Dear Earthwatcher,

I am writing on behalf of Ganaa, Amgaa, Jed, our Mongolian and American team members, and myself, to express our gratitude to you for all your hard work on behalf of Mongolian wildlife.

Our 2007 fieldwork went exceedingly well. For the first time we were able to field six teams spread throughout the year and thanks to your energy and enthusiasm, we collected a tremendous amount of data. Wild animals captured and radio-tagged included argali, ibex, red foxes, Daurian hedgehogs, and long-eared hedgehogs. Significant numbers of cinereous vultures were monitored, wing tagged, and leg banded, and we found and monitored a good number of lesser kestrel nests. We also sampled a record number of vegetation plots.

A couple of you were repeat volunteers and we were greatly honoured by your decision to return to Mongolia, as well as being thrilled by how much you trained field workers were able to accomplish. Others of you were already well trained by your past experiences in other areas – some in areas that we would never have thought were relevant, but your skills were invaluable – helping maximize your benefits to us!

Many of you have kept in touch. Thanks! For those who want to receive updates, if you have not already done so please send me an e-mail (rreading@denverzoo.org) with your e-mail address and request that I add your name to our distribution list. I periodically send out updates to volunteers who wish to be included on this list.

I want to conclude by re-iterating my thanks. We were thrilled by all the energy, hard work, and wonderful goodwill you all provided. We hope that our many new friendships will last! We look forward to continuing our work with Earthwatch and hope to see many of you in the future.

Please keep in touch.

With best regards,

Rich Reading, Ph.D.

Conservation Biology Director
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EARTHWATCH INSTITUTE FIELD REPORT 2007

Project title: Wildlife of the Mongolian Steppe
Completed by: Dr. Richard Reading
Date of report: December 22, 2007

PROJECT TITLE
Wildlife of the Mongolian Steppe

PRINCIPAL INVESTIGATOR/S
Richard P. Reading, Sukh Amgalanbaatar, James D. Murdoch, and Ganchimeg Wingard

POSITION/AFFILIATIONS
Director of Conservation Biology/Denver Zoological Foundation (DZF); Wildlife Biologist & Research Associate/Mongolian Academy of Sciences & DZF; Doctoral student, WildCRU, Oxford University; and Research Associate/Denver Zoological Foundation, respectively

RESEARCH SITE
Ikh Nart Nature Reserve, Dalanjargal Soum, Dornogobi Aimag, Mongolia

SCIENTIFIC NAMES OF PRIMARY SPECIES BEING STUDIED
Argali Sheep (*Ovis ammon*); Siberian Ibex (*Capra [Ibex] sibirica*); Cinereous Vulture (*Aegypius monachus*); lesser kestrel (*Falco naumanni*); Corsac Fox (*Vulpes corsac*); Red Fox (*Vulpes vulpes*); Eurasian Badger (*Meles meles*); Pallas' Cat (*Otocolobus manul*); Daurian Hedgehog (*Hemiechinus dauuricus*); Long-eared Hedgehog (*Hemiechinus auritus*); gerbils (*Meriones* spp.), jerboas (*Allactaga sibirica*, *Dipus sagitta*); hamsters (*Cricetulus* spp.); and dwarf hamsters (*Phodopus* spp.).

KEY RESEARCH OBJECTIVES

Overall Objective: To understand the behaviour, ecology, and community-level interactions of target species well enough to develop a long-term conservation management plan for the species.

1) Capture and mark
   (a) Mammals for radio collaring, including
      (i) 2 – 4 adult argali sheep,
      (ii) 2 – 8 adult ibex,
      (iii) 5-10 small carnivores, and
      (iv) 1-4 hedgehogs; and

   (b) Birds for leg banding and wing tagging, including
      (i) 20-30 vulture chicks and
      (ii) 2-5 kestrel chicks and 2-5 adult kestrels (leg bands only)
2) Determine sources of mortality for collared animals.
3) Understand movement patterns and habitat use of collared animals.
4) Compare habitat use and food sources of argali sheep, ibex, domestic sheep and goats, small carnivores, and hedgehogs.
5) Determine cinereous vulture and lesser kestrel nesting success rates and sources of nest failure.
6) Use the data collected from our research to develop a conservation management plan for wildlife in Ikh Nart.
7) Train Mongolian biologists and conservationists.

DATA COLLECTION AND RESULTS

We scheduled six research expeditions in 2007 as part of our fourth field season. Teams operated in the first two weeks of May, first two weeks of July, first two weeks in August, first two weeks in September, and last two weeks in September.

Argali Sheep & Siberian Ibex

All teams participated in argali and ibex radio telemetry tracking and vegetation sampling to assess ungulate forage. Both September teams also participated in drive net captures for argali and ibex. We obtained 95 locations on our radio-collared argali and 90 locations on our collared ibex during Earthwatch expeditions. Field teams gathered group size and composition data on 174 argali herds and 92 ibex herds. We sampled 125 vegetation plots during year.

We captured and collared fewer animals than in past years, purely because fewer animals were required. At this point, we generally only capture adult animals to replace animals that die, migrate from the area, or whose collars fail, as we only have the capacity to monitor a couple of dozen animals from each species. This year, however, we also deployed six global positioning system (GPS) collars that store data on the collars until they drop off and so are not actively monitored by field personnel.

This past September, drive net captures occurred on five different capture events (three with Team V and two with Team VI). We captured and collared:

- 3 adult ewe argali (3 GPS)
- 2 adult ram argali (1 GPS)
- 1 billy ibex (1 GPS)
- 3 nanny ibex (1 GPS)
- 1 female kid ibex
- 1 male kid ibex in drive nets
- 1 billy and 1 kid ibex, both already collared: kid collar replaced

One of the primary goals of our radio telemetry work is to determine causes of mortality. So far in 2007, we have lost seven collared argali. Two adult argali ewes appear to have died as a result of complications from giving birth; predators killed four neonatal lambs (two to wolves or dogs and two to unknown carnivores); and one neonatal lamb died of an unknown cause. We recorded no deaths to our collared ibex in 2007 through October.

Finally, we encountered 14 argali (6♂: 8♀) and six ibex (2♂: 4♀) skulls during our fieldwork in Ikh Nart (Table 1). These data include skull measurements from the six argali and six of the eight ibex we captured. These data were added into our overall database, which now contains measurements for 317 argali and 142 ibex. We hope to evaluate the data for argali in the next year or so.

Table 1. Argali (*Ovis ammon*) and Ibex (*Capra sibirica*) Horn Measurements (cm).

Species	Gender	Age	Length		Basal Circumference		Span
			Right	Left	Right	Left	
Argali	**Female**	11	-	46.5	-	17	-
		7	47.5	44	18	19.5	37
		4	31.5	30	15	14	31.5
		5	37.5	40	16	16.5	29
		6	42	42.5	17	17	28
		5	42.5	43	15.5	15.5	30
		5	42.5	43	15.5	15.5	42
		9	89	84	36	37	-
	Male	7	60.5	58	28	28	43.5
		4	44	43	22.5	23	-
		3	53	-	23	-	-
		4	44.5	43.5	19.5	20.5	42.5
		2	14	14	11	12	23.5
		4	31	32.5	20.5	21	37.5
Ibex	**Female**	3	22	21	10	10	14.5
		0.5	6	5.5	6.5	7	6.5
		6	29.5	29.5	11.5	11.5	19.5
		2	14	15	9	9	8
	Male	2	27.5	26.5	17.5	16.5	13.5
		0.5	7	7.5	8	8	7

Raptor Nesting Ecology

We dramatically expanded research on raptors in Ikh Nart in 2007 to include all raptor species nesting in Ikh Nart, with a particular focus on cinereous vultures and lesser kestrels. As with previous years, we checked all known nest sites (*n* = 224) for breeding pairs. We discovered five new nest sites and located 51 breeding pairs that we monitored from a distance throughout the incubation and chick rearing stages. We wing tagged, leg banded, and collected morphometric data on 25 chicks, and collected data on a 26th bird that we did not wing tag, as both of its wings were broken.

From last autumn until the spring of 2007, we received several reports of birds that we had wing-tagged in previous years, including five birds sighted in different parts of South Korea, one bird south of Beijing in China, and one bird in the Sakha Republic of Russia (Yakutia). These sightings confirm that birds from Mongolia move thousands of km from their natal sites. In 2007 we collected data on 15 cinereous vulture egg lengths, widths, and weights (Table 2). We gathered data on egg shell thicknesses for 3 eggs (Table 2). For shell thicknesses, we gathered five measurements for each shell.

We initiated more intensive work on lesser kestrels in 2007, with initial focus on identification of nest site locations, followed by capture of kestrels for morphometric measurement and leg banding. Volunteers assisted with the difficult task of locating nests in talus slopes and banding for adults and fledglings. They were also invaluable in the construction and testing of dho-gaza mist nets and various noose nets. We located 29 nest sites in 2007 and leg banded 16 birds.

Banded birds included 7 adults (6♂ and 1♀) and 9 fledglings (3♂, 2♀, and 4 unknown gender). We also collected morphometric data on these 16 birds.

Finally, we recorded positions on two saker falcon (*Falco cherrug*), one upland hawk (*Buteo hemilasius*), and one black kite (*Milvus migrans*) nest sites in 2007. We added these sites to our growing database of nesting sites for other raptors in Ikh Nart, which includes data on golden eagles (*Aquila chrysaetos*), eagle owls (*Bubo bubo*), little owls (*Athene noctua*), and common kestrels (*Falco tinnuculus*).

Table 2. Cinereous Vulture Egg Measurements in Ikh Nart Nature Reserve, Mongolia, 2007. We took five measurements of egg shell thickness for each nest in which we found egg shell fragments.

