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Creating a Habitat Suitability Index Model for Argali Sheep (Ovis ammon), and Siberian Ibex (Capra sibirica) in Ikh Nartin Reserve, Mongolia

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ABSTRACT

Mongolia is a country with a park system of protected areas, preserving native flora and fauna. In order to inform decision makers about the status of endangered species and park land health, two species of concern, the Argali sheep *(Ovis ammon)* and Siberian ibex *Capra siberica)* in the Ikh Nart Reserve in Mongolia were studied. A Habitat Suitability Index Model was developed to study the Argali and ibex habitat preference and discern if the reserve and core zone offer optimal habitat. A total of 57 animals were examined, creating 95% and 50% home range kernels, and minimum convex polygons. The percent use of six vegetation classes were rated from 0 (most preferred) to 6 (least preferred). The 3 most preferred vegetation classes for Argali and ibex are dense rock, low-density shrub, and short grass forb. The core zone was designed appropriately offering the same proportion of vegetation classes as Argali and ibex prefer.

Table of contents

List of Tables

List of Figures

INTRODUCTION

Argali sheep, *Ovis ammon,* is a majestic species in decline. The largest and heaviest species in the genus, *Ovis,* Argali are built for fast running over long distances. The Mongolian Red List of Mammals lists the Argali as endangered. The Siberian ibex, *Capra sibirica,* is sympatric with the Argali and the largest and heaviest of the genus, *Capra*. The Mongolian Red List of Mammals lists the Siberian ibex as near threatened, but little is known of their ecology and status due to lack of studies (Reading et al. 2007). In Ikh Nart, a reserve in Mongolia, both species inhabit the same area. Since Argali are endangered and little is known about Siberian ibex, my goal is to determine the optimal environment for Argali sheep and Siberian ibex. Determining the optimal environment can inform decision makers in how reserves are designed. The question can be asked, '*does Ikh Nart encompass an area appropriate for sustainability of Argali and ibex?*' Also, Argali and ibex can be used as indicator species to determine the health of the habitat in an area. This information can help decision makers plan, alter, and adjust managing protected areas. Preserving suitable habitat for endangered species is a recurring theme in conservation planning. Endangered species are continually marginalized by human behavior such as economic development, habitat alterations, and creating unsustainable living environments. Mongolia is at a critical stage in conservation planning. While Mongolia has not developed industry at a critical pace, there are internal and external pressures for development (Reading et al 2006). The pressure for development could marginalize the existing reserve structure and goal of preserving 30% of Mongolian land as protected areas.

Spatially-explicit wildlife habitat models can be useful in conservation planning. Models can be developed to determine habitat preservation priorities, suitability of habitat for reintroduction of endangered species, understand the impact of land management decisions, and identify potential risks to species (Yamada et al. 2003). Using a Geographic Information System (GIS), a model can spatially examine the interactions between a species and its environment. A widely used method in habitat modeling is the habitat suitability index model (HSIM). The HSI model uses an index scale to rate appropriate and inappropriate habitat for a species (Yamada et al. 2003). Minimum convex polygons and home range kernels estimate an animal and species home range by mapping telemetry points and creating polygons representing home range areas. The polygons are the building blocks for creating the HSI model. Once an HSI model is created, it can be used to calculate the effectiveness of an area in supporting wildlife. Also, the HSI model can be transferred to other areas in search of appropriate land to support wildlife. Using the HSIM method, wildlife species can be used as indicators of rangeland health, (Reading et al. 2006). I've created an HSIM for Argali sheep, (*Ovis ammon*), and Siberian ibex, (*Capra sibirica*) inhabiting the Ikh Nartin Reserve in Mongolia. I've examined available vegetation and compared the amount of habitat available to where animals are located and what habitats these species use. My comparison used data for years 2003 through 2008. I've compared my results to available habitat in the Study site, Ikh Nart reserve boundary and core protected area and found that the core area best supports Argali sheep and Siberian ibex.

LITERATURE REVIEW

The Argali sheep, *Ovis ammon,* is a protected species, listed as endangered, (Clark et al. 2006), whose range includes Mongolia, China and India (Maroney 2005). *Ovis ammon*, is the largest species in the genus, with a stout body, robust legs and massive horns being the largest of wild species of sheep (Fedensko and Blank 2005). Argali prefer topography of foothills, high plateaus, intermountain valleys, gentle slopes, and rolling steppes in high mountains (Fedensko and Blank 2005; Amgalanbaatar and Reading 2000). The ecology of Argali is poorly understood, but data suggest that Argali are declining quickly (Mandakh 2005; Reading et al. 2000; Zakharenka 2008). Further, a 2001 national survey estimated Argali population between 13,000 and 15,000 (Wingard 2005). The primary threats to are poaching, competition with domestic livestock, predation, trophy hunting, and starvation (Fedosenko and Blank 2005; Reading et al. 2005). An increasing number of livestock have displaced and limited forage availability even though Argali have co-existed with livestock for centuries (Figure 1 and 2; Zakharenka 2008). Degradation of land by overgrazing has limited and fragmented Argali ranges (Maroney 2005). Wingard (2005) studied forage competition between domestic livestock and Argali. She found that dietary overlap occurs in all seasons with the highest overlap in winter and spring. Reading et al. (2005) studied the ecology of Argali in the Gobi Gurvan Saykhan National park, investigating plant species, movement of animals, and preferred foraging diet and found no seasonal movement. However, the study was built as a baseline with the intent for further comprehensive investigation.

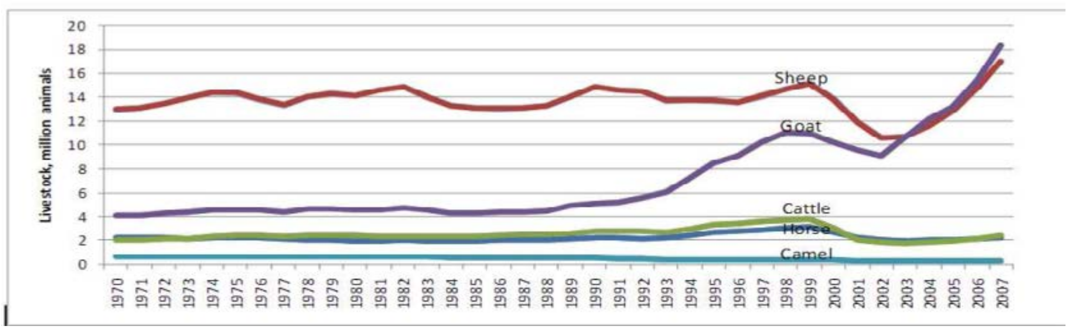

Figure 1. Livestock numbers, 1970-2007, *Source: National Statistical Office of Mongolia*

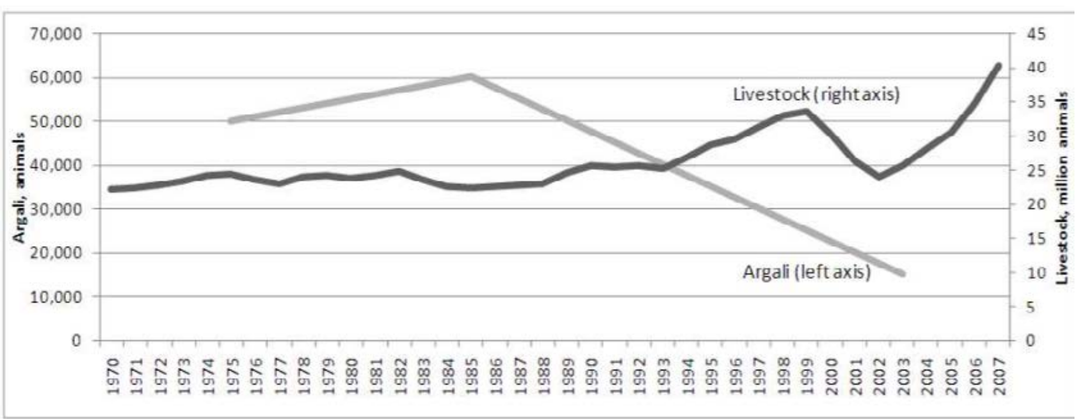

Figure 2. Argali abundance and livestock total numbers, 1970-2007
Source: National Statistical Office of Mongolia, WWF Mongolia

The Siberian ibex, *Capra sibirica* is also a protected species, listed as near threatened, (Clark et al. 2006), and poorly understood due to lack of studies. The ibex range includes mountains of central and middle Asia, southern Siberia, and the northwest Himalayas. Fedosenko and Blank (2001) describe the Siberian ibex as the largest and heaviest in the *Capra* genus, with males weighing up to 130 kg. They prefer rocky terrain, steep slopes of rocks and scree. They are agile at climbing sharp rocky slopes and cliffs to escape predators as they cannot run quickly on plains. Siberian ibex use the Ikh Nart reserve, and overlap in home range with Argali in the reserve as well as other areas in Mongolia (Reading et al. 2006; Fedosenko and Blank 2005). Even though Siberian ibex are sexually dimorphic in size and morphology, Reading et al. (2007) found there was no segregation between sexes in habitat range and use. Poaching, livestock grazing competition for forage and water and possibly guard dog predation, are the main threats to Siberian ibex.

