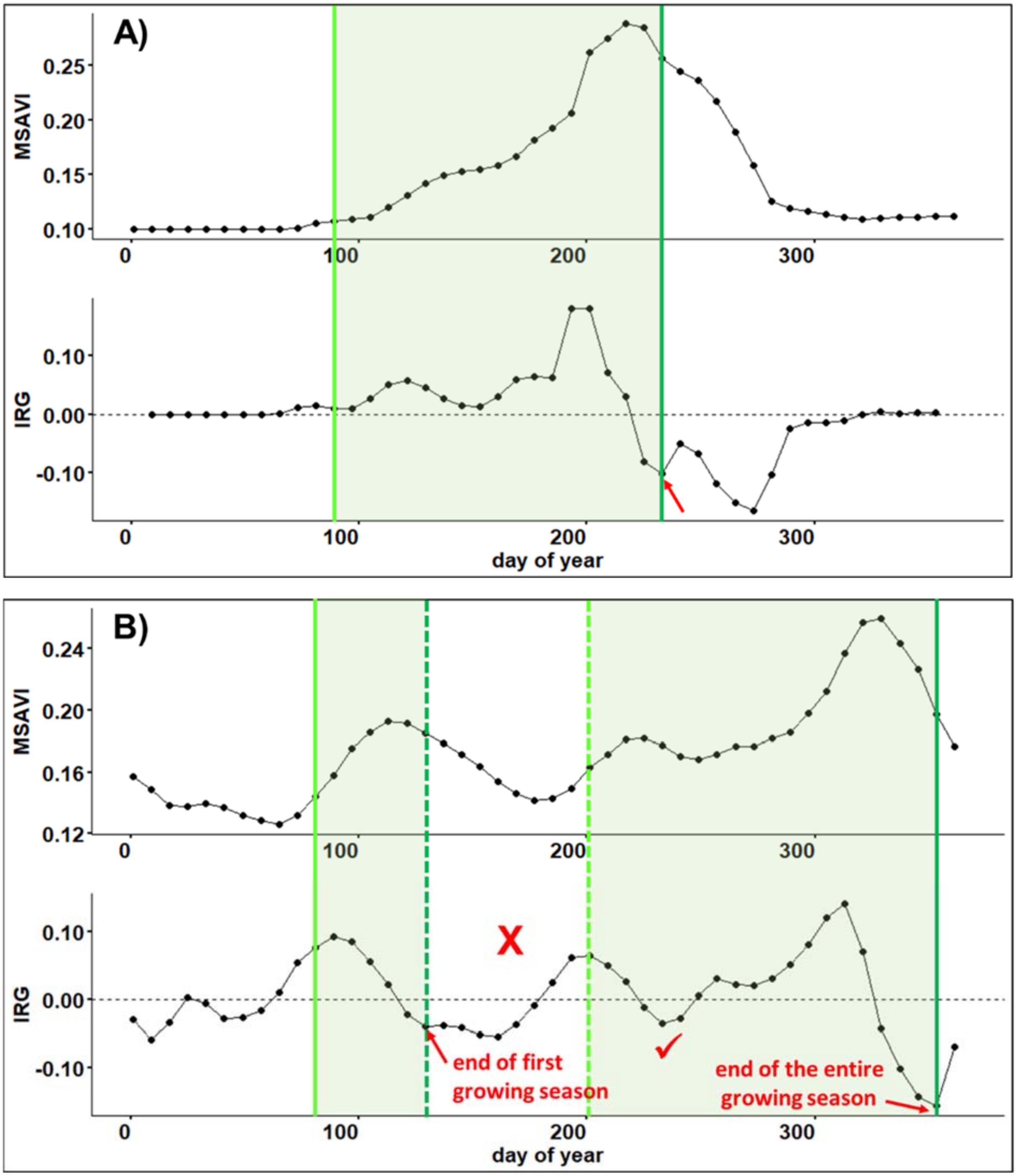

Figure S1. Illustrations of phenology profiles for study areas with (A) a single growing season (e.g., Przewalski's horse habitat in Hustai National Park, Mongolia) and (B) multiple growing seasons (e.g., Grevy's zebra in Laikipia, Kenya). To ensure that positive values of IRG were available to all individuals, we restricted our data set to only those relocations that occurred during growing seasons. For study areas with a single growing season (25 out of 30 study populations), we plotted annual MSAVI and IRG profiles and operationally defined the beginning of the “growing season” as the Julian day when IRG became positive for three consecutive scenes (solid, light green line), and the end of the growing season as the Julian day when IRG reached the minimum negative point (red arrow and solid, dark green line) followed by IRG values less than or equal to zero (*sensu* Jesmer *et al.* 2018). For study areas with multiple growing seasons (B), we excluded non-growing season periods following the end of the first growing season (dashed, dark green line), which we identified as the period between when IRG minimized and remained negative for more than 3 to 4 scenes (e.g. red X). The start of subsequent growing seasons (dashed, light green line) was identified as the Julian day when IRG became positive for three consecutive dates (consistent with panel A). Dashed lines indicate the start and end of each single growing season, whereas the solid lines indicate the entire growing season (Julian day reported in Table S1). We did not exclude periods possessing negative IRG values if positive IRG was observed within any three scenes preceding or proceeding the negative IRG value (e.g., red check mark).