Nest	Length (mm)	Width (mm)	Weight (mm)	Thickness (mean ±SD mm)
5D03N	89.3	72.2	230	
5F01T	91.5	72.9	260	
6D01U	93.6	73.6	240	
6D06N	87.5	70.0	200	0.55 ± 0.042
7E00U	96.1	70.4	240	
8C03U	100.1	76.0	280	
8D03U	90.6	71.6	235	
7J03N	91.6	70.0	220	0.63 ± 0.024
3K02E	87.1	71.2	220	0.62 ± 0.026
3L02W	93.6	71.8	250	
5M05N	96.6	73.8	280	
6L06E	90.7	72.6	240	
6M01U	86.5	71.6	230	
6M06E	93.6	72.9	250	
3Q01E	90.0	73.7	240	
Mean ± SD	**91.9 ± 3.79**	**72.3 ± 1.63**	**241 ± 24.1**	**0.60 + 0.049**

Small Carnivores & Hedgehogs

We captured and radio tagged six hedgehogs (five Daurian and one long-eared) during Earthwatch expeditions, as well as one corsac fox. We collected key information on the use of habitats by carnivores and hedgehogs in our study area. During Earthwatch expeditions, we collected ~600 radio telemetry locations used to estimate home range characteristics and examine habitat selection to determine which habitats or landscape features are most important for each species.

We also collected fine-scale data on the movements of carnivores and hedgehogs using antenna stations located on hilltops or high rocky outcrops. These data allow us to understand activity patterns, assess foraging behaviour, and identify key habitat corridors for each species.

We conducted 26 intensive 24-hour tracking sessions (~2,000 animal locations obtained) during expeditions. Preliminary results were analyzed using a detailed habitat map (from a classified satellite image) developed with the help of volunteers.

We also collected 850 scats (or droppings) used to determine the food habits of carnivores and hedgehogs. To understand prey preferences (i.e. the most important prey for each species) we surveyed the two most commonly occurring prey groups, small mammals and insects.

We conducted 18 small mammal and insect abundance surveys. Each survey involved five sampling days. For small mammals, this involved setting grids of live box traps; for insects, it involved setting transects of live pitfall traps.

Other

Earthwatch volunteers assisted in maintaining our research camp, charging batteries, helping in the kitchen, getting water, entering data, and keeping our equipment clean and organized. Team VI volunteers also visited Dalanjargalan Soum Governor's office and the local nature history museum at the Soum center. Volunteers asked Governor Bold various questions about Dalanjargalan Soum in general and other questions regarding wildlife conservation. During the museum visit the volunteers learned about the Soum's history, culture, and traditions.

We collected limited data on soils and water quality in Ikh Nart in 2006 and 2007 (Tables 3 - 4). Team V in 2007 collected soil samples from three of our randomly located, but permanent vegetation sampling sites (see above under Argali and Ibex) (Table 3). Away from the water sources, the few soil samples we have collected are primarily comprised of sand (93 – 97%).

The essential elements phosphorus (P) and potassium (K) vary widely from trace amounts to very high amounts. Alternatively, nitrogen (N) was limiting in all sites sampled both this year and last Element indices in our soil sampling kit were directed at assessing arable land productivity and, since semi-desert vegetation characterizes Ikh Nart, the values we recorded were not surprising.

Table 3. Soil quality test results in Ikh Nart Nature Reserve, Mongolia, 2006-2007. Vegetation plots (Veg. plots) are randomly selected, established sampling points for vegetation analyses.

	Location				
Variable	**Spring (N 45.7238° E 108.6430°)**	**N. plateau (N 45.7268° E 108.6440°)**	**Veg. plot #9 (N 45.7717° E 108.6638°)**	**Veg. plot #25 (N 45.7989° E 108.6479°)**	**Veg. plot #63a (N 45.7800° E 108.6102°)**
Altitude (m)	1171	1198	ND	1201	1108
Date	7/24/06	7/25/06	9/9/07	9/9/07	9/9/07
% Sand	67	93	96.6	93.3	96.0
% Silt	27	7	2.7	4.0	1.3
% Clay	6	0	0.3	2.7	2.7
pH	8.0	8.0	8.0	7.5	8.5
Phosphorus[1]	Med/High	Trace	Low/Trace	Trace	High
Nitrogen[2]	<Trace	<Trace	<Trace	Trace	Trace
Potassium[3]	Med/High	Med	Med/High	Medium	Very high

[1] *Trace = very little vegetation production capacity, Low = 0-56 kg/ha, Medium = 57-112 kg/ha, High = <112 kg/ha.*
[2] *Trace = very little vegetation production capacity, Low = 0-34 kg/ha, Medium = 35-67 kg/ha, High = <67 kg/ha.*
[3] *Trace = very little vegetation production capacity, Low = 0-135 kg/ha, Medium = 136-225 kg/ha, High = <225kg/ha.*

A spring emanating near our research camp at Ikh Nart represents the source of water for researchers, wildlife, and livestock from the region. We conducted water quality tests in 2006 and 2007 (Table 4). Each test included five replicate tests for total bacteria count to examine suitability for drinking without treatment. All replicates at all sites in both years yielded positive results, emphasizing the importance of filtering or boiling all water. We found no evidence of hydrogen sulfide (H_2S), nitrites, sulfates, free chlorine, iron, or arsenic. Total nitrates varied from 5-10 ppm. One test found 250 ppm of chloride and 1 ppm of chlorine. Copper varied from 0.0 – 0.05 ppm. Total alkalinity varied from 80-150 ppm and total hardness from 50-120 ppm. The pH varied from 5.0 – 7.0.

Table 4. Water quality test results in Ikh Nart Nature Reserve, Mongolia, 2006-2007.

	Location				
Variable	**N 45.7237° E 108.6437°**	**N 45.7237° E 108.6437°**	**N 45.7237° E 108.6437°**	**N 45.7294° E 108.6286°**	**N 45.7237° E 108.6437°**
Date	8/31/06	9/4/07	9/7/07	9/4/07	9/4/07
Bacteria	Positive	Positive	Positive	Positive	Positive
Temp	46° F	48° F	53° F	57° F	52° F
Hydrogen Sulfide (ppm)	0	0	ND	ND	ND
Total Nitrate (ppm)	10	10	8	7	5
Nitrite (ppm)	0	0	0	0	0
Chloride (ppm)	250	ND	ND	ND	ND
Sulfate (ppm)	0	0	0	ND	ND
Free chlorine (ppm)	0	ND	ND	ND	ND
pH	6.5	6.5	5.0	7.0	6.5
Total alkalinity (ppm)	120	80	80	150	100
Total chlorine (ppm)	1.0	ND	ND	ND	ND
Total hardness (ppm)	50	50	80	120	80
Copper (ppm)	0.05	0	0	ND	ND
Iron (ppm)	0	0	0	0	0
Arsenic	ND	Negative	ND	ND	ND

WHAT PROGRESS HAVE WE MADE TOWARDS ACHIEVING OUR ORIGINAL OBJECTIVES?

Overall Objective: To understand the ecology of target species well enough to develop a long-term conservation management plan for the species.

We continue making progress toward this overall objective, learning about sources of mortality, habitat use, resource partitioning, behavior, and more. We used the knowledge gleaned from our work to assist Dalanjargal Soum in developing a management plan for Ikh Nart that includes actions directed at conserving wildlife. This draft plan is currently being finalized. We have also used data in national level conservation policy, plans and databases, such as recent revisions of mammalian and bird species lists and range maps, including two guidebooks in press or review. We hope to influence national level management with our data and are drafting manuscripts for publication in Mongolia and in international journals. Yet our knowledge of these species' ecology remains incomplete. We hope to continue our work for several more years.

1) *Capture and mark (a) mammals for radio collaring, including (i) 2 – 4 adult argali, (ii) 2 –6 adult ibex; (iii) 2-8 small carnivores; and (iv) 1-4 hedgehogs; and (b) birds for leg banding and wing tagging, including (i) 20-30 vulture chicks and (ii) 2-5 kestrel chicks and 2-5 adult kestrels (leg bands only).*

   We met or exceeded most of our objectives in terms of animal captures, with the exception of small carnivores. We captured and radio collared six adult argali, four adult ibex, two ibex kids, one red fox, six hedgehogs (five Daurian and one long-eared), 28 cinereous vulture chicks, seven adult lesser kestrels, and nine fledgling lesser kestrels. We also captured two collared adult ibex, so we simply released them (we changed the collar on one animal). We decided not to aggressively pursue small carnivore captures and collaring in 2007, as we are currently evaluating whether to continue that project at its current level. At this point, we plan to reduce the number of argali and ibex we capture and collar each year, as we are unable to track many more animals. We may deploy more GPS collars, which do not require active tracking by personnel on the ground.

2) *Determine sources of mortality for collared animals.*

   We continually monitor collared animals and immediately work to locate animals that die (our collars include mortality switches). For the majority of animals this is possible, but even getting to a dead animal quickly does not guarantee that we can determine the cause of death (in some cases we only find collars); a large proportion of animals that die are not easily diagnosed. Still, our project has determined the cause of mortality for most animals that died (e.g., 2 of 3, or 67%, of argali that died in 2007 and 51 of 69, or 73.9%, argali during all years of the study) and we are beginning to gain an understanding of the most important mortality factors for the different species we study.

3) *Understand movement patterns and habitat use of collared animals.*

   We have been tracking radio collared animals throughout the year, although we do not get locations on all animals each day (usually only once every several days) and some animals go several days without locations being recorded. We have not had the time to rigorously analyze all of the movement data collected, but we are beginning these analyses (see below and Reading et al. 2003, 2005a, in review, Murdoch et al. in press). We have gathered some satellite imagery data and collected a substantial amount of vegetation data as well

that will permit us to examine habitat use in the future (Jackson et al. in review). We are also gathering data on small carnivore prey that we will use to compare with carnivore use areas (Murdoch et al. in review).

4) *Compare habitat use and food sources of argali sheep, ibex, domestic sheep and goats, small carnivores, and hedgehogs.*

   Our analyses of dietary overlap between argali sheep and domestic shoats are complete and published or in review (Wingard 2005, Wingard et al. in preparation a, b). Basically, we found substantial overlap in the diets of these ungulates, which has serious management implications for the reserve. We have just begun a Master's project comparing argali and ibex habitat utilization (Tuugii). We completed a comparison of red and corsac fox prey (Murdoch et al. in review) that found substantial overlap at broad, categorical levels, but less overlap when analyzed at a finer level (i.e., the foxes eat similar amount of invertebrates and small mammals, but the species composition of their diets differs). We collected good data on Daurian hedgehogs (Murdoch et al. in press), but insufficient data thus far on long-eared hedgehogs for a good comparison of the two species. PI James Murdoch will be analyzing more of the small carnivore data for Ph.D. dissertation at Oxford University in 2008.