Sexual segregation and seasonal movement in the form of different home range areas and habitat use is an important component in understanding a species' ecology and planning for its' preservation. Both species are sexually dimorphic with males being larger than females. Sexual segregation is common in species with dimorphism and suggests that Argali and ibex in Ikh Nart partition their use of habitat. Ecological studies have shown sexual segregation in Argali and ibex in other regions with males using a larger area. Studies have also shown seasonal movement for the two species. Male and female Argali usually separate when females are lambing. Fedosenko and Blank (2001) write that Argali male and females separate during lambing. They also migrate seasonally in response to deep snow cover or drying vegetation limiting their forage capacity. Male and female Alpine ibex, *Capra ibex*, used almost exclusive ranges in summer and early autumn in the French Alps, using different types of habitat (Villaret and Bon 1995). Female Alpine ibex, studied in the Gran Paradiso National Park, showed a reduction in home ranges and selection of sub-optimal, safer, habitats to reduce predation risk for their offspring (Grignolio et al. 2007).

Mongolia is a central Asian country with over 156 million ha and approximately 2.5 million people. It contains one of the largest remaining grassland ecosystems in the world and has a long history of pastoralism (Reading et al. 2006). With limited industrialization and low population growth, pastoralists have used the dry land for grazing domestic stock (horses, cows and yaks, camels, sheep and goats) for millennia (Reading et al. 2006). Pastoralism has been the ability to use variegated environmental conditions through mobility (Sternberg 2008). This mobility maintained a sustainable environment. Yet, Mongolia is struggling to adjust from a communist, command-control economy to a democratic, free-market since 1990 (Reading et al. 2010). Mobility for pastoralists was essential for sustainable rangeland. But, as infrastructure has declined herders have clustered their livestock near towns to gain access to water. Also, transportation costs have increased since the fall of the command economy and herders need more economically viable access to schools and health care. Water is a key issue for herders as the number of wells has dropped from 35,000 to 20,000 due to a lack of maintenance (Sternberg 2008). In addition, livestock numbers have increased since 1990. As the command economy collapsed, many were without jobs and returned to their traditional pastoralist activities. Half of Mongolia's population now depends on livestock production for a livelihood. Further, a shift in increasing goat numbers (~215% increase) over other livestock denudes the land faster (Reading et al. 2006). This had led to degradation of land and in some cases desertification (Sternberg 2008). Over 70% of land in Mongolia is considered degraded and 7% severely degraded, with 40% of the population depending on pastoralism for a livelihood (Reading et al. 2006).

Mining has become an important, reliable source of revenue that previously was untapped (Farrington 2005). Mineral wealth includes vast deposits of gold, copper, uranium, fluorspar and molybdenum. As of 2004 companies had licensed 29.9 percent of Mongolia's territory for exploration and mining, and found over 6,000 significant deposits of 80 minerals. Internal and external pressures from Mongolia's government and foreign capital, support developing mineral resources – as Mongolia struggles with a free market. However, sound environmental laws, regulations, licensing, and monitoring do not exist (Reading et al. 2006; Reading et al. 1999). Mongolia requires an Environmental Impact Assessment, reclamation activity and placement of a percentage of a company's budget into a government account prior to beginning work. Yet, these requirements are not enforced. In addition, exploration fees are low US$0.05/ha for the 1st year rising to US$1.50/ha by the seventh year and the government is not required to approve business or operational plans. Under these conditions, the monetary benefit to Mongolia is low. Also, with an increase in development, talks are underway to construct transportation corridors to export goods (Reading et al. 2006). Transportation development will further fragment habitat and limit wildlife movement through corridors.

With over 80% of land used by pastoralists for extensive livestock grazing, reform is needed in the form of protected areas management, grazing reform, and integrated solutions for both sustainable pastoralism and conservation (Reading et al. 2006).

Mongolia has had a long tradition of reverence for nature and conservation dating back to Chinggis Khan in the 13th century. In this time period a code of law forbade pollution of water and soil in order to preserve the pastoral-centric empire. Further, creating protected areas was and is a part of Mongolian culture. In 1778 hunting and logging was banned at Bogdkhan Mountain near Ulanbaatar. This, the Mongolians, believe is the first world national park. Today, Mongolia remains committed to nature conservation and creating an international model (Farrington 2005; Reading et al. 2006).

Mongolia has a system of protected areas which includes 50 reserves covering 20.68 million ha or almost 13% of the country, as of 2002 (Figure 3; Reading et al. 2006). Since 1992, after the collapse of the command economy, Mongolia has increasingly established protected areas with a goal of protecting 30 percent of the land mass by 2030. In 1994 the Mongolian Parliament passed a new "Protected Areas Law" and created four categories for protection: Strictly Protected Areas, National Parks, Nature Reserves, and National Monuments. Reading et al. (1999, 213) best describes the categories of protected areas:

- "Strictly Protected Areas shall consist of territories taken under state special protection, upon consideration of the preservation status of the original condition and features of the natural zones, in order to represent specific traits of the zones and scientific importance and to ensure environmental balance" (Protected Areas Law, Chap. 2, Art. 7). IUCN Category I. Strict Nature Reserve/Wilderness Areas).
- "National Conservation Parks shall consist of those areas taken under state special protection in order to create conditions for the conservation, preservation, and restoration of certain natural features, natural resources, and wealthy" (Protected Areas Law, Chap. 4, Art. 19-20). IUCN Category III. Natural Monument and Category IV.

Habitat/Species Management areas).

- "Nature Reserves shall consist of those areas taken under state special protection in order to create conditions for the conservation, preservation, and restoration of certain natural features, natural resources, and wealth" (Protected Areas Law, Chap. 4, Art. 19-20). (IUCN Category III. Natural Monument & Category IV. Habitat/Species Management Areas).
- "Monuments shall consist of land taken under state special protection for the purposes of preserving the heritage of natural unique formations as well as historical and cultural traces in their natural state" (Protected Areas Law, Chap. 5, Art. 22-23). (IUCN Category III. Natural Monument)

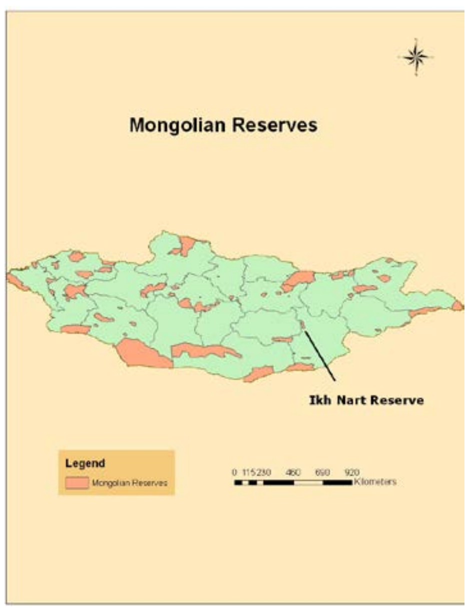

Figure. 3. Map of Mongolia pointing to the Ikh Nart Reserve.

Strictly Protected Areas restrict human use. However, lack of monitoring, enforcement, and capacity leave protected areas open to human use in all four protected categories. Actual management of protected areas is lacking (Maroney 2005). There are too few staff, inadequate professional staff training, lack of experience and insufficient resources. Only 194 rangers patrol the nation's 20.7 million ha of protected areas. Only 1 ranger per sum (county) monitors a protected area which leaves the area open to natural resource exploitation (Reading et al. 2006). The lack of monitoring leaves wildlife open to poaching as well (Reading et al. 1999). When the Mongolian Law on Land was passed, jurisdiction over grazing regimes returned to the local level (*Soum* and *Duureg* governors). The government relaxed restrictions on herd movement and gave herders a certain level of freedom to manage livestock. With this new freedom came a desire to be closer to markets and social services as mentioned above and results in a concentration of grazing around urban centers (Wingard 2005).

While Mongolia's aim to allocate 30 percent of its land to protected areas is noble, there is a bias in designated ecological zones. Deserts and taiga forests are best represented. However, steppe ecosystems, while representing a vast land area, are poorly represented (Reading et al. 1999). Ikh Nart Nature Reserve (Ikh Nart) is a nature reserve, created in 1996 to protect 63,740 ha of rocky outcrops in the northwestern Dornogobi Aimag and part of the Mongolian Park System (Reading et al. 2005). Within the park are several threatened species among which are Argali sheep, (*Ovis ammon)*, and Siberian ibex, (*Capra sibirica).* Also, the reserve houses approximately 43 human families with 180 members. During extreme winters, called *'dzud',* additional families use the area for relief (Wingard 2005). Lack of monitoring and competition from domestic livestock puts a strain on the available vegetation required by Argali sheep and Siberian ibex (Wingard 2005).

Mongolia is at a critical stage in conservation. Investigating available habitat and its use by Argali and ibex can inform decision makers as to the status of the Ikh Nart Reserve and if that area is designed appropriately. Investigating habitat use by creating a HSI model for Argali sheep and Siberian ibex not only gives more insight in how they use designated areas, but hopefully can be used for other species in other areas.