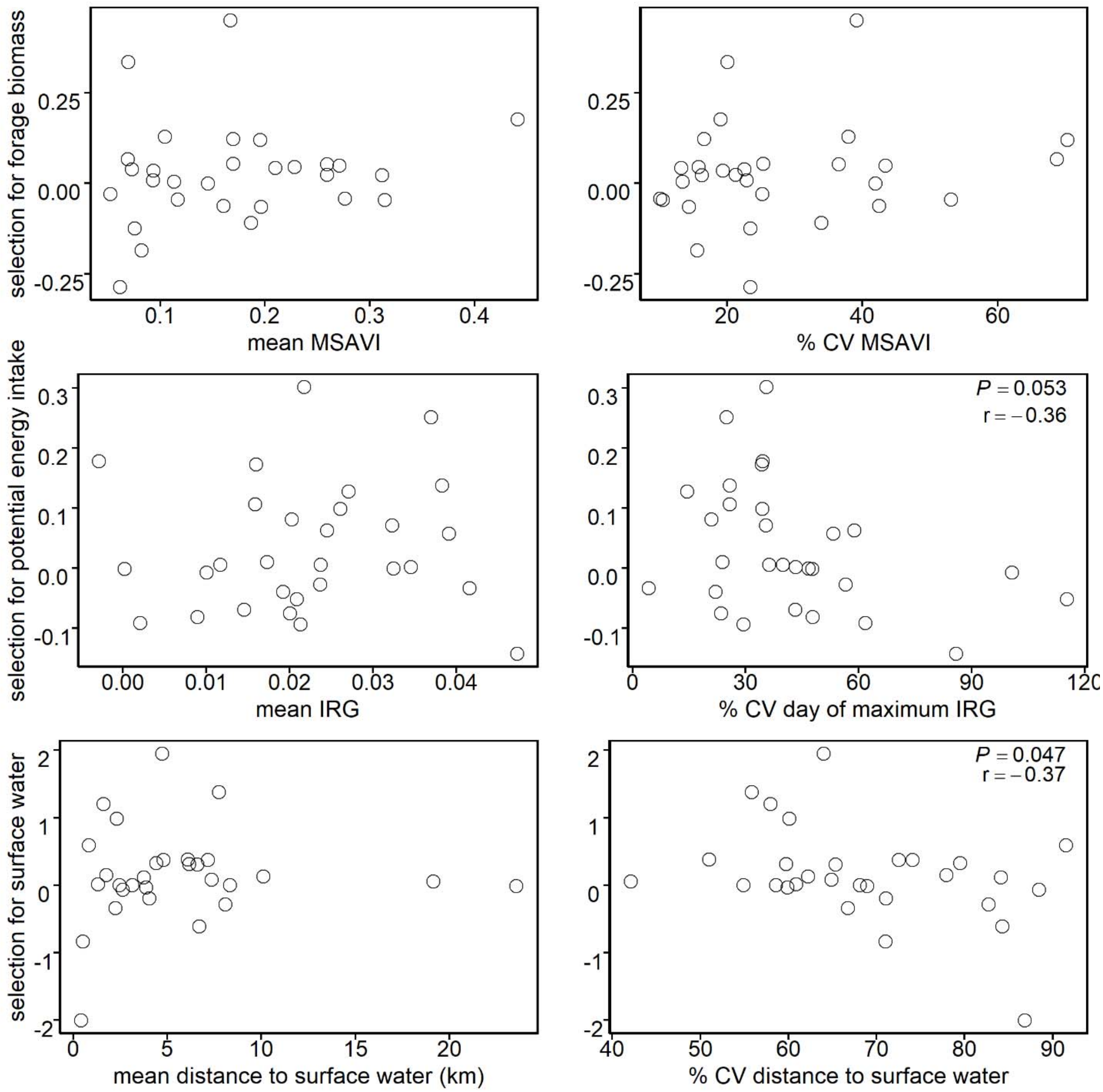

Figure S2. Pearson's correlations between mean and percent of coefficient of variation (% CV) and selection for forage biomass (MSAVI), selection for potential energy intake (i.e., instantaneous rate of green-up: IRG), and selection for surface water within the minimum convex polygon of each study population during growing seasons. We calculated the CV in day of maximum IRG across each study area to represent spatial variability in IRG. Pearson's correlation between selection for potential energy intake and % CV of day of maximum IRG (r = -0.36, *P* = 0.05) and selection for surface water and %CV distance to surface water (r = -0.37, *P*=0.05) were marginally significant. All other correlations were not statistically significant ($P \geq 0.35$).

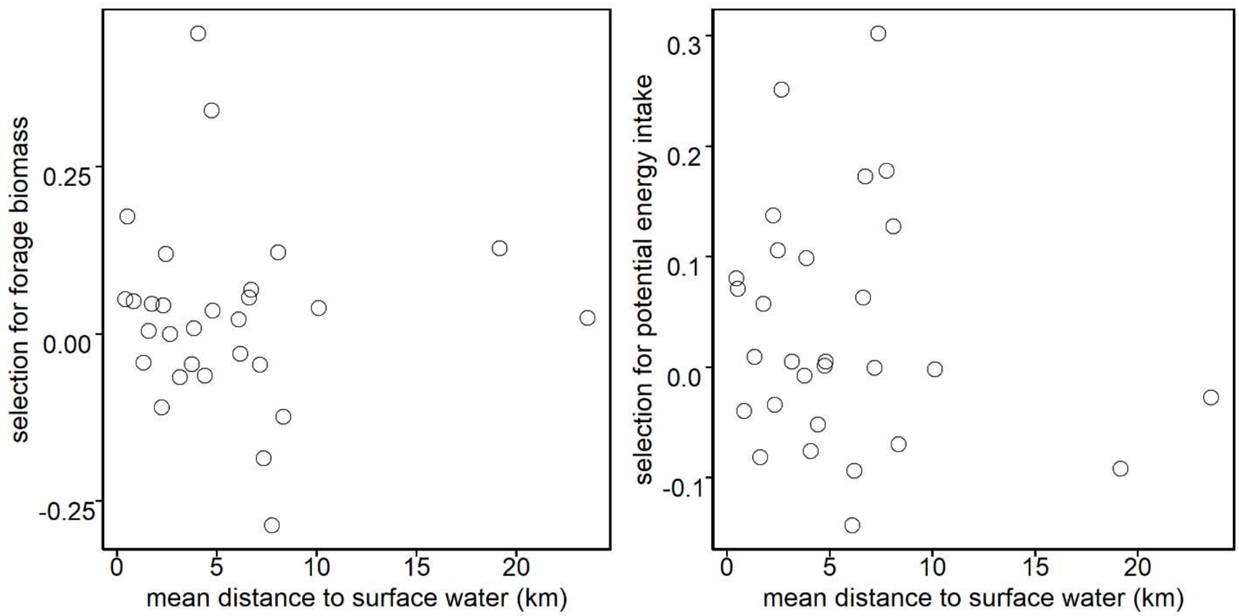

Figure S3. Pearson's correlation between selection for forage biomass and mean distance to surface water (left) and between selection for potential energy intake and surface water (right) within the minimum convex polygon of each study population during growing seasons. Correlations were not statistically significant ($P \geq 0.40$).

References

Cagnacci, F., Focardi, S., Heurich, M., Stache, A., Hewison, A. M., Morellet, N., ... & Urbano, F. (2011). Partial migration in roe deer: migratory and resident tactics are end points of a behavioural gradient determined by ecological factors. *Oikos*, *120*, 1790-1802.

Chamaille-Jammes, S., Charbonnel, A., Dray, S., Madzikanda, H., & Fritz, H. (2016). Spatial distribution of a large herbivore community at waterholes: an assessment of its stability over years in Hwange National Park, Zimbabwe. *PloS One*, 11(4).

Cole, E. K., Foley, A. M., Warren, J. M., Smith, B. L., Dewey, S. R., Brimeyer, D. G., ... & Cross, P. C. (2015). Changing migratory patterns in the Jackson elk herd. *J Wildlife Manage.*, 79, 877-886.

Courbin, N., Loveridge, A. J., Fritz, H., Macdonald, D. W., Patin, R., Valeix, M., & Chamaillé-Jammes, S. (2019). Zebra diel migrations reduce encounter risk with lions at night. *J Anim Ecol*, 88, 92-101.