5) *Determine cinereous vulture and lesser kestrel nesting success rates and sources of nest failure.*

   Our cinereous vulture nesting ecology study is progressing well. Our first two years served as a pilot study (Reading et al. 2005b) for our more rigorous research since that time. We have completed the initial analyses of our 2007 data (summarized below). Although we are getting a handle on vulture chick development and nest failure rates, we still do not understand the factors that influence nesting success, but may gain more insight as we conduct more in-depth analyses of our data. In any case, we will continue collecting data in 2008 at the reduced intensity of monitoring we used in 2007 (we will simply check nests, but not go into any during the nesting period). We began our lesser kestrel work in 2007 and have insufficient data to adequately evaluate the factors influencing nesting success and sources of nest failures at this point.

6) *Use the data collected from our research to develop a conservation management plan for wildlife in Ikh Nart.*

   We have worked with the Mongolian federal government to develop a national management plan for argali. However, despite our optimism for completion of this management plan last year, it remains in draft form. It is not clear that the government has an interest in finalizing the plan, but we continue to monitor the situation. A revised Mongolian Red Data Book on threatened and endangered species and associated actions plans appeared in early 2007 (Clark et al. 2006a, 2006b) to which we contributed substantially.

   On a local level, we continue to work actively with the Soum governor (equivalent to county level) and other local officials to improve management of Ikh Nart. Toward that end, we drafted a management plan that we hope to finalize in 2008; provided training and equipment to the ranger corps we created in 2006; continued to develop environmental education programs in the Soum and throughout the region; finalized plans to construct an ecotourism camp adjacent to Ikh Nart in 2008 to help generate revenue for the reserve; and finalized a sister park relationship with Anza-Borrego State Park in California, USA. We are searching for funding to construct a visitor center for Ikh Nart.

7) *Train Mongolian biologists and conservationists*.

Training continues to progress well. In 2007, we worked with and trained three Mongolian undergraduate students, four Mongolian graduate students, three researchers with the Mongolian Academy of Sciences, and one Mongolian researcher with a Mongolian NGO. One of the Mongolian researchers at the Academy is also pursuing his Ph.D. at the Mongolia National University.

SUMMARY OF RESULTS

Argali Sheep

We continue to gain an ever-improving picture of the ecology of argali sheep in Ikh Nart (Reading et al. In review b, Wingard et al. In preparation a, b). We submitted several papers for publication over the past year and have others that we continue to draft. Management recommendations based on our research were included in a draft conservation management plan for Ikh Nart that we hope will become final soon. Unfortunately, continued changes in government (the most recent government, formed less than two years ago, collapsed in October and the new coalition is working to create a new government) prevent us from working effectively at the national level on argali conservation, although we continue to try.

Some of work on argali lambs over the past few years is summarized in a paper currently in review with the Journal of Mammalogy – Argali lamb (*Ovis ammon*) morphometric measurement and survivorship in Mongolia. Rather than repeat the analyses in that draft manuscript, we enclose a copy as a part of this report. The abstract of that paper follows. Please refer to the full, attached manuscript for more detail (Reading et al. In review b):

> **Reading et al. (In review b) Abstract**:
> Argali sheep (*Ovis ammon*) are globally threatened, but little data exists on the biology and ecology of the species. From 2003 to 2007 we hand captured 66 argali lambs (33♂, 32♀, one undetermined) and attached expandable, drop-off radio collars in Ikh Nart Nature Reserve, Mongolia. We collected morphometric and physiological measurements and radio tracked lambs to obtain data on survivorship and mortality factors. We believe this is the first large scale analysis for lamb morphometrics and survivorship for this threatened species. We found similar morphometric and physiological measurements for male and female lambs, with significant differences only in tail length and respiration rates (♀ > ♂ for both). Few argali lambs (25.5%) survive the first three months of life, but thereafter their mortality rate decreases substantially. Early survival varied significantly by year. We found no significant effect of any physiological or morphometric variables we measured on lamb survival. Argali lambs die from several causes, with predation (37.0%), starvation (19.6%), and unknown causes (32.6%) being most important. We found high mortality in year with severe drought in (2005 – 2006), that depressed overall survivorship in our study.

Movement Patterns & Habitat Use.

We continue to a better understanding of argali movement patterns and home range sizes. We finished analyzing home ranges of argali through 2006 during this past year using both minimum convex polygon (MCP) and adaptive kernel methods (Table 5), although our last publication on this topic was Reading et al. (2005a). From 2002-2006 we found no significant difference in MCP home range sizes during spring, summer, fall, and winter (F = 1.20, df = 3, 28, P = 0.33, adj. R^2 = 0.11). Similarly, in our earlier analyses (Reading et al. 2005a), we found no evidence for seasonality in argali movement patterns. This may be due to the fact that argali in our study site do not inhabit a mountain range, but a relatively level area with rocky outcrops.

Home range sizes varied substantially between years even for the same individual animals (Table 5, Figure 1). Excluding 2002, for which we had very little data, we found that home range sizes were significantly different among years for smaller % kernel home ranges (25% Kernel: $F_{3,56}$ = 3.22, P = 0.03; 50% Kernel: $F_{3,55}$ = 2.85, P = 0.04), but these differences were more equivocal for larger % kernel home ranges (75% Kernel: $F_{3,55}$ = 2.72, P = 0.5; 95% Kernel: $F_{3,55}$

= 2.58, *P* = 0.06). We found no significant differences among years for MCP home ranges ($F_{3,63}$ = 1.14, *P* = 0.34). We found significant differences in pairwise comparisons among years using Bonferonni's post hoc test on any home range analysis for any pair of years (P > 0.25). Nevertheless, mean home ranges were smallest in 2002 (but again, we had very little data), followed by 2004 and 2005. Mean home ranges were largest in 2006. These changes may reflect changes in forage availability (i.e., during poor forage year, the argali range further), increased harassment of argali (by illegal miners, for example) in some years, or a combination of these and other factors. In any case, these ranges are mostly larger than ranges for desert bighorn sheep (*Ovis canadensis*), but this is not surprising, as argali are more of a cursorial animal than bighorn, built more for running than climbing.

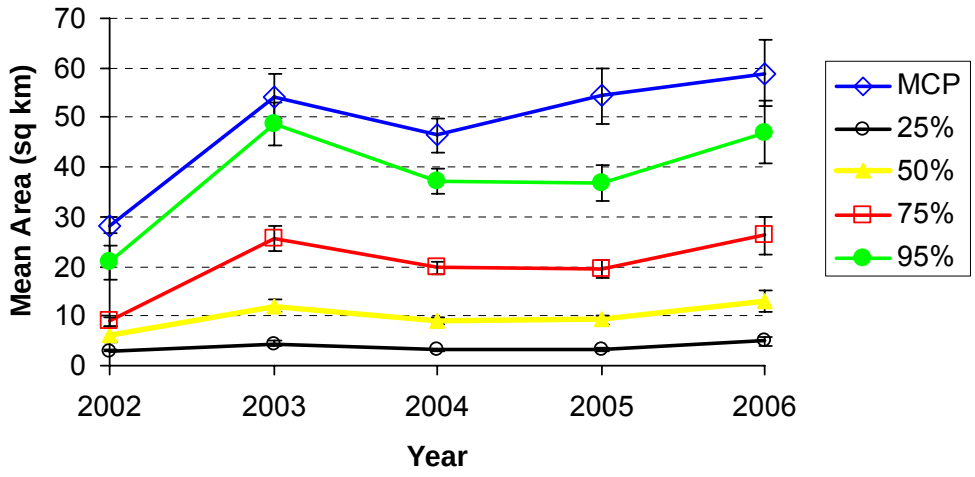
Table 5. Argali (*Ovis ammon*) home ranges using telemetry data in Ikh Nart Nature Reserve, Mongolia, 2002-2006. Only animals with greater than 25 fixes per analysis used.

			Kernel (km^2)			
Name	**Year**	**MCP (km^2)**	**25%**	**50%**	**75%**	**95%**
Amaraa	2004	44.04	1.80	4.86	12.41	24.34
	2005	45.43	2.18	6.87	16.71	35.44
Ambii	2004	30.32	2.40	6.08	11.38	19.63
Amgaa	2002	26.95	2.80	4.55	9.70	17.49
Baatarmaa	2004	23.43	2.15			
	2006		2.60	6.40	11.40	19.70
Bandi	2005	54.15	1.50	3.77	6.75	11.19
Barkhas	2006	84.97	6.26	15.14	28.69	50.72
Bataa	2004	44.49	2.82	8.67	21.07	42.11
	2005	118.70	6.82	17.20	35.96	72.03
Batbold	2003	48.51	4.45	11.80	23.58	45.09
Batorshik	2003	49.50	6.29	15.93	33.26	58.41
	2004	20.55				
Bayanaa	2003	36.97	1.68	6.07	16.69	33.91
Bor	2002	24.35	3.11	7.84	8.11	24.27
	2003	19.77	1.95	4.50	8.11	13.89
Brian	2004	36.53	2.38	7.35	18.10	37.87
Buya	2006	67.24	5.66	16.17	32.07	55.41
Choi	2003	42.23				
	2004	42.70	4.00	10.52	19.74	34.00
Debmaa2	2003	46.52	3.22	9.99	22.16	46.37
Dot	2004	31.67	2.69	7.27	15.19	28.20
	2005	19.94	2.28	5.40	10.20	19.43
Eggnog	2004	37.15	2.48	6.87	13.14	22.44
	2005	23.29	1.48	4.78	10.89	20.32
Ganaa2	2004	39.45	3.19	8.83	18.13	31.64
	2005	92.00	4.51	11.39	23.17	45.59
	2006	59.04	4.13	11.15	25.21	46.96
Janice	2005	62.81	2.14	5.82	12.32	23.77
Jargal	2004	39.21	3.55	9.15	18.26	33.55
	2005	87.94	3.65	11.12	23.89	43.05
Jed	2004	49.67	4.21	10.80	22.91	44.23

Table 5. Continued.