METHODS

My goal in creating a model was to calculate the vegetative composition of an animals' home range and determine if an area contained optimal habitat for the species. First, I created a home range polygon in GIS software. Then, I overlaid the polygon onto the study sites (study site, Ikh Nart reserve, and core zone) and calculated the percent of vegetation classes in the polygon. This gave me the proportion of each vegetation class that an animal used. This is described in detail below.

STUDY AREA

Mongolia is located in Inner Asia and is landlocked to the north by Russia and to the south by China (Figure 4). Grasslands comprise 80% of the country's 1.56 million km2 area that is home to over 30 million livestock (camels, cattle, yaks, horses, sheep, and goat. Bio-climatic zones include montane (8%), forest steppe (15%), steppe (34%), desert steppe (23%), and desert (19%). Average precipitation is 224 mm with a range from <50mm in the southern Gobi region to >400 mm in mountain areas. Mongolia has a continental arid climate and short growing season. Approximately half of Mongolia's population of 2.5 million depends on pastoralism for their livelihood (Sternberg 2008).

Figure 4: Relief map of Mongolia with the Russian Federation to the north and China to the south.

The study site is an area encompassing most of the Ikh Nart Reserve and beyond. The study site was created using Landsat images bounded by latitude of N45.838943°-N45.54545245°; E108.489732°-E108.731806° and comprising 72,937 ha. This site is the basis for vegetation classification in my model and the Ikh Nart Reserve and core zone are overlaid to analyze habitat use (Figure 5).

The Ikh Nart Nature Reserve (Ikh Nart) is a reserve in the Mongolian Park System established in 1996 and comprising 66,760 ha. The reserve is located in the northwest region of the Dornogobi Aimag (N45.723°, E108.645°, (Figure 5). Ikh Nart is part of the Mongolian steppe with a climate strongly continental and arid, with temperatures ranging from -40°C to 43°C. Wind can be strong in the spring and up to 25 mps. Humidity and precipitation is low with most rain falling in the summer (<100 mm/year). Water is available from permanent cold-water springs draining the reserve. Also, ephemeral river valleys and creek beds occur in the reserve along with short streams, oases, alkaline pools, and ephemeral ponds (Wingard 2005; Reading et al. 2007; Jackson et al. 2006). "Vegetation is sparse. Xerophytic and hyperxerophytic semi-shrubs, shrubs, scrub vegetation, and turfy grasses dominate, including *Haloxylon ammondendron*, *Sympegma ergelli*, *Anavasis brevifolia*, *Ephedra prjewaliskii*, *Ilynia regeli*, *Stipa glareosa*, *S. orientalis*, and *Reumuruia songarica*. Different plant communities can be found around oases and streams, on rocky outcrops, and other localized areas" (Reading et al. 2007, 30).

The core zone is a core protected area of 7,120 ha that lies within the Ikh Nart Reserve and was established to protect the endangered Argali sheep (Figure 5), (Jackson et al. 2006). The core zone was identified based on location data collected on Argali from previous studies (M. Rubenstein, pers. comm.).

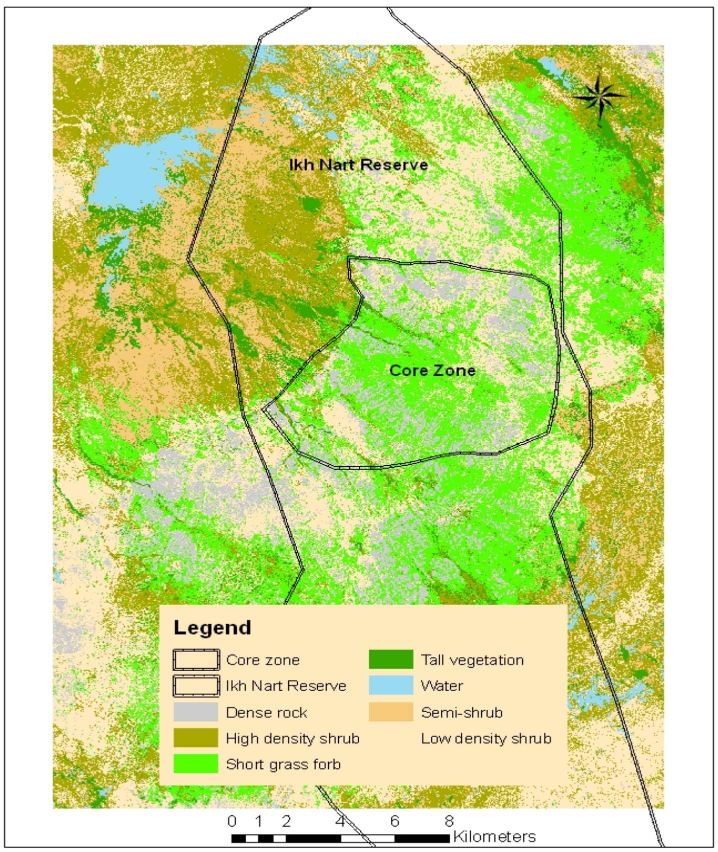

Figure 5: Map of the study site, Ikh Nart Reserve, and core zone. The map shows 7 vegetation classes: dense rock (DR), high density shrub (HDS), short grass forb (SGF), tall vegetation (TV), water (W), and low density shrub (LDS).

DATA ANALYSIS

I used data produced from previous studies to create my model. I used a vegetative map produced by Jackson *et al.* 2006, as the baseline for vegetation classes and this is represented by the study site. Jackson et al. (2006), used a maximum likelihood supervised classification of a five-band multispectral composite Landsat 7 Enhanced Thematic Mapper Plus (ETM+) image of the Dalanjargalan Soum section of the Ikh Nart reserve and surrounding areas in Dornogobi and Dundgobi Aimags. In addition to the Landsat image, Jackson *et al.* based the habitat classifications on botanical surveys, local knowledge, and a stratified random sampling on the ground. The image was classified into 7 habitat classes: dense rock, high-density shrub, low-density shrub, semi-shrub, short-grass form, tall vegetation, and water. Vegetation was furthered classified from the 7 habitats as follows: Low-density shrub rock mix described areas dominated by woody shrubs at densities of ≤100/ha interspersed with patchy rock outcrops and talus; high-density shrub described open areas with shrub density of > 100/ha; semi-shrub habitat includes areas dominated by turfy semi-shrubs; short-grass forb describes areas containing mostly perennial forbs and grasses; tall vegetation describes areas with tall grasses and trees > 1m in mean height in late summer/autumn; water describes ponds, pools, and springs with seasonally variable standing water. Low-density shrub, short grass forb, and high-density shrub dominate the study site while semi-shrub, rocks, tall vegetation, and ephemeral water bodies occur at lower percentages. The map is at 30 m resolution and presents detailed distribution of habitats that may be suitable for analysis of wildlife ranging behavior and the identification of priority areas for conservation (Figure 5).

Telemetry data points have been collected from Argali and ibex since 2003. Collared animals were tracked using a traditional receiver; a yagi, handheld, two- or three-element antenna; and a Global Positioning System (GPS) (Reading et al. 2007; Reading et al. 2005). Binoculars and a spotting scope were used to locate and identify animals at a distance. Once the animal moved, a GPS location was recorded. Data was collected year round by Mongolian staff living in the Ikh Nart Reserve.

I used telemetry data collected by Mongolian staff in the Ihh Nart Reserve, consisting of a latitude and longitude in an excel spreadsheet and limited sampling to the years 2003-2008 (Figures 6 and 7). I imported the excel document into ArcGIS 9.3.1 Geographic Information Systems software (Environmental Systems Research Institute, Redlands, CA; Figure 8). I created minimum convex polygons (mcp) and 95 and 50% fixed kernel home ranges (kernel), using ArcGIS 9.3.1 and Hawth's tools (Figures 9 and 10; Beyer 2004; Reading et al. 2007) As the data was clumped, I used least squares cross validation to select a smoothing factor for each kernel polygon. Telemetry fixes of 25 or more per animal were used to for analysis. I calculated the area for each polygon by using X-tools Pro (X-Pro tools extension for ArcGIS Desktop Copyright C Data East, LLC). I concentrated on polygons representing each year from 2003-2008.