Cross, P. C., Owen-Smith, N., & Macandza, V. A. (2004). Forage selection by African buffalo in the late dry season in two landscapes. *S Afr J Wildl Res*, 34, 113-121.

Esmaeili, S. (2020). *Quantifying Resource Selection and Community Attitude to Inform Conservation of the Globally-Endangered Onager* (Doctoral dissertation, University of Wyoming).

Friedl, M., Sulla-Menashe, D. (2015). *MCD12C1 MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 0.05Deg CMG V006* [Data set]. NASA EOSDIS Land Processes DAAC. Accessed 2021-01-06 from https://doi.org/10.5067/MODIS/MCD12C1.006

Godfrey, E.B. & Berger, J. (1987). *Wild Horses of the Great Basin: Social Competition and Population Size*. *West. Hist. Q.* University of Chicago Press.

Godvik, I. M. R., Loe, L. E., Vik, J. O., Veiberg, V., Langvatn, R., & Mysterud, A. (2009). Temporal scales, trade-offs, and functional responses in red deer habitat selection. *Ecology*, *90*(3), 699-710.

Gundersen, V., Myrvold, K. M., Rauset, G. R., Selvaag, S. K., & Strand, O. (2020). Spatiotemporal tourism pattern in a large reindeer (Rangifer tarandus tarandus) range as an important factor in disturbance research and management. *Journal of Sustainable Tourism*, *29*(1), 21-39.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., and Townshend, J.R.G., 2013, High-Resolution Global Maps of 21st-Century Forest Cover Change: *Science*, v. 342, no. 6160, p. 850-853

Hennig, J. D., Beck, J. L., & Scasta, J. D. (2018). Spatial ecology observations from feral horses equipped with global positioning system transmitters. *Hum-Wildl Interact*, 12, 75-84.

ICPAC. (2017a). Kenya - Rivers. Available at: http://geoportal.icpac.net/

ICPAC. (2017b). Kenya - Water points. available at: http://geoportal.icpac.net/

ICPAC. (2017c). Tanzania - Rivers. available at: http://geoportal.icpac.net/

Imai, S., Ito, T.Y., Kinugasa, T., Shinoda, M., Tsunekawa, A. & Lhagvasuren, B. (2017). Effects of spatiotemporal heterogeneity of forage availability on annual range size of Mongolian gazelles. *J Zool*, 301, 133-140.

Imai, S., Ito, T.Y., Kinugasa, T., Shinoda, M., Tsunekawa, A. & Lhagvasuren, B. (2019). Nomadic movement of Mongolian gazelles identified through the net squared displacement approach. *Mamm Study*, 44, 111-119.

Imai, S., Ito, T.Y., Shinoda, M., Tsunekawa, A. & Lhagvasuren, B. The benefit and strategy of spring movements in Mongolian gazelles. *J. Mammal.* (2020). Published online: DOI: 10.1093/jmammal/gyz209

International Steering Committee for Global Mapping. (2010). Inland waters, Mongolia. available at: https://earthworks.stanford.edu/

Ito, T.Y., Miura, N., Lhagvasuren, B., Enkhbileg, D., Takatsuki, S., Tsunekawa, A. *et al.* (2006). Satellite tracking of Mongolian gazelles (*Procapra gutturos*a) and habitat shifts in their seasonal ranges. *J Zool*, 269, 291-298.

Ito, T. Y., Tsuge, M., Lhagvasuren, B., Buuveibaatar, B., Chimeddorj, B., Takatsuki., *et al.* (2013). Effects of interannual variations in environmental conditions on seasonal range selection by Mongolian gazelles. *J Arid Environ*, 91, 61-68.

Ito, T.Y., Sakamoto, Y., Lhagvasuren, B., Kinugasa, T. & Shinoda, M. (2018). Winter habitat of Mongolian gazelles in areas of southern Mongolia under new railroad construction: An estimation of interannual changes in suitable habitats. *Mamm Biol*, 93, 13-20.

Jesmer, B.R., Merkle, J.A., Goheen, J.R., Aikens, E.O., Beck, J.L., Courtemanch, A.B., *et al.* (2018). Is ungulate migration culturally transmitted? Evidence of social learning from translocated animals. *Science*, 361, 1023–1025.

Kaczensky, P., Ganbaatar, O., Von Wehrden, H., & Walzer, C. (2008). Resource selection by sympatric wild equids in the Mongolian Gobi. *J Appl Ecol*, 45, 1762-1769.