Name	Year	MCP (km^2)	Kernel (km^2) 25%	50%	75%	95%
Jerry	2004	42.72				
	2005	48.90	4.82	11.88	22.62	40.74
	2006	34.85	2.63	6.53	15.30	30.31
Jill	2006	57.56				
Joe	2005	25.90	2.71	7.52	15.11	26.31
	2006	19.44				
Khatan	2006	56.39				
Khokh	2005	60.92	4.48	13.19	29.09	54.30
Khongilt	2005	44.89	3.04	9.39	21.75	37.95
Lauren2	2004	75.80	2.63	8.65	24.02	50.37
Lisa2	2005	63.66				
	2006	109.77	10.12	26.35	50.44	878.75
Lynn	2004	39.39				
	2005	45.48	1.82	5.04	11.38	24.13
	2006	46.35	1.04	4.58	12.50	23.98
Mandakh	2002	29.35				
	2003	75.43	4.64	13.67	31.02	61.13
	2004	60.46	3.27	9.91	21.27	39.91
	2005	69.18	4.49	12.27	26.40	48.38
	2006	63.17	4.51	11.63	24.08	45.80
Namshir	2003	62.62	3.15	8.19	18.27	41.24
	2004	61.45	4.46	11.04	21.63	38.30
Onon	2003	56.56	3.97	11.51	24.96	47.01
Otgoo	2003	60.39	8.77	21.50	39.95	66.36
Purev	2004	57.02	3.50	9.66	21.19	40.13
Scott	2005	20.19	1.82	4.87	10.18	18.49
Sue	2004	54.48	2.27	7.36	18.95	37.67
	2005	43.47	4.41	11.80	23.32	42.06
	2006	51.44	6.67	17.97	35.74	62.38
Tonimaa	2003	74.07	4.60	13.51	31.88	61.29
Toogii	2004	5 2.89	3.53	9.23	19.79	40.37
Tuya	2002	32.32				
	2003	76.99	4.72	13.04	27.31	51.62
	2004	52.10	3.59	9.98	21.20	39.36
	2005	59.75	3.27	9.80	21.23	40.26
	2006	56.84	5.54	13.96	26.66	47.75
Vicky	2005	44.79	5.74	13.98	28.45	54.24
Zulaa	2003	54.52	5.61	14.93	31.42	57.84
	2004	86.36	5.78	17.65	36.57	64.22
	2005	55.83	3.20	10.05	22.14	42.37

Figure 1. Mean (±SE) home range sizes of argali sheep in Ikh Nart Nature Reserve, Mongolia, 2002-2006.



Argali sheep from the northern part of Ikh Nart utilize two main areas of the reserve: an area just north of our research camp with some large, rocky outcrops and an area even further north, with less rocks and more rolling terrain (see figures in Reading et al. 2005a). Another important region exists in the southern park of Ikh Nart near another permanent water source. Now that we have these telemetry data we can analyze the habitat characteristics that draw argali to these regions. We have been collecting data on vegetation within and outside of these heavy use areas for future comparisons. We will also use a geographic information system (GIS) to analyze other variables, such as proximity to water, roads, people, and rocky areas.

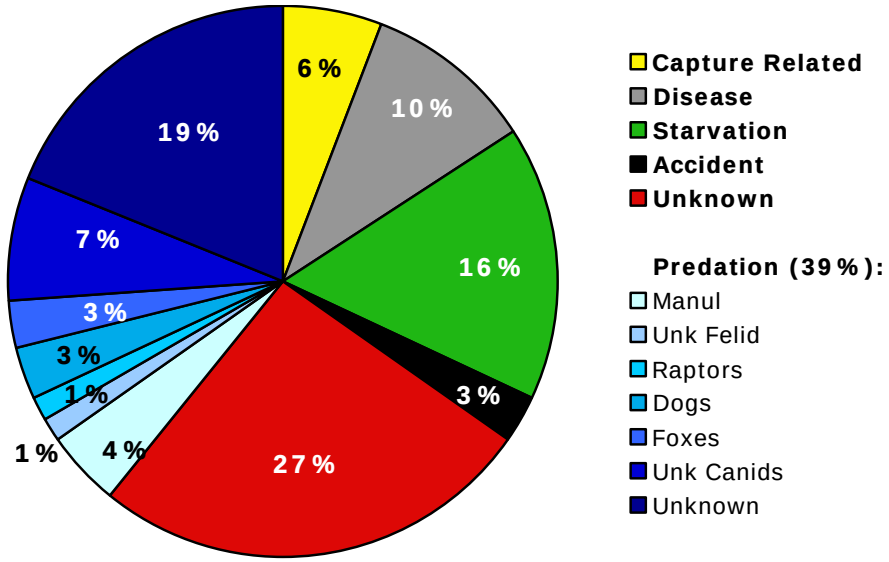
During Team V in September, we confirmed the location of a five month old radio collared argali lamb who, with her mother, travelled about 150 km to south from his capture site. This lamb was radio-collared in the beginning of the April and we were unable to locate him in the Nature Reserve since the end of June. These data suggest that this lamb travelled south when he was only three months old!

Mortality.

Overall, of the 107 argali we collared in Ikh Nart since 2000, at least 69 (64.5%) have died. An additional 15 animals lost their collars (some collars are designed to fall off) and may or may not still be alive. Lambs comprised the vast majority (71.0%) of the mortalities we recorded, and we expect high mortality rates for neonatal animals (< 6 weeks old), which comprised 52.2% of all mortalities. Predators killed the majority of argali (n = 27) for which we could determine a cause of death (Figure 2). In addition, 11 animals died of starvation, 7 died from disease, 4 from capture related problems, and 2 from accidents (e.g., falling; Figure 1). We could not determine the cause of death for the other 18 animals.

For 13 (18.8%) argali killed by predators, we were unable to determine the predator (Figure 2). Of the remaining 14 mortalities, nine were killed by canids, three neonatal lambs were killed by Pallas' cats, one animal was killed by an unknown felid, and one neonatal lamb was killed by a raptor. Kills by canids included two neonatal lambs killed by red foxes, two yearlings killed by domestic dogs (we witnessed these), and five argali killed by either domestic dogs or wolves. Of course, predation might well be the proximate cause of mortality for animals already predisposed due to illness or starvation, which should be considered the ultimate cause of death.

Figure 2. Causes of Death for Radio Collared Argali in Ikh Nart Nature Reserve, Mongolia, 2000-October, 2007.



Behavior.

Although we did not collect additional behavioral data on argali during the 2007 Earthwatch season, we did work on analyzing the data. Tsogoo completed his Master's degree at the Mongolian National University last March, and we are currently working to draft at least one publishable manuscript from that body or work.

Siberian Ibex

We are beginning to gain a preliminary understanding of Siberian ibex ecology and submitted our first paper on the species for publication (Reading et al. In review a). One of our Mongolian Master's students is comparing the ecology of ibex and argali sheep for his Master's project.

Rather than repeat the analyses from our draft manuscript - Siberian Ibex (*Capra [ibex] sibirica*) Home Ranges and Mortality in Ikh Nart Nature Reserve, Mongolia - we enclose a copy of that paper as a part of this report. The abstract of that paper follows. Please refer to the full, attached manuscript for more detail (Reading et al. In review):

Reading et al. (In review a) Abstract:
Siberian ibex (*Capra [ibex] sibirica*) populations in Mongolia appear to be relatively stable, but little is known about their ecology, as few ecological studies have been conducted outside of Russia. We began studying ibex in Ikh Nartiin Chuluu, Dornogobi Aimag, Mongolia to better understand the species' ecological needs and threats. We captured 27 ibex and fit them with radio telemetry collars using drive nets for adults and juveniles (*n* = 24) and hand captures for neonatal kids (*n* = 5). We collected 1,029 locations from September 2003 to February 2007. Throughout the study, nineibex with 40+ fixes used mean, annual home range sizes of 3,115.5 ± 504.2 ha using the Minimum Convex Polygon method. Home ranges calculated using the fixed kernel method were smaller: 171.5 ± 2.8 ha for 25% kernel; 475.9 ± 14.7 ha for 50% kernel; 982.9 ± 33.8 ha for 75% kernel; and 1,808.0 ± 88.1 for 95% kernel. Ibex from different demographic groups (males vs. females and juveniles vs. adults) used remarkably similar home ranges; we found no significant differences among any demographic groups. Although not quantified, ibex mostly restricted their activities to areas with steep cliffs and rocky outcrops and home ranges overlapped extensively. Of the 27 ibex we have captured and collared, 9 (33.3%) have died, primarily (*n* = 4; 44.4%) due to predation.

Cinereous Vultures

We located a total of 51 vulture pairs that attempted to nest in 2007, of which 32 were located on rocky outcrops and 19 on trees (Siberian elm; *Ulmus pumila*). As in past years, most of nesting failures occurred during the ~55 day incubation period from March to early May (Figure 3). By June, all nestlings that we located were destined to survive until fledging. Overall, 70.6% (N = 36) of the nesting pairs raised a chick to fledgling. This was our highest nesting success rate to date, but it was also a relatively small number of nesting pairs. It is possible that several pairs that nested in March failed before we began checking nests in the first week of April.

Figure 3. Cinereous vulture (*Aegypius monachus*) nesting success for nests located in trees or on rocky outcrops over time in Ikh Nart Nature Reserve, Mongolia, 2003-2007. Top: Number of active nests remaining over time. Bottom: Percentage of active nests remaining over time.