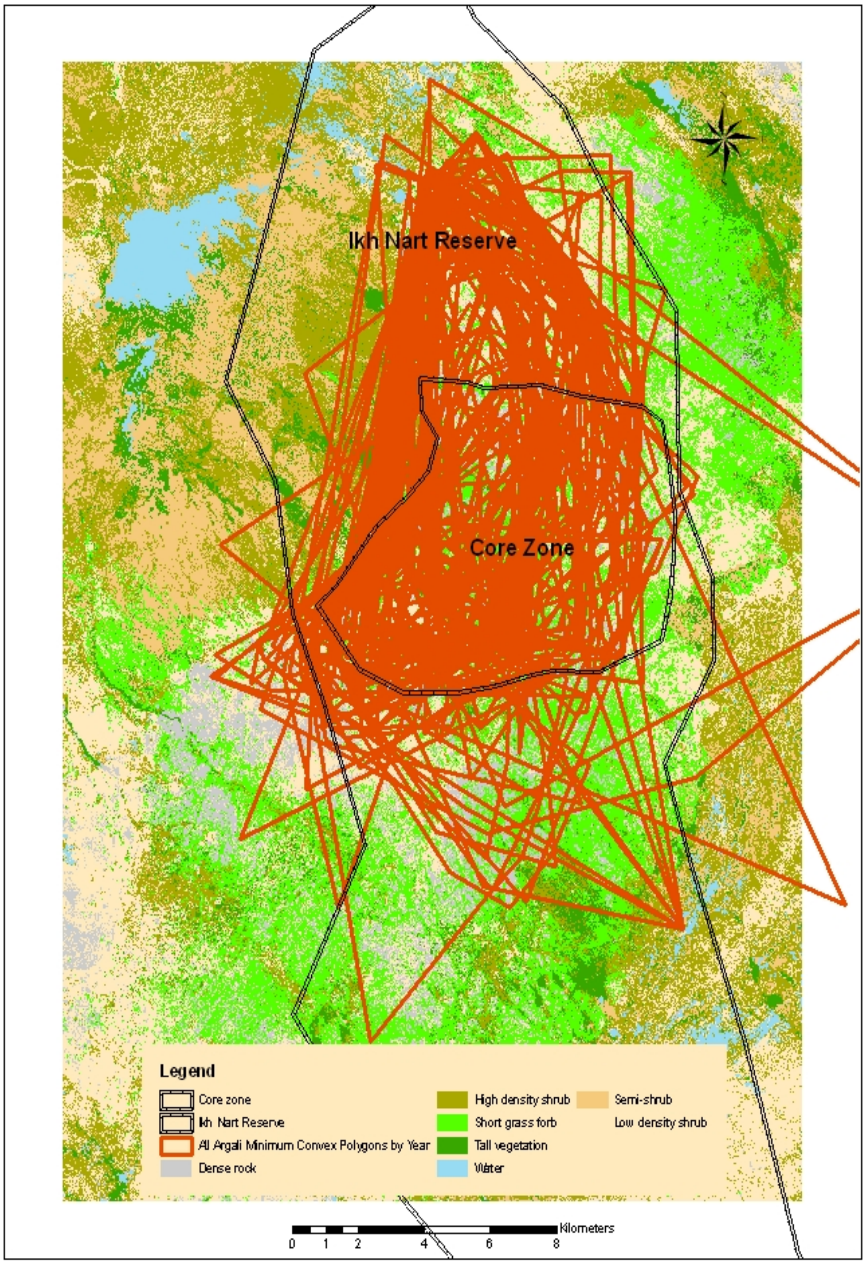

Figure 6: Map of minimum convex polygons by year for all Argali sheep.

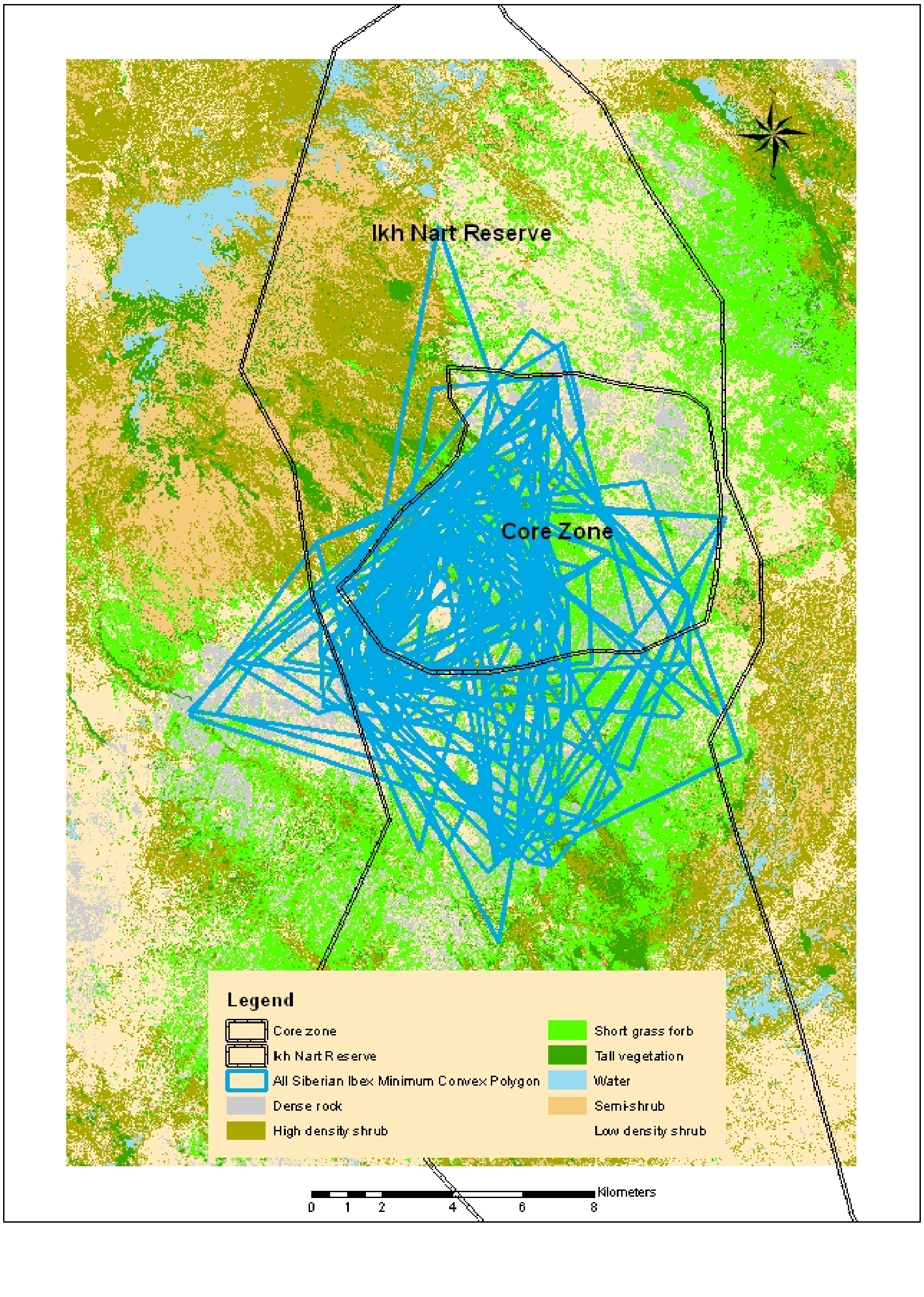

Figure 7: Map of minimum convex polygons by year for all Siberian ibex.