Kaczensky, P., V. Dresley, D. Vetter, H. Otgonbayar, and C. Walzer. (2010) Water use of Asiatic wild asses in the Mongolian Gobi. Exploration into the Biological Resources of Mongolia (Halle/Saale, Germany) 11, 291-298.

Monteith, K. L., Hayes, M. M., Kauffman, M. J., Copeland, H. E., & Sawyer, H. (2018). Functional attributes of ungulate migration: landscape features facilitate movement and access to forage. *Ecol Appl*, 28, 2153-2164.

Morellet, N., Bonenfant, C., Börger, L., Ossi, F., Cagnacci, F., Heurich, M., ... & Mysterud, A. (2013). Seasonality, weather and climate affect home range size in roe deer across a wide latitudinal gradient within Europe. *J Anim Ecol.*, *82*, 1326-1339.

Muntifering, J.R., Ditmer, M.A., Stapleton, S., Naidoo, R. & Harris, T.H. (2019). Hartmann's mountain zebra resource selection and movement behavior within a large unprotected landscape in northwest Namibia. *Endanger Species Res*, 38, 159-170.

Mysterud, A., Bischof, R., Loe, L. E., Odden, J., & Linnell, J. D. (2012). Contrasting migration tendencies of sympatric red deer and roe deer suggest multiple causes of migration in ungulates. *Ecosphere*, *3*, 1-6.

Nandintsetseg, D., P. Kaczensky, O. Ganbaatar, P. Leimgruber, and T. Mueller. (2016). Spatiotemporal habitat dynamics of ungulates in unpredictable environments: the khulan (*Equus hemionus*) in the Mongolian Gobi as a case study. *Biol Cons*, 204, 313–321.

Nandintsetseg, D., Bracis, C., Leimgruber, P., Kaczensky, P., Buuveibaatar, B., Lkhagvasuren, B., *et al.* (2019). Variability in nomadism: environmental gradients modulate the movement behaviors of dryland ungulates. *Ecosphere*, 10, e02924.

Norwegian Institute of Bioeconomy Research (NIBIO). (2016). AR50 land cover map. Available at: https://www.geonorge.no.

Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V., Underwood, E. C., *et al.* (2001). Terrestrial ecoregions of the world: new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. *BioScience*, 51, 933-938.

Payne, J. C., Buuveibaatar, B., Bowler, D. E., Olson, K. A., Walzer, C., & Kaczensky, P. (2020). Hidden treasure of the Gobi: understanding how water limits range use of khulan in the Mongolian Gobi. *Sci Rep*, 10, 1-13.

Reid, R., H. Gichohi, and M. Said. (2008). Fragmentation of a peri-urban savanna, Athi-Kaputiei Plains, Kenya. Pages 195–224 in K. A. Galvin, R. S. Reid, R. H. Behnke Jr., and N. T.Hobbs, editors. *Fragmentation in semi-arid arid landscapes: consequences for human and natural systems*. Springer, New York, USA.

Richter, L., Balkenhol, N., Raab, C., Reinecke, H., Meißner, M., Herzog, S., ... & Signer, J. (2020). So close and yet so different: The importance of considering temporal dynamics to understand habitat selection. *Basic and Applied Ecology*, *43*, 99-109.

Sawyer, H., Korfanta, N. M., Nielson, R. M., Monteith, K. L., & Strickland, D. (2017). Mule deer and energy development—Long-term trends of habituation and abundance. *Glob Change Biol*, 23, 4521-4529.

Schoenecker, K. A. (2012). *Ecology of bison, elk, and vegetation in an arid ecosystem*. Doctoral dissertation, Colorado State University.

Skinner, J. D., & Chimimba, C. T. (2005). *The mammals of the southern African sub-region*. Cambridge University Press.

Stabach, J. A., Wittemyer, G., Boone, R. B., Reid, R. S., & Worden, J. S. (2016). Variation in habitat selection by white-bearded wildebeest across different degrees of human disturbance. *Ecosphere*, 7, e01428.

Sundaresan, S. R., Fischhoff, I. R., & Rubenstein, D. I. (2007). Male harassment influences female movements and associations in Grevy's zebra (Equus grevyi). *Behav Ecol*, 18, 860-865.

USGS. (2018). National Hydrography Dataset (NHD) Best Resolution 20180226 for Wyoming state or Territory Shapefile Model Version 2.2.1. available at: https://catalog.data.gov/organization/usgs-gov.

Wilson, D.E. & Mittermeier, R.A. (2011). *Handbook of the mammals of the world: v.2: Hoofed mammals*. Barcelona, Spain: Lynx Edicions.