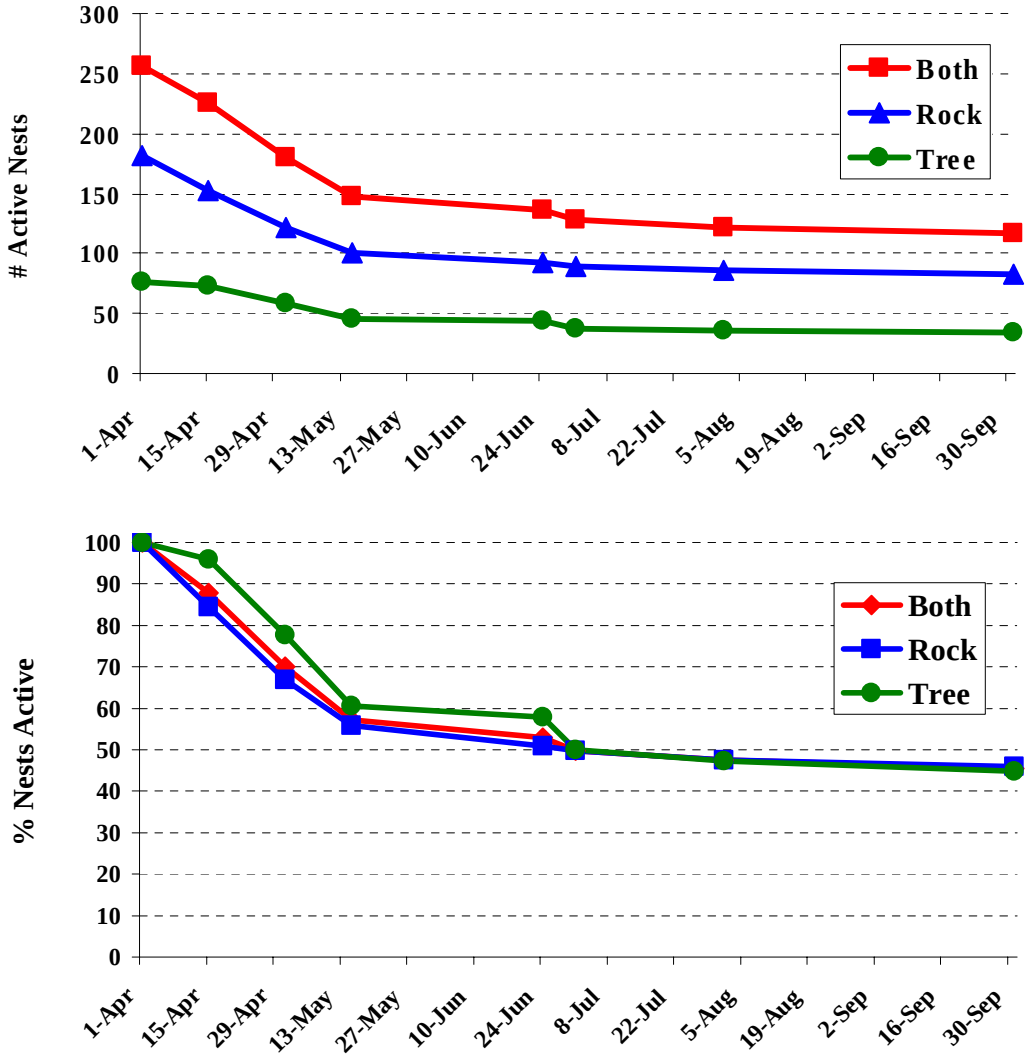


Figure 4. Dispersal of cinereous vulture (*Aegypius monachus*) fledglings from Ikh Nart Nature Reserve, Mongolia, 2006-2007.

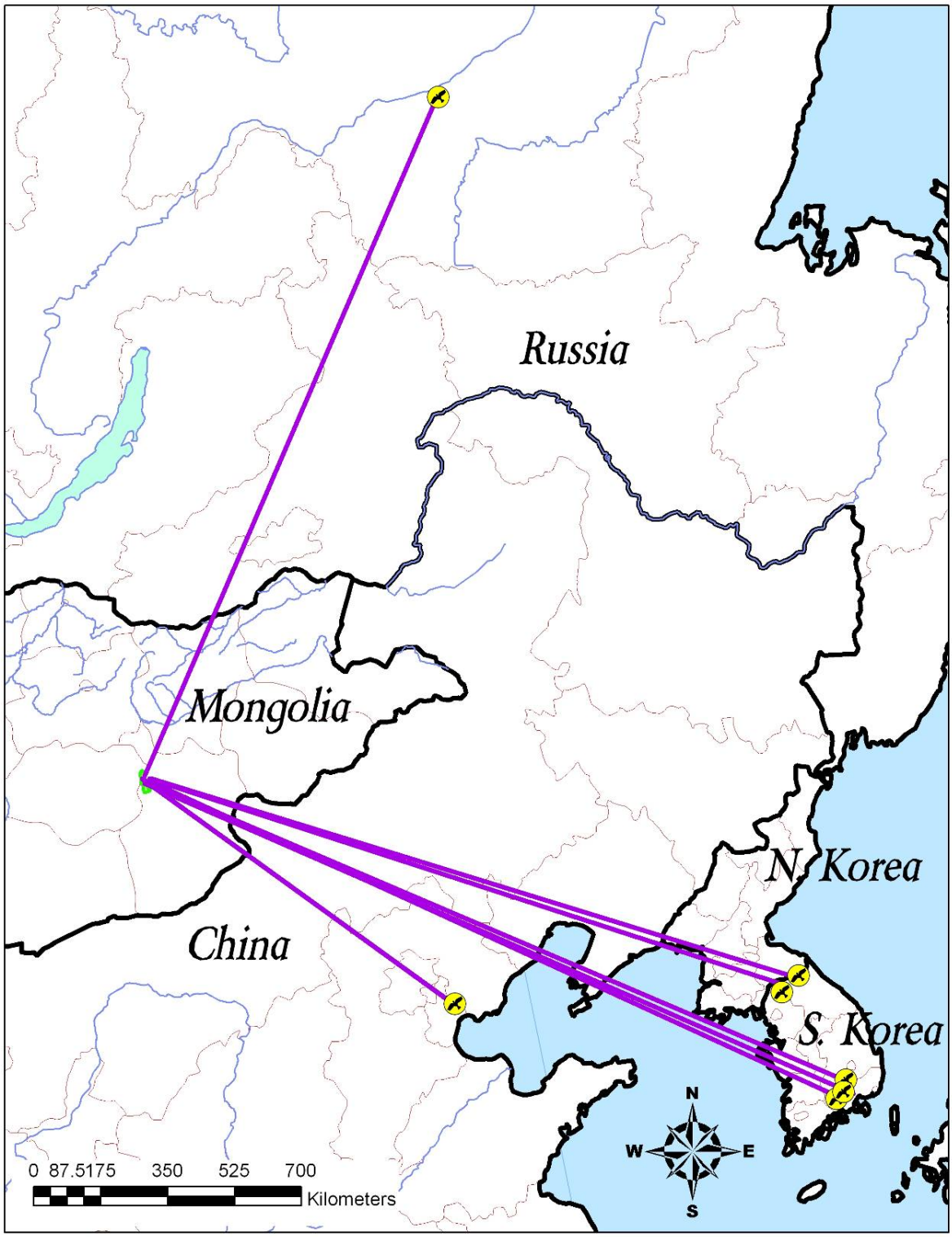


Table 6. Cinereous vulture (*Aegypius monachus*) mean (±SE) egg characteristics in Ikh Nart Nature Reserve, Mongolia, 2005-2007.

Year	Length (cm)	Width (cm)	Weight (g)	Shell Thickness (mm)
2005	9.43 ± 0.12 (n = 10)	7.21 ± 0.11 (n = 10)	240.56 ±8.95 (n = 9)	No Data
2006	9.40 ± 0.06 (n = 51)	7.26 ± 0.03 (n = 51)	249.11 ± 3.22 (n = 51)	0.48 ± 0.02 (n = 19)
2007	9.26 ± 0.11 (n = 15)	7.23 ± 0.04 (n = 15)	241.00 ± 5.53 (n = 15)	0.60 ± 0.03 (n = 3)
All Years	9.38 ± 0.05 (n = 76)	7.25 ± 0.03 (n = 76)	246.46 ± 2.68 (n = 75)	0.49 ± 0.02 (n = 22)

Lesser Kestrels

We investigated the reproductive biology and nesting colonialism of this small falcon species. Colonial nesting is rare among falcons. We located and observed 29 nest sites on talus slopes by three biologists and two teams of volunteers from June 1 to August 14. Of these 29 nests, we found 23 in five colonies and the remaining 6 as lone, isolated nests. Nesting colony varied, ranging from 2 to 10 nests in a colony. Each nesting pair that fledged chicks successfully reared 1 to 3 chicks. We banded 7 adults (6♂ and 1♀) and 9 fledglings (3♂, 2♀, and 4 of unknown gender; Table 7). In addition, we collected morphometric data on these 16 birds that we hope to analyze in 2008. These data should provide important baseline data for our future work.

Table 7. Lesser kestrels (*Falco naumanni*) banded in Ikh Nart Nature Reserve, Mongolia, 2007.

Nest Colony	Date	Nest	Gender	Age
A	7/15/2007	25	♂	Adult
A	7/16/2007	41	♂	Adult
C	7/15/2007	39	♂	Adult
D	7/14/2007	34	♂	Adult
D	7/14/2007	35	♂	Adult
E	7/12/2007	33	♀	Adult
F	7/13/2007	30	?	Chick
F	7/13/2007	30	?	Chick
A	8/7/2007	16	?	Chick
A	8/8/2007	22	♀	Chick
B	8/9/2007	29	♂	Adult
E	8/9/2007	33	♂	Chick
E	8/9/2007	33	♂	Chick
New 3	8/13/2007	43	♀	Chick
B	8/14/2007	29	?	Chick
B	8/14/2007	29	?	Chick

Small Carnivores & Their Prey

This project studies four small carnivores and their insect, reptilian, and small mammal prey. Corsac foxes and Pallas' cats occupy mainly steppe biotopes, relying especially on areas covered in tall vegetation (>1m) where prey density is high relative to other habitats. Corsacs also rely on marmot burrows (typically found in open shrub habitats) for shelter from daytime weather and refuge from predators. Red foxes and badgers occupy rockier, semi-desert biotopes, but also range in steppe areas. Rocky areas tend to have lower prey density, but are hunted considerably less by herders relative to steppe areas. Red foxes, badgers, and Pallas' cats use steep-sided drainages as important corridors between habitats. We speculate that drainages are key to their survival and should be considered as conservation priority areas.