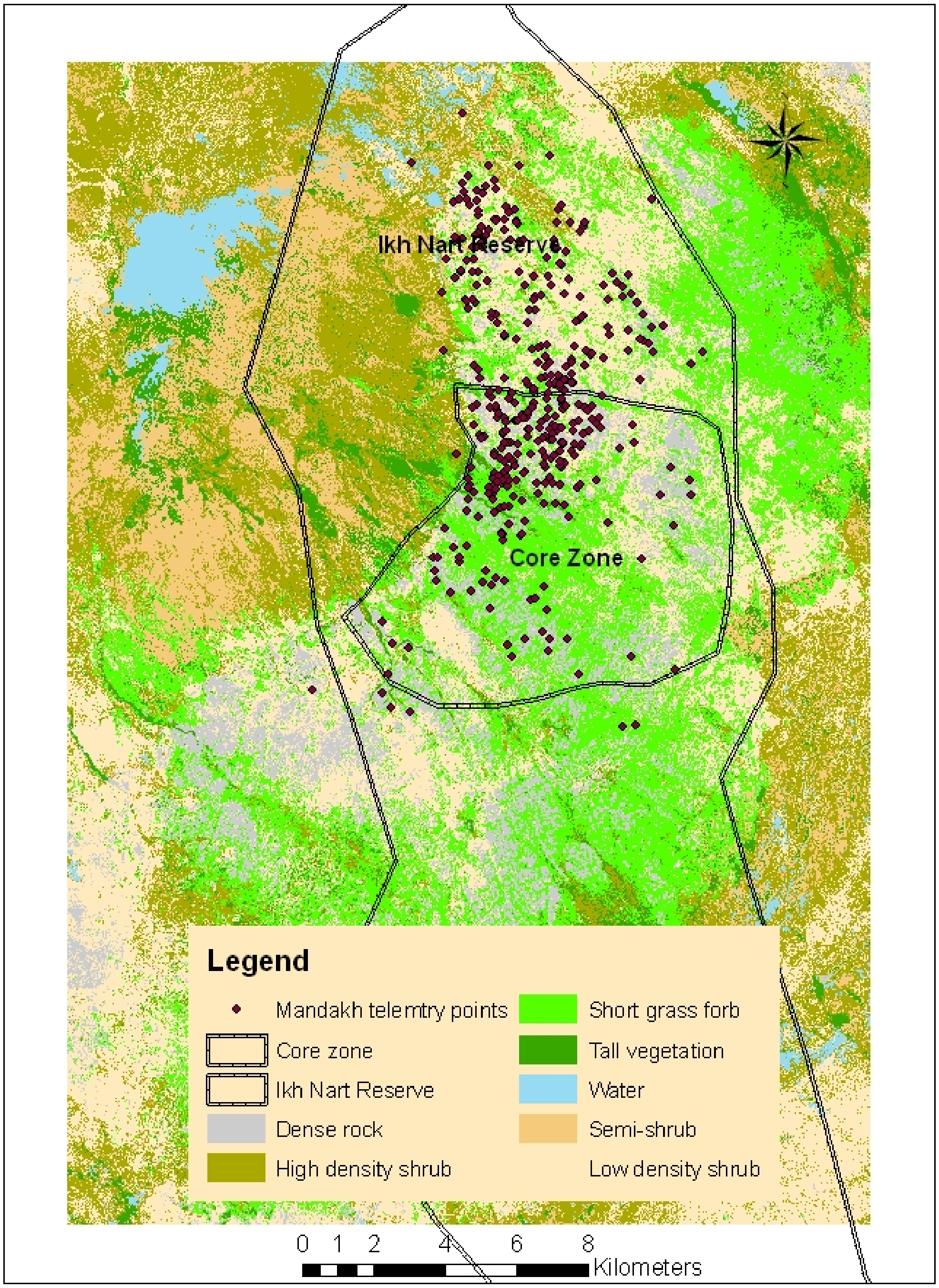

Figure 8: Example of telemetry points laid over vegetation layers for 1 female Argali sheep (*Ovis ammon*).

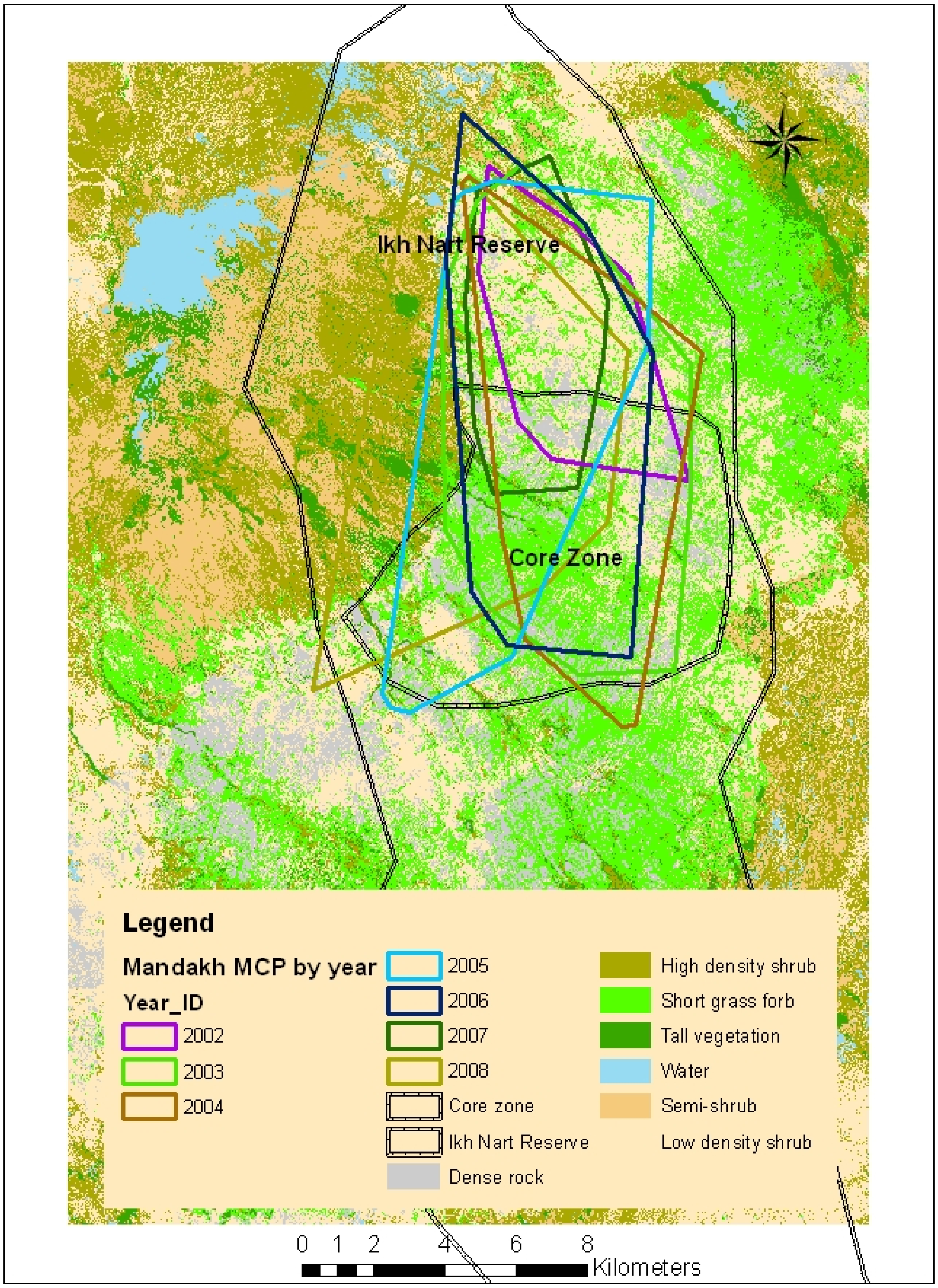

Figure 9: Example of minimum convex polygon for 1 female Argali sheep.

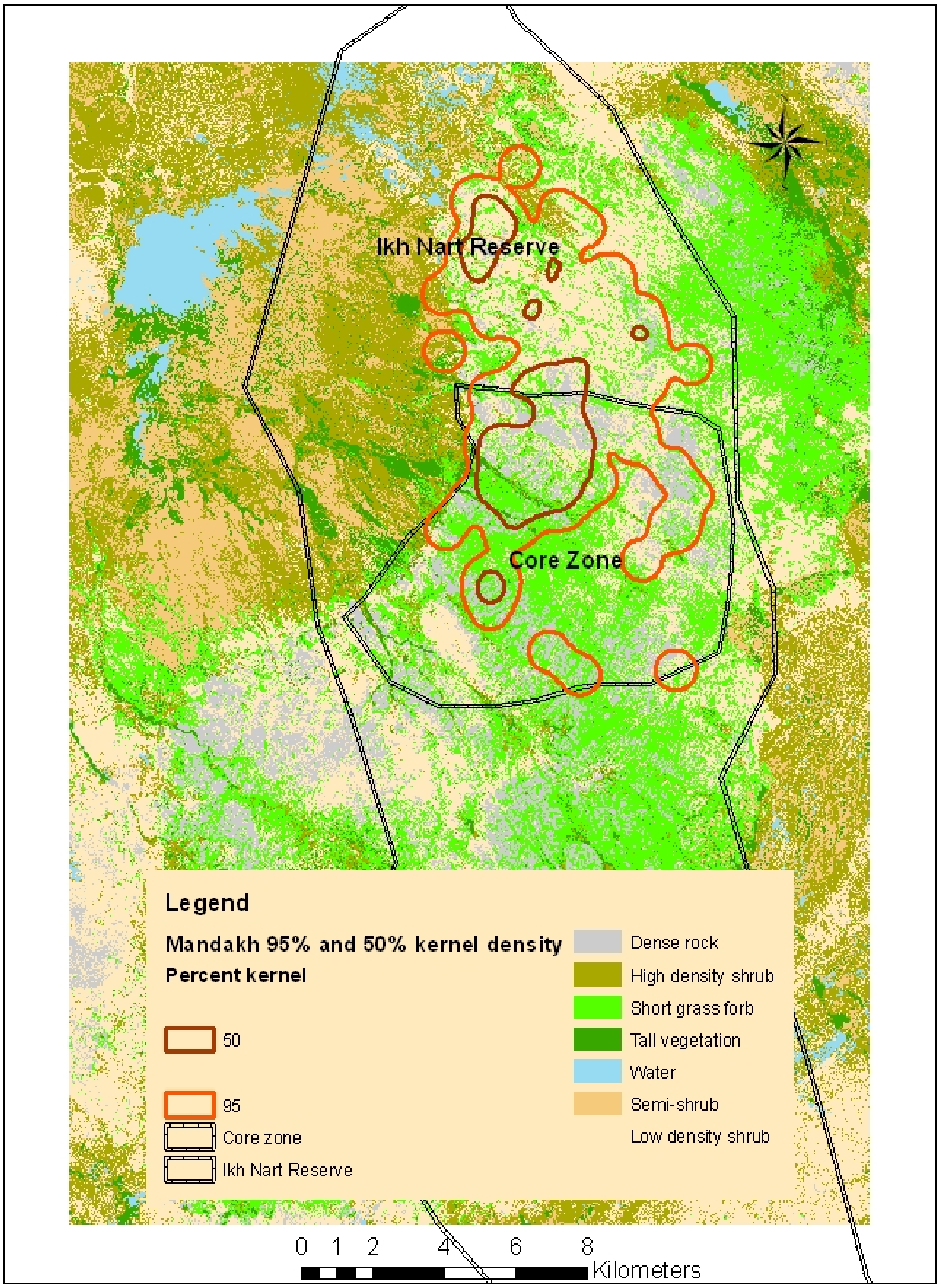

Figure 10: Example of 95% and 50% home range kernel for 1 female Argali sheep. 95% kernel = and 50% kernel =