We began a more in-depth analysis of the biotopes for the two fox species and submitted a paper on this topic for publication (Murdoch et al. In review a) – Biotope of corsac and red fox in Ikh Nart Nature Reserve. We include the abstract for that paper below:

> **Murdoch et al. (In review a) Abstract:**
> Corsac foxes (*Vulpes corsac*) and red foxes (*V. vulpes*) range widely across northern and central Asia, occupying a variety of arid biotopes. In Mongolia, both species live sympatrically throughout most of the country, but few details of their habitat associations exist. We examined the biotope of corsac and red foxes in Ikh Nart Nature Reserve in Dornogobi Aimag, Mongolia, which lies at the confluence of steppe and semi-desert vegetation zones. We evaluated the extent to which both species occur in these two zones and the habitats within them based on locations of scats (*n* = 1,967), opportunistic sightings (*n* = 219), and captures (*n* = 35) collected from August 2004 to August 2007. Corsac and red foxes occurred in both steppe and semi-desert zones and all habitat types in the reserve. However, corsacs occurred more frequently than expected in steppe zone and red foxes occurred more than expected in semi-desert zone. Corsac locations associated positively with steppe habitats, including grass, shrub, and semi-shrub plains, whereas red fox locations fell mainly in drier, more rugged semi-desert habitats, suggesting ecological separation exists between species. As corsac and red foxes appear to be declining in Mongolia, our results suggest that protection efforts in Ikh Nart should focus on steppe habitats for corsacs and semi-desert habitats for red foxes.

All carnivore species consumed a wide diversity of foods including small mammals, insects, reptiles, birds, fruits and seeds, and refuse. During winter months when prey becomes scarce, diets between species overlap substantially. Conservation efforts need to focus on protecting a broad spectrum of prey sources, not only a select few. We drafted a paper on fox diets that we submitted for publication and is currently in review (Murdoch et al. In review b) – Seasonal food habits of sympatric corsac and red foxes in Mongolia. The abstract of that paper follows:

> **Murdoch et al. (In review b) Abstract:**
> Corsac foxes (Vulpes corsac) and red foxes (V. vulpes) live sympatrically across many parts of Asia. The mechanisms that allow them to coexist, however, remain largely unknown, but probably involve the partitioning of food and habitat resources. We examined the food habits of both species in an arid steppe region of Mongolia by analyzing scats collected from April 2005 to April 2006 to test the extent to which partitioning of diet occurs. We estimated diet composition by calculating the percent occurrence and percent volume of food items in scats and tested for differences between species each season and overall. We analyzed 426 corsac fox and 480 red fox scats. Corsac and red fox diet consisted mainly of insects and small mammals. Both species also consumed a variety of other foods including birds, reptiles, large mammals (carrion), and plant material (seeds and fruit). These groups, however, occurred less frequently and

accounted for lower overall volume than insects and small mammals. Despite high overlap (79 to 90%) in the proportion of food items consumed, differences existed between species in overall diet. We detected interspecific differences during the pup rearing and dispersal seasons, when prey was abundant, but not during the breeding season, when prey was scarce. Each species' diet also differed seasonally and exhibited moderate overall breadth. Our results suggest that partitioning of food resources during most of the year facilitates coexistence and limits the potential for competition. Corsac foxes (Vulpes corsac) and red foxes (V. vulpes) live sympatrically across many parts of Asia. The mechanisms that allow them to coexist, however, remain largely unknown, but probably involve the partitioning of food and habitat resources. We examined the food habits of both species in an arid steppe region of Mongolia by analyzing scats collected from April 2005 to April 2006 to test the extent to which partitioning of diet occurs. We estimated diet composition by calculating the percent occurrence and percent volume of food items in scats and tested for differences between species each season and overall. We analyzed 426 corsac fox and 480 red fox scats. Corsac and red fox diet consisted mainly of insects and small mammals. Both species also consumed a variety of other foods including birds, reptiles, large mammals (carrion), and plant material (seeds and fruit). These groups, however, occurred less frequently and accounted for lower overall volume than insects and small mammals. Despite high overlap (79 to 90%) in the proportion of food items consumed, differences existed between species in overall diet. We detected interspecific differences during the pup rearing and dispersal seasons, when prey was abundant, but not during the breeding season, when prey was scarce. Each species' diet also differed seasonally and exhibited moderate overall breadth. Our results suggest that partitioning of food resources during most of the year facilitates coexistence and limits the potential for competition.

Hedgehogs

We conducted in-depth analyses of some of our data on Daurian hedgehog ecology (we do not yet have enough data on long-eared hedgehogs). We included these analyses in a manuscript accepted for publication (Murdoch et al. In press). Rather that repeat the analyses from that manuscript - Ecology of the Daurian Hedgehog (*Hemiechinus dauuricus*) in Ikh Nart Nature Reserve, Mongolia: Preliminary Findings - we enclose a copy of it with this report. The abstract follows. Please refer to the full, attached manuscript for more detail (Murdoch et al. In press):

Murdoch et al. (In press) Abstract:
The Daurian hedgehog ranges across northern Mongolia, southern Siberia, and northern China. However, few details of the species' behavior, ecology, or distribution are known. We conducted a pilot study of the ranging behavior and diet of Daurian hedgehogs in Ikh Nart Nature Reserve, Mongolia. We captured and radio-tagged 8 hedgehogs (6 males/2 females) between June and September 2006. We tracked their movements until hibernation to estimate home range sizes and daytime nest characteristics. We also analyzed scats (N = 38) to gain a preliminary understanding of the food habits of the species. During the study, we collected 237 hedgehog locations, including 91 night, 141 day, and five hibernation sites. Hedgehogs were followed a mean of 53.43 ± 4.35 SE days from capture before entering hibernation. Mean home range size for seven hedgehogs was 422.72 ± 94.07 SE ha. Daytime nest sites had one, rarely two entrances, and usually occurred in rocky outcrops or at the base of shrubs. The most frequently occurring prey groups in scats included beetles (47%), cockroaches (28%), and grasshoppers (20%). Scats also included bird (3%), reptile (1%), and rodent (1%) remains. Daurian hedgehogs in Ikh Nart were generally larger in size, occupied larger home ranges, and ate similar foods compared to Daurian hedgehogs in other regions. The presence of Daurian hedgehogs in Ikh Nart also represents a range extension for the species.

SIGNIFICANCE/BENEFITS OF RESEARCH

What is/are the significance/benefits of our research at the local, national, and international levels?

How do our findings contribute to issues of sustainability?

Our research and conservation efforts are beginning to provide benefits locally, nationally, and internationally. Overall, our work is improving our understanding of several globally significant species about which very little is currently known. Some of the work was incorporated into IUCN Red Book summaries for Mongolian mammals and Action Plans for several species (Clark et al. 2006a, 2006b). We hope our work will also contribute to conservation efforts throughout the range of several of these species. We were the first and remain the only long-term research project that extensively studies argali sheep, Siberian ibex, corsac foxes, and Daurian hedgehogs using radio telemetry. We are also conducting the first intensive studies of lesser kestrels, red foxes, and Eurasian badgers in Central Asia. The insight gleaned through this work is already significant, as we have identified:

1. range extensions for several species;
2. an important and previously unrecognized source of mortality for argali – domestic guard dogs;
3. the importance of invertebrates to the diets of small carnivores in our study area;
4. over-harvesting of small carnivores as a significant threat to those species, and
5. the significance of Ikh Nart as an important bird breeding area for cinereous vultures and lesser kestrels.

We are also elucidating several other important ecological traits and threats that should help wildlife managers in Ikh Nart, in Mongolia, and throughout the range of these species in Central Asia to better manage them (for example, by better estimating the potential impacts of pastoralism, animal harvests, and the size of protected areas required to conserve each species).

Currently, little is understood about all of the species we study. Yet, the pressures on the species we study continues to grow inside and outside Mongolia. Some of these pressures relate to increasing demands by growing livestock herds, while other pressures relate to exploitation of natural resources (especially unregulated mining) and to the demand for pelts and body parts for traditional Chinese medicine. This increases the importance of management, which should be based on sound science.

We conduct our work as if it is one large training program for our Mongolian colleagues. As such, the project is benefiting the local area and Mongolia in general by training Mongolian ecologists and conservation biologists who will be better able to take these skills and use them to advance wildlife management and conservation locally and nationally (if not internationally). Over the past year, we continued training three Mongolian undergraduate students, four Mongolian graduate students, three researchers with the Mongolian Academy of Sciences, and one Mongolian researcher with a Mongolian NGO. One of the Mongolian researchers at the Academy is also pursuing his Ph.D. Several of our colleagues are already involved in conservation management planning on the national level. All of this bodes well for the sustainability of our work, because it is our Mongolian colleagues who will continue our research

and conservation initiatives into the future. It is they who are in the best position to meld our research results with the local culture to develop sounder, more sustainable management plans. Indeed, one of our graduate students completed his Master's in March and now works for a Mongolian conservation non-profit organization.

Hopefully, the benefits of a better managed nature reserve will extend beyond the animals and plants inhabiting the reserve to the people living in and around Ikh Nart. Our work is already demonstrating benefits in terms of growing wildlife populations that are more habituated to humans. This work increases the opportunities for nature-based tourism and associated job opportunities, which we are promoting through our project to develop better, more active and sustainable management of Ikh Nart. Our project already employs two local people full time, 12 local people part time, and has created an additional eight positions through our Ikh Nart management project. As such, our project enjoys the full support of the county governor and the local community. We worked with a local tour operator in 2007 to create an agreement that will result in establishing an ecotourism camp near Ikh Nart in 2008. Part of that agreement includes a conservation tax to create a sustainable source of income for the local government to help support their conservation and management activities for Ikh Nart. Luckily, we work in a region where the local people strongly value a healthy environment and support our efforts to ensure a sustainable future for them, their families, and the myriad of plants and animals that co-inhabit Ikh Nart with them.

DISSEMINATION OF RESULTS

Publication of results in scientific papers

Peer Reviewed & Published

Reading, R. P., D. J. Bedunah, and S. Amgalanbaatar. 2006. Conserving biodiversity on Mongolian rangelands: Implications for protected area development and pastoral uses. Pp 1-17, in: D. J. Bedunah,E. D. McArthur, M. Fernandez-Gimenez (Comps.) Rangelands of Central Asia: Transformations, Issues and Future Challenges. 2004 January 27; Salt Lake City, UT. RMRS-P-39. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Peer Reviewed & In press

Clark, H., J. Murdoch, D. Newman, and C. Sillero-Zubiri. In press. *Vulpes corsac*. Mammalian Species, in press.

Kenny, D. E., A. J. DeNicola, S. Amgalanbaatar, Z. Namshir, G. Wingard, and R. P. Reading. In press. Three field capture techniques for free-ranging argali sheep (*Ovis ammon*) in Mongolia. Zoo Biology.

Murdoch, J. D., Batdorj, B. Suuri, D. Kenny, and R. P. Reading. In press. Ecology of the Daurian hedgehog (*Hemiechinus dauuricus*) in Ikh Nart Nature Reserve, Mongolia: preliminary findings. Mongolian Journal of Biological Sciences.

Reading R., S. Amgalanbaatar, J. Murdoch, G. Wingard, and D. Kenny. In press. Working to conserve Mongolia's natural heritage. In: Proceedings of the Association of Zoos and Aquariums Annual Conference, Philadelphia, Pennsylvania. (Ed. by T. Lewthwaite). AZA, Bethesda, Maryland, USA.

In Review

Jackson, D. S., J. D. Murdoch, and B. Mandakh. In review. Habitat classification using Landsat-7ETM+ imagery of the Ikh Nart Nature Reserve and surrounding areas in Dornogobi Aimag, Mongolia. Mongolian Journal of Biological Sciences.

Murdoch, J., T. Munkhzul, B. Suuri, and R. Reading. In review a. Biotope of corsac fox and red fox in Ikh Nart Nature Reserve. Mongolian Journal of Biological Sciences.

Murdoch, J., B. Suuri, T. Munkhzul, C. Sillero-Zubiri, and R. Reading. In review b. Seasonal food habits of corsac and red foxes in Mongolia. Journal of Zoology.

Murdoch, J. D., Ts. Munkhzul, S. Amgalanbaatar, and R. P. Reading. In review c. Checklist of mammals in Ikh Nart Nature Reserve. Mongolian Journal of Biological Sciences.

Reading, R. P., S. Amgalanbaatar, D. Kenny, A. DeNicola, and E. Togoldor. In review a. Siberian Ibex (*Capra [ibex] sibirica*) Home Ranges and Mortality in Ikh Nart Nature Reserve, Mongolia. Ecological Research.

Reading, R. P., D. Kenny, S. Amgalanbaatar, A. DeNicola, and G. Wingard. In review b. Argali lamb (*Ovis ammon*) morphometric measurements and survivorship in Mongolia. Journal of Mammalogy.

Wingard et al. In preparation a. Forage Composition and Dietary Overlap of Argali sheep (*Ovis ammon*) and Domestic Livestock in Ikh Nart Nature Reserve, Mongolia

Wingard et al. In preparation b. Seasonal Forage Availability and Nutritional Quality for Argali sheep (*Ovis ammon*) in Ikh Nart Nature Reserve, Mongolia

Books, chapters, illustrations

Argali photograph in the April 2007 issue of National Geographic Magazine.

Management plans and reports

We contributed to the following publications that are used by natural resources agencies in Mongolia:

Clark, E. L., Munkhbat, J., Dulamtseren, S., Baillie, J. E. M., Batsaikhan, N., Samiya, R. and Stubbe, M. (compilers and editors). 2006a. Mongolian Red List of Mammals. Regional Red List Series Vol. 1. Zoological Society of London, London. (In English and Mongolian)

Clark, E. L., Munkhbat, J., Dulamtseren, S., Baillie, J. E. M., Batsaikhan, N., King, S. R. B., Samiya, R. and Stubbe, M. (compilers and editors). 2006b. Summary Conservation Action Plans for Mongolian Mammals. Regional Red List Series Vol. 2. Zoological Society of London, London. (In English and Mongolian)

Presentations

Kenny, D. and R. P. Reading. 2007. Veterinary Involvement at the Ikh Nart Nature Reserve, Mongolian. Working Together, Answering the Call of the Wild. Association of Zoos and Aquariums Western Regional Conference, March 26-31, Denver, Colorado. (Audience: Zoo and aquarium professionals; Attendance: ~30)

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SECTION II: VOLUNTEERS

VOLUNTEER TASKS AND ACCOMPLISHMENTS

a) How did the volunteers contribute ideas, skills, expertise and motivations beyond that which you anticipated?

We are constantly amazed by the breadth and diversity of backgrounds among Earthwatch volunteers. Expeditions in 2007 included medical doctors, military personnel, educators, entrepreneurs, engineers, and students, to name a few, and each volunteer contributed in unique meaningful ways. Earthwatch volunteers contributed significantly to our work over the past year, although we were a bit short-handed for drive netting with Team V and were forced to recruit additional help. Luckily, we enjoyed high productivity from the few, excellent volunteers that assisted us. Advice from past volunteers continues to improve our training programme and increase the comfort of the stay for new recruits. We enjoyed having a volunteer on Team V who was an animal keeper and therefore had extensive animal handling skills. Volunteers helped fix and construct equipment, for example our falcon traps. On Team VI we especially appreciated Dwight Sangrey from Oregon, who helped enormously with organizational and intercultural issues.

b) How have volunteers helped you to achieve your research or educational objectives? Please give specific and quantitative measures of the volunteers' contribution to your data collection.

Volunteers greatly increase our capacity to collect data and are vital to our drive netting exercise. When Earthwatch volunteers are not in the field, we usually have one team (rarely two teams) of researchers collecting data on argali, one team collecting data on vultures or kestrels, and one team collecting data on small carnivores and their prey. Having volunteers enabled us to use two teams for the argali work, one team for the raptor work, and 1-2 teams for the small carnivore and small mammal work. The only reason we were able to expand our work in 2007 to include a study of lesser kestrels was because had volunteer assistance. Locating eleven dispersed and isolated kestrel nesting site required hours of stationary observation. In addition, the development of prototype noose traps would not have been possible without our volunteers' patience and skill in knot tying during the countless hours of development. As it was, we collected substantially more data. In addition, we are only able to collect vegetation data when we have volunteers to assist us. Even with our incomplete volunteer teams we are able to collect more data.

We also could not drive net as effectively without volunteers. Indeed, lacking a complete team of volunteers we had to recruit other volunteers to enable us to net drive effectively (we used friends – a wildlife biologist and a veterinarian – who wanted to visit the project this past September). Volunteers increase the effective size of our nets by forming a human barrier extending past the end of the nets. They also greatly decrease our processing time for each captured animal (by about 50%). Finally, having volunteers increased the comprehensiveness of our data collection (in the past we always forget to collect at least one datum, but this rarely occurred when we used volunteers).

Volunteers enabled us to complete 26 overnight tracking periods for small carnivores from antenna towers. Without volunteers, we would never be able to complete even half as many.

They also enabled us to complete far more small mammal trapping grids (n = 18) and insect trapping transects (n = 18) than would otherwise be possible.

Volunteers help increase the visibility of our work by contributing high quality photographs, art and videos of our work. We use these to develop or maintain support for our project within our cooperating organizations.

PROJECT DEVELOPMENT

a) What logistical or scientific challenges have you encountered in the past season and how will you address them during the next field season?

Overall, our project ran quite smoothly. Most logistical problems we encountered related directly to weather events – dust storms, flash floods, or hot temperatures. It's often difficult to predict and prepare for such events. Still, volunteers often find such severe weather events "exciting", especially after they pass!

We had problems with one of our field vehicles (a Mitsubishi van). As a result, we were required to rent a vehicle for some teams. Luckily, we received a generous grant from the Denver Zoological Foundation that enabled us to purchase Toyota Land Cruiser over the summer. This purchase greatly facilitated transportation from the train station to camp and during fieldwork. The greater number of smaller teams increased our ability to collect more data on more species and begin a project focused on lesser kestrels, a globally threatened species. Hiring a full-time cook adds to our salary costs, but is greatly appreciated by volunteers and the research team alike!

A continuing scientific challenge is the communication barrier that exists between some researchers and some volunteers. Our researchers enjoy varying levels of English proficiency. Although they are all improving, many researchers retain only rudimentary English skills. To address this concern, we have been paying for English lessons, working to encourage greater interaction between the volunteers and the researchers (to increase their exposure to and practice in the English language), and are working to ensure that we always schedule at least one Mongolian with good English skills to accompany volunteers. We recruited additional staff from the Denver Zoo to work on our projects in 2007 to ensure that we have at least one native English speaker on each team. We will do so again in 2008.

One more difficult challenge involves volunteers that are physically unable to participate in our work. On very few occasions, we receive volunteers that were obviously not truthful in completing their forms with respect to their physical abilities. While not common, this does happen from time to time and can create safety problems for our team. There is no easy way to address this problem, but we will continue to stress the difficult nature of our project in the expedition briefing. Thankfully, the other volunteers are usually very understanding and the staff terrific in accommodating these individuals.

Continuing conservation challenges include illegal mining in the protected area. We have been working to address this issue for years and continue to help with law enforcement and by working with local miners to encourage them to follow the law. We also helped address these issues by working to increase the capacity of the protected area to enforce the laws by putting up boundary markers and signs, as well as hiring more rangers.

b) Have you used any additional methods/strategies to meet your research objectives? If so, please describe them.

We used volunteers in 2007 to work on a new lesser kestrel project to study their nesting ecology. Volunteers were instrumental in helping us locate nesting sites, which involves hours of watching talus slopes to identify the precise nesting holes. Volunteers work in pairs or with a researcher to spot the hole and then direct a second person to that nesting hole to mark it (it is far easier to lose site of the exact location of nesting holes than we expected!). Volunteers also helped researchers:

1. develop and test prototype capture methods including dho-gaza mist nets and noose snare traps
2. constantly monitor nets and noose snares to capture adult and juvenile kestrels
3. band adult and juvenile birds
4. record morphometric measurements of birds being banded.