For final analysis, I used data for each year and averaged all years to create a final mean number of forage use for male, female, and all, by species (Appendix II). I calculated the percent of vegetation use by creating a GIS model which clips the home range polygon from the vegetation map and summarizes each vegetative class by hectares (Figure 11). The percent of each vegetation class was calculated by dividing hectares for one class by the total number of hectares. These percentages were averaged for all years for one animal. Once the mean of each polygon per animal per vegetation class was calculated, I imported the data into an excel spreadsheet. I calculated a mean for each vegetation class by species and sex. Water continually showed an insignificant percentage value and was excluded from the final analysis, leaving six vegetation classes for investigation (Table 1, 2, and 3). I imported this data into the SYSTAT Software (SYSTAT 13 for windows, SYSTAT Software, 2009) and used a two-way table using Pearson chi-square, Likelihood ratio chi-square, and phi tests to test significance. I weighted the vegetation percent since this was the only numerical value in my tables. I also compared the percent vegetation composition of the core zone, Ikh Nart reserve, and study site to the percent of animal usage. The animal usage is conveyed by ninety-five and fifty percent home range kernels, and minimum convex polygons. A value of $p \leq 0.05$ was used to determine significance (Appendix II). Figure 11 shows the process for crunching the GIS data.

FLOW CHART FOR GIS HABITAT SUITABILITY INDEX MODEL

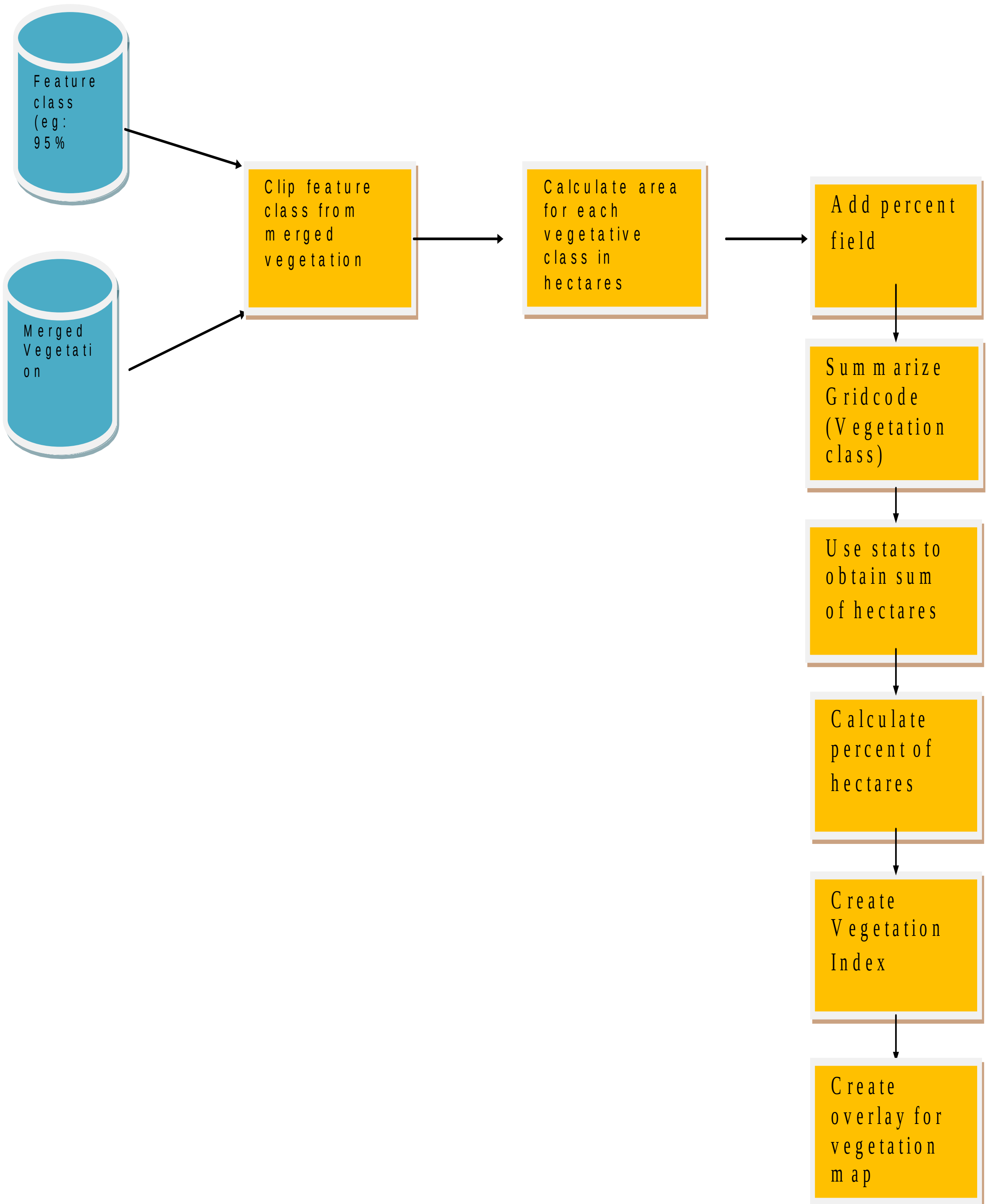

Figure 11: GIS model for processing telemetry data and creating a Habitat Suitability Index Model.

Table 1: Mean percent vegetation classes preferred by Argali and ibex from the 95% home range kernel compared to the Study site, Ikh Nart Reserve, and core zone.

Name	Sex	DR	HDS	SGF	TV	SS	LDS
IbMean*	All	27.01819	4.52044	37.35776	3.833518	0.288012	26.98208
IbMMEan	M	27.26936	4.179135	37.30246	3.752975	0.293485	27.20259
IbFMean	F	26.78477	4.837634	37.40915	3.908372	0.282926	26.77714
ArMean	All	21.39898	4.912213	33.8825	3.142296	1.776183	34.88783
ArMMean	M	21.26368	5.212487	33.43657	3.246897	1.784436	35.05593
ArFMean	F	21.53707	4.605742	34.33764	3.035536	1.76776	34.71625
StudySite		9.090691	21.72835	24.7901	6.78334	9.743203	27.86432
IkhNart		10.78596	17.9354	29.2036	6.462978	7.088031	28.52404
Core		24.46685	2.426471	41.39237	2.66061	0.485827	28.56787

*IbMean = mean of all ibex; IbMMean = mean of all male ibex; IbFMean = mean of all female ibex; ArMean = mean of all Argali; ArMMean = mean of all male Argali; ArFMean = mean of all female Argali; DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 2: Mean percent vegetation classes preferred by Argali and ibex from the 50% home range kernel compared to the Study site, Ikh Nart Reserve, and core zone.

Name	Sex	DR	HDS	SGF	TV	SS	LDS
IbMean*	All	33.90685	2.678867	39.73263	4.381121	0.673385	18.62715
IbMMean	M	34.47368	2.973482	38.18327	4.477671	0.681138	19.21076
IbFMEan	F	33.26916	2.347425	41.47567	4.272501	0.664663	17.97058
ArMean	All	29.78811	2.096976	34.09872	2.471356	0.807834	30.73701
ArMMean	M	30.40757	2.370565	32.84296	2.759898	0.877306	30.7417
ArFMean	F	29.40094	1.925982	34.88357	2.291017	0.764414	30.73408
StudySite		9.090691	21.72835	24.7901	6.78334	9.743203	27.86432
IkhNart		10.78596	17.9354	29.2036	6.462978	7.088031	28.52404
Core		24.46685	2.426471	41.39237	2.66061	0.485827	28.56787

*IbMean = mean of all ibex; IbMMean = mean of all male ibex; IbFMean = mean of all female ibex; ArMean = mean of all Argali; ArMMean = mean of all male Argali; ArFMean = mean of all female Argali; DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 3: Mean percent vegetation classes preferred by Argali and ibex from the minimum convex polygon compared to the Study site, Ikh Nart Reserve, and core zone.

Name	Sex	DR	HDS	SGF	TV	SS	LDS
IbMean*	All	24.97427	3.761905	40.4761	3.035568	0.578012	27.17414
IbMMean	M	26.49689	3.462661	37.67582	3.033208	0.495637	28.83578
IbFMean	F	24.0613	3.941334	42.15518	3.036982	0.627406	26.1778
ArMean	All	16.67187	16.67187	31.90431	3.482111	1.627412	29.64242
ArMMean	M	18.16647	6.592361	36.00417	4.366646	2.03118	32.83917
ArFMean	F	19.20237	5.510057	36.04085	3.684679	1.727569	33.83447
StudySite		9.090691	21.72835	24.7901	6.78334	9.743203	27.86432
IkhNart		10.78596	17.9354	29.2036	6.462978	7.088031	28.52404
Core		24.46685	2.426471	41.39237	2.66061	0.485827	28.56787

*IbMean = mean of all ibex; IbMMean = mean of all male ibex; IbFMean = mean of all female ibex; ArMean = mean of all Argali; ArMMean = mean of all male Argali; ArFMean = mean of all female Argali; DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Once a preference for vegetation was established, I created an index giving a number of 0 for most favorable vegetation class through 6 for least favorite (Table 4). I used ArcGIS to create a layer of preference which is overlaid onto the study site, Ikh Nart Reserve and core zone vegetation (Figure 12).