In 2007 we also deployed GPS telemetry collars on argali and ibex for the first time. Capturing animals and attaching collars remains the same as with traditional collars, but we do not need to track these animals, as they store location data on the collars, which will eventually fall off, allowing us to retrieve the collars and data. These collars will provide substantially more data and the data will be very precise.

Finally, our project required a detailed map of the distribution of habitats in our study area to accurately analyze our animal location information. Several volunteers contributed to the creation of a map over the summer, which involved painstaking work surveying vegetation plots. We finished the map in October, using the plot data and computer models to classify a satellite image. The image may be seen at: http://www.ikhnart.com/landsat3.html
GIS files of each habitat are also available to download for free.

c) How will you develop your research in the coming field season?

In 2008, we plan to build on our new research schedule that we developed this past year (i.e., one team every month from May to August and two teams in September). We plan to expand our raptor work significantly in 2008 and plan to send several researchers (some will be team leaders) to help us collect more comprehensive data on nesting raptors, including more data on lesser kestrels and, if get the funding, putting satellite telemetry transmitters on some cinereous vultures. We will assess how well our new GPS collars work on argali and ibex, and use that information to determine what kind of collars we will deploy next September (GSP or traditional radio collars). In addition, we will begin focusing more seriously on resource partitioning between argali and ibex through a Master's project of one of our Mongolian researchers. We will focus on finding and radio tagging more long-eared hedgehogs in 2008 to compare with the good data we are received on Daurian hedgehogs. Our vegetation surveys will continue and we hope to publish a book on the plants of Ikh Nart in 2008.

We will probably reduce our level of activity on our project focusing on small carnivores and their prey (insects, small mammals, and lizards), as former PI James (Jed) Murdoch will be in Britain for most of the year writing his Ph.D. dissertation (although we hope he can make it out for at least one team. We will be deciding how much work on this project will continue in 2008 during the winter. At a minimum, in the coming year we plan to develop a carnivore monitoring program. The program will involve monthly carnivore surveys using spotlight and scent-station

surveys over the entire northern half of the reserve. Results will allow us to collect long-term data on the population trends of various species that can be used to understand factors affecting distribution and abundance and help reserve managers identify priority conservation areas for carnivores.

Research teams will again vary by month. Although most of the Mongolian team members will remain the same, different researchers from the U.S. will lead teams in 2008, including Mary Jo Willis and John Azua from the Denver Zoo (both of whom now have experience at Ikh Nart). This new schedule again means that Rich Reading will be present during the stays of only two of the six teams (possibly even for only parts of two teams). This intentional absence continues to help build on the (already strongly competent) ability of the rest of our crew to manage an Earthwatch team. Ganchimeg Wingard will also likely miss some of the teams in 2008, as she did in 2007. In any case, we plan to have at least one American present the entire stay, as well as PI Sukhiin Amgalanbaatar. We do not envision any difficulties, as by now our team is well experienced.

EDUCATIONAL OPPORTUNITIES

a) Does your project directly or indirectly involve the following groups in your research topic?

- **Local communities**
- **Students**
- **Early career scientists**
- **Other groups**

Our project works with local people, students, early career scientists, and researchers with the Mongolian Academy of Sciences and Mongolian non-governmental organizations (NGOs). We enjoy a very good relationship with the local government (the Soum – like a county). That relationship has resulted in

1. a cooperative partnership to monitor the reserve with a team of rangers, one of whose salary we provide
2. improved law enforcement, especially with respect to poaching and illegal mining, as the Soum responds rapidly to information we provide them about illicit activities
3. continually improving protected areas management.

The latter project includes components on law enforcement (we now have six rangers), natural resources management, ecotourism (that will include a camp to generate income for the Soum in 2008), and education.

We also enjoy good relationships with most of the local, nomadic pastoralists. We continue to employ several of these pastoralists as horseback or motorcycle riders to assist with our net driving operations. They thoroughly enjoy this experience and earn additional income. In addition, we helped hire and equip new rangers from among the local pastoralists. Finally, we have developed strong friendships whereby local nomads will often store equipment, charge equipment batteries for us, and even assist us in conducting field work (several really enjoy the work). In return, we often provide transportation, mechanical assistance, and similar support for them. Most local people are happy that we have stemmed poaching and

are working to do the same with illegal mining (both of which are mostly conducted by people from towns and cities) in the region, as they enjoy watching wildlife.

As described throughout this report, we work with a large number of Mongolian students from several different universities. This work provides students with on-the-ground training on real projects. In some cases, students are prepared well for future employment, while in other cases students realize that fieldwork is not enjoyable to them (also an important outcome). Since student involvement is covered in greater detail elsewhere, we will not expand on this here.

We employ both early career scientists and established scientists at the Mongolian Academy of Sciences and local NGOs (see list below). This provides career development in both cases. Tenure with our project varies considerably. Some scientists have been with us from the beginning, others have worked a couple of years, others just a season, and some come down for just for a few weeks or days to learn about our work and how we conduct it. We do not maintain detailed numbers, but we have influenced dozens of research biologists from Mongolia, the U.S., Germany, Russia, and Britain.

b) Please tell us the ways your research helps these groups better understand the conservation of a sustainable environment (see the UNESCO definition above).

In addition to learning about our field conservation efforts, we are committed to developing sustainable practices that permit the co-existent of local people and the natural world upon which they depend. Mongolian pastoralists have inhabited Ikh Nart with local wildlife for millennia. That is perhaps the best definition of sustainable practice. New pressures, including a rising human population and greater demands for wildlife products from China and other Asian countries (in particular) and natural resources by both Western nations and new Asian “tiger” economies, increasingly threaten to disrupt this balance. Many, if not most, local people recognize these new threats, as do several of the students and most of our collaborating scientists, and our education program is starting to teach them how their activities contribute to these problems. Through our project we hope to better educate all of these stakeholder groups, as well as demonstrate how we can maintain a sustainable co-existence.

This effort has developed into a protected areas management project that is striving for sustainability in both local livelihoods (pastoralists have the legal right for at least some, limited grazing in Nature Reserves in Mongolia) and the nature of the region. This likely will require greater management of human uses in the area, something we have already initiated by working with local pastoralists to identify core areas for wildlife in Ikh Nart. To pay for that management, we have begun to develop eco-tourism to fund sustainable park management. We engaged an external ecotourism company to further develop this initiative by entering into a formal agreement with the soum. They initiated limited ecotourism in 2007 and will construct an ecotourism camp in 2008 that promises to greatly increase visitation and income for management. Much additional progress has been made over the past few months, including

1) additional ranger training;
2) working to finalize the draft management plan for Ikh Nart;
3) holding a variety of educational and public relations activities, including initiation of our “travelling trunk” program that will bring environmental education materials to local school on a rotating basis; and

4) provisioning ranger and other protected areas' staff with additional equipment.

Through our outreach efforts, local herders and community members increasingly recognize the tremendous impact of hunting and illegal poaching on wildlife populations and the need for practical conservation actions. For students and early career scientists, it directly shows the value of science in finding solutions to complicated, interdisciplinary issues. We plan to continue this work in 2008.

In addition to these activities, our project provides much needed income for the region; something greatly appreciated by the Soum governor and local people. And, because of the international attention and especially the visitation of Earthwatch volunteers, all of these groups are beginning to recognize how special and internationally significant Ikh Nart is. This generates a sense of pride and desire to maintain a healthy environment. Finally, because our work has resulted in animals better habituated to people that almost anywhere else in the country, Ikh Nart is increasingly being viewed as a target for ecotourism. We are working to ensure that ecotourism provides even more jobs, income, and a sense of pride and value in nature by and for local people.

c) Has your project helped lead to the completion of Masters' theses, or other educational research findings?

Our project continued to benefit from the involvement of an American Ph.D. student, an American Full Bright Scholar, a Mongolian Ph.D. student, four Mongolian Master's students, and several Mongolian undergraduate students. One student, Tsogoo, completed his Master's degree earlier this year and now works for a Mongolian conservation non-profit organization. Students hail from Oxford University, Oberlin College, the Mongolian National University, and the Mongolian Pedagogical University. We hope that 3-4 students will complete advanced degrees in 2008. We believe our work with students benefits both our projects and the students and envision working with additional students in future years (we hope to recruit additional students in 2008). Indeed, one of our primary goals is training Mongolian researchers.

PARTNERSHIPS

a) List partnerships or collaborations with other organizations that you have developed or maintained in the past season.

Argali Wildlife Research Center (AWRC)
Denver Zoological Foundation
Endangered Species Recovery Program, California, USA (ESRP)
Mongolian Academy of Sciences (MAS)
Mongolian Conserv. Cooperative (MCC)
Mongolian National University (MNU)
Mongolian Pedagogical University (MPU)
Oberlin College (OC)
Oxford University/WildCRU (OU)
University of Colorado-Denver (UCD)

b) How have these organizations contributed to your project objectives?

AWRC: Assists with publicizing our work in Mongolia; involved in developing the national management plan for the species; and active with Ikh Nart management activities.
DZF: Provides logistical and administrative support; researchers and expertise; equipment; and financial support.
ESRP: Provides research and logistical expertise and equipment.
MAS: Provides logistical and administrative support; researchers and expertise; financial support; and office space.
MCC: Provides logistical and administrative support and financial support.
MNU & MPU: Provide students.
OC: Provided a funded student as a Fullbright scholar
OU: Provides a student researcher with expertise; advice; and financial support.
UCD: Provides a graduate student working on Ikh Nart management and expertise in GIS.

c) How do you anticipate these organizations will use the results generated by the project, and in what timeframes?

AWRC: They will use the results to produce additional public relations pieces (newspaper stories, T.V., and nature shows in Mongolia) and to develop the national and Ikh Nart conservation management plans.
DZF & MCC: They will use the results to publicize what they are doing for conservation, for fund raising, and in scientific and popular publications and presentations.
ESRP: They will use the results to publicize what they are doing for conservation and in scientific and popular publications and presentations.
MAS: They will publish the results.
MNU & MPU: They will use the results to draw in additional students and provide real-world, practical training and experience for their students.
OC: They will publish the results and use the experience to attract other students
OU & UCD: They will use the results to draw in additional students who want international experience and in scientific and popular publications and presentations.

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