Table 4: Argali and ibex MEAN percentages of vegetative use.

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Species	Category	DR	HDS	SGF	TV	SS	LDS
Ibex	95% krnl	27.01819	4.52044	37.35776	3.833518	0.288012	26.98208
Ibex	50% krnl	33.90685	2.678867	39.73263	4.381121	0.673385	18.62715
Ibex	MCP	24.97427	3.761905	40.4761	3.035568	0.578012	27.17414
Index		1	4	0	3	5	2
Argali	95% krnl	21.39898	4.912213	33.8825	3.142296	1.776183	34.88783
Argali	50% krnl	29.78811	2.096976	34.09872	2.471356	0.807834	30.73701
Argali	MCP	16.67187	16.67187	31.90431	3.482111	1.627412	29.64242
Index		2	4	0	3	5	1

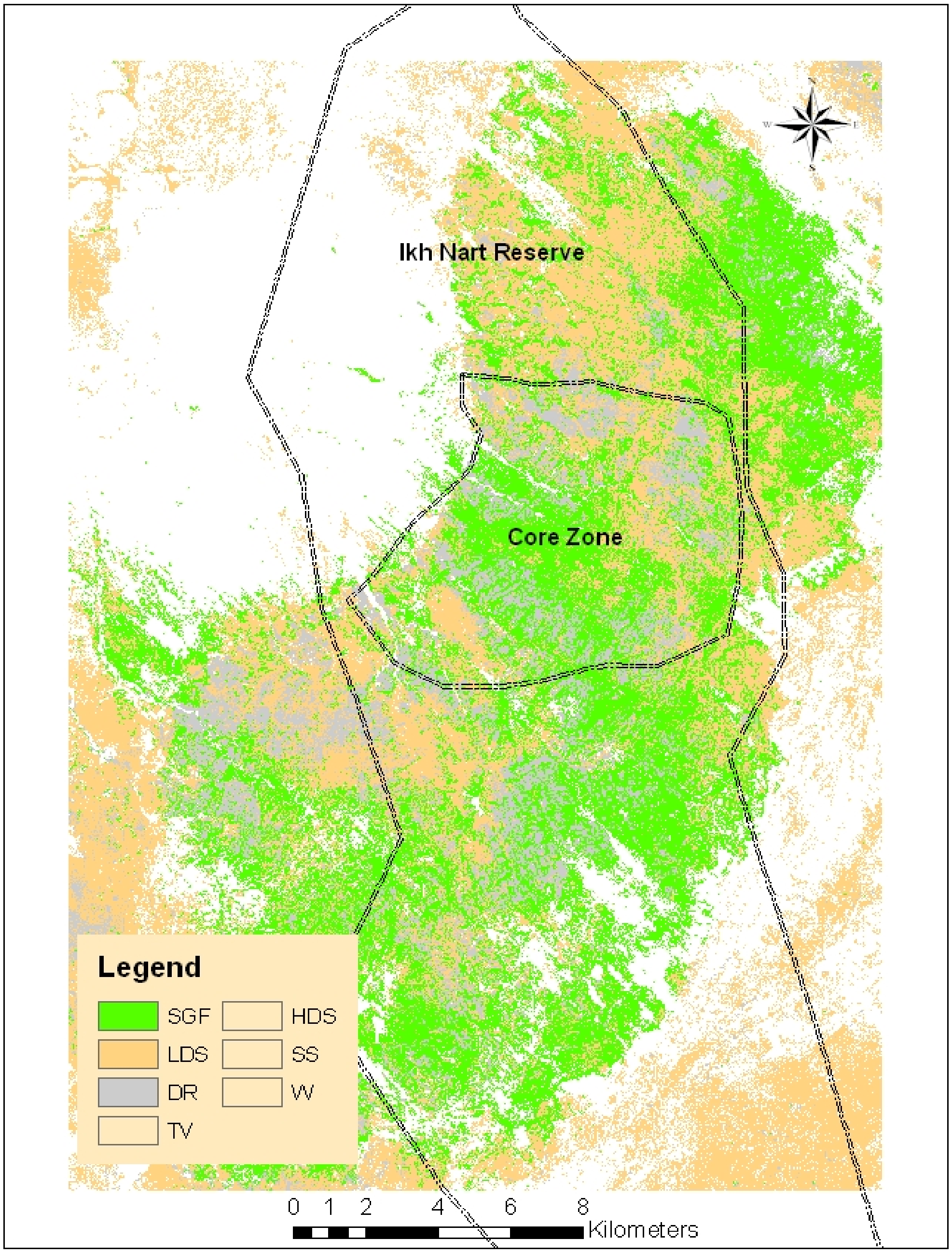

Figure 12: Top three vegetative classes preferred by Argali sheep and Siberian ibex. Short grass forb, low-density shrub, and dense rock are the most preferred vegetation. Tall vegetation, high-density shrub, semi-shrub, and water are the least preferred vegetation.

RESULTS

I've grouped my table results according to the subject, ie: Argali, ibex, core zone, Ikh Nart, and study site. Then, 95% kernel, 50% kernel and minimum convex polygon are discussed as a group. I analyzed 15 male and 24 female Argali sheep for all three categories of polygons. However, Siberian ibex differ in each category as follows: ten males and eight females for 95% kernel; nine males and eight females for 50% kernel; and eight males and nine females for minimum convex polygon. The total number of animals in the analysis alternates between 56 and 57 animals.

There are 3 classes of vegetation preferred by Argali and ibex: low-density shrub, short grass forb, and dense rock. But, looking at the data for the study site, Ikh Nart Reserve, and core zone, only the core zone provides similar proportions of vegetation classes preferred by both species. At first glance, there are significant differences in comparing Argali and ibex with the core zone, Ikh Nart, and the study site for all categories ($p < 0.01$; *Appendix II*). However, looking at individual categories such as species, sex, and individual study areas gives a better definition of where there are differences and how significant they are. My goal is to determine if there are differences in how Argali and ibex use the core zone, Ikh Nart, and study site, and whether segregation of sexes or seasonal migration occurs. I need to know if Argali and ibex use the three areas differently, if Argali and ibex together use the areas differently, and if male and female Argali and ibex use the areas differently. Understanding the use of the study areas will help determine if land is appropriated correctly according to their ecology.

The study site and Ikh Nart Reserve show a significant difference ($p<0.01$) between Argali and ibex habitat use with one exception. The minimum convex polygon for Argali shows a significant correlation in the use of the Ikh Nart Reserve, ($p = 0.330$ and 0.301 for Pearson Chi-Square, and 0.044 for Likelihood Ratio Chi-Square respectively). The proportion of vegetation used by Argali is similar to the proportion of vegetation available. This may be explained in how minimum convex polygons are created. The mcp method takes the outer telemetry points and connects the dots. This method shows the outer most area an animal may use. The kernel method smoothes the data and creates the probability of where an animal's home range exists. It is possible that the mcp for Argali in Ikh Nart shows an outlier which will be discussed below.

The core zone is designed appropriately for habitat use by Siberian ibex. The percent composition of the core zone closely matches the percent vegetation used by ibex in all polygonal categories (95, 50% kernel and mcp). The 95 and 50% kernels for Argali also show a correlation between use of the core zone and the proportion of habitat available. However, the minimum convex polygon shows a significant difference in habitat composition and use ($p<0.05$ for Pearson Chi-Square, Likelihood Ratio Chi-Square). At first glance Argali and ibex use of the core zone shows an appropriate balance of vegetative classes. But, the mcp for Argali is not balanced. Dense rock comprises 24.5 percent of the core zone, yet Argali use only 16.7 percent. High-density shrub comprises 2.4 percent of the core zone, yet this vegetative class comprises 16.7 percent of Argali use. Again, this could be due to the outlier telemetry points.

There is no significant difference between male and female use of vegetation classes for either Argali or ibex. Both sexes use the same vegetation in the same proportions.

Finally, looking at the actual percent use of vegetative classes for Argali and ibex gives an indication of which vegetative classes they prefer. It is necessary to rank the different classes in order to create a GIS layer signifying the appropriate balance of vegetative classes needed for habitat planning. At first glance, Argali and ibex use vegetation in similar proportions. However there are a couple of discrepancies. Dense rock is used more by ibex than Argali and given a higher rating for the ibex HSI model. The low-density shrub is used more by Argali than ibex and given a higher rating for the Argali HSI model. The results of this ranking can be seen in Figure 12.

DISCUSSION

Argali sheep and Siberian ibex vegetative preferences

My results indicate that there are three vegetative classes preferred by Argali sheep and Siberian ibex. The three vegetative classes are low-density shrub, short grass forb, and dense rock. Tall vegetation and high density shrub are used to a lesser, but equal extent at 3-4% each. Semi-shrub is the least preferred between 0.578 for ibex and 1.627 percent for Argali in the minimum convex polygon. Water is excluded from analysis since initial figures show an insignificant use of this vegetative class. Looking at the mcp for Argali and ibex, there is a significance in the use of vegetation classes. Both use dense rock at significant percentages with ~16.7 percent use by Argali and ~25 percent use by ibex (percentages are rounded from the original table figures, Table 24). This difference may be explained by the necessity of ibex using rocky areas for escape while Argali have a better capacity to run from predators (Reading et al. 2007). Another explanation may be the displacement by domestic livestock which will be discussed further. Both species show a comparable use of low-density shrub, preferring this vegetation at ~29.6% for Argali and ~27% for ibex for the minimum convex polygon. Both species show a high use of short-grass forb, but ibex show a greater preference at ~40.5% for ibex and ~32% for Argali.

Study Areas

My results show that the core zone is better suited overall for Argali and ibex habitat use while Ikh Nart and the study site do not comprise an area with vegetative proportions needed. With the exception of Argali and the HDS and SGF categories, the core zone comprises a similar proportion of vegetative classes to what Argali and ibex use. Looking at table 3, low-density shrub is distributed fairly equally between the core zone, Ikh Nart, and the study site and Argali and ibex use the vegetation proportionately to its distribution. But, all other vegetative classes show a significant difference in proportionality of use when compared to Ikh Nart and the study site. Argali and ibex need rocky outcrops and elevation for escape, yet Ikh Nart and the study site contain half the percentages of what is used in the core zone (Figure 13). In contrast, Ikh Nart and the study site have higher proportions of HDS, SS, and TV, than used by both species. This indicates, at least for the reserve, that the structure of the boundary is opposite to where key vegetative classes exist (Figure 12).

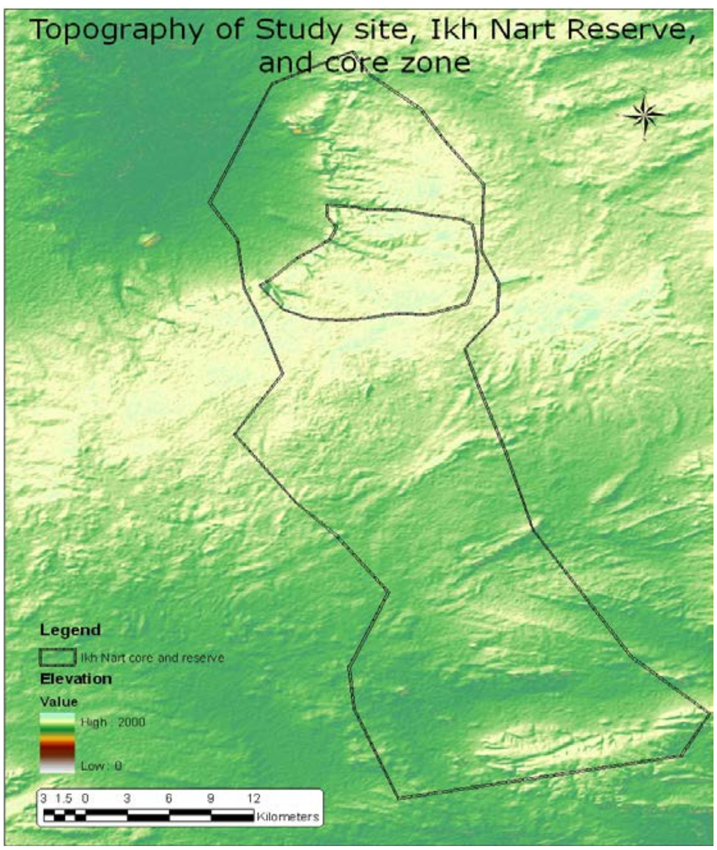

Figure 13. Topography of study site, Ikh Nart reserve, and core zone.

Sexual segregation and seasonal movement

My data does not show segregation in habitat use between males and females in either species. Both Argali and ibex male and females use the core zone and vegetative classes in surprisingly the same proportions.

Other studies show partitioning in male and female use of habitat. Fedosenko and Black (2005) report that Argali segregate by sexes. Grignolio (2004) found that female Alpine ibex, *Capra ibex ibex*, use smaller home ranges than males. Other ungulate studies report sexual segregation (Reading et al. 2007). However, past studies of ibex in Ikh Nart report similar results of no sexual segregation (Reading et al. 2007).

My data suggests that there is no seasonal movement for either species. Although specific investigation into seasonal data needs to confirm this, the home range polygons stay clumped in the same core area for both species. Past studies in Ikh Nart confirm a lack of seasonal movement (Reading et al. 2005; Reading et al. 2007).

Competition with domestic livestock

Competition with domestic livestock can negatively impact wildlife species. For Argali and ibex in Ikh Nart this is a serious threat. Livestock numbers have increased in the past 20 years with no regulation or oversight to create a sustainable environment for wildlife, livestock, and herders. Land is denuded, decreasing the capacity for Argali and ibex to forage. The species in this study show no sexual segregation or migration from the core zone and surrounding areas even though these behaviors are documented in other regions. This may indicate that the species are confined to a limited space due to livestock pressure. The outliers in the data may suggest that Argali are trying to expand their range, but may be pushed back by unknown circumstances.

Namgail et al. (2007), found that Tibetan Argali are pushed by domestic livestock to sub-optimal habitat, shifting to steeper inclines with lower vegetation cover. Competition from domestic livestock is an issue that should be addressed.

Management Implications

Mongolia has an opportunity to avoid land degradation and create a model for sustainability in the form of conserving livelihoods, wild flora and fauna, and economic stability. There is limited industrialization, agriculture, and natural resource exploitation. But, internal and external pressures could change Mongolia's current situation. In arid environments, land can degrade at a faster rate due to over-grazing, development, and introducing agriculture. This in turn can decrease the capacity of Mongolia's pastoralists to sustain their way of living. Unsustainable development will also impact wildlife species which many times are indicators for the health of an environment, whether that is soil, water, or air. Wildlife such as Argali and ibex are triggers. They can trigger caution in how we use our natural resources and trigger conflict when viewed as an obstacle to human livelihood. In order to create a sustainable environment an interdisciplinary approach is needed to address the issues of flora and fauna protection, environmental protection, economic sustainability, and sustainable development.

Results from this study can inform decision makers in how wildlife is using protected areas. It can also inform as to the pressures wildlife face for example, in the form of livestock competition. Information should be used to create a management plan. Mongolia has a great start in creating protected areas. Now, a management plan that includes monitoring protected areas, training staff, capacity building, government action, and stakeholder inclusion, should be created to close the gap that exists between labeling an area protected on paper, and actively protecting the area.

CONCLUSION

Understanding optimal habitat for wild flora and fauna can inform planners and managers on park health in a protected area system. One tool that is useful in determining optimal habitat is the Habitat Suitability Index Model. The HSIM can help discover if designated protected areas are designed appropriately, offering wildlife species optimal habitat. My study was informative in how two species of concern, Argali sheep and Siberian ibex, use the Ikh Nart Reserve, the core zone and surrounding areas. This information can be used for managing existing concerns and planning for future development, in an interdisciplinary approach which includes all stakeholders, the government, communities, and native flora and fauna.

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APPENDIX I: Tables 1-6, raw data for Argali and ibex percent classes.

Table 1: Aragli mean percent of vegetation use by years 2003-2008 for 95% home range kernel, measured in hectares.

Name	Species	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Alison	Argali	F	283.0059	33.4039	392.4357	31.3072	0	7.1472	258.9619
Amaraa	Argali	F	655.339	110.8045	1013.117	93.1245	2.64625	62.54835	1069.311
Batbold	Argali	F	797.6724	128.2764	1178.529	70.7448	3.5948	62.0595	2030.58
Bayasaa	Argali	F	902.1923	164.8835	1427.691	144.7403	0.745	85.79445	874.7509
Debmaa2	Argali	F	820.7357	326.0456	1249.497	161.1105	22.6047	180.0498	1904.75
Diane	Argali	F	1221.947	367.5003	2497.296	228.5514	5.9043	140.6314	1871.687
Dot	Argali	F	581.2185	117.8284	849.2942	102.3965	2.09535	21.983	720.5031
Eggnog	Argali	F	613.1866	49.4375	782.2659	52.52715	0.16245	8.9639	644.22
Ganaa2	Argali	F	1108.394	157.6146	1810.491	139.3348	1.24462	41.94522	1310.835
Janice	Argali	F	547.9573	129.0959	876.4924	110.8149	1.7677	21.9315	702.7805
Jargal	Argali	F	1030.201	151.1345	1453.263	123.6393	1.5637	15.8835	1077.358
Jerry	Argali	F	809.1729	124.6661	1035.6	75.22957	13.64057	19.9984	542.5832
Jill	Argali	F	1002.035	294.8515	1562.991	195.9162	16.8073	102.7461	1387.01
Khatan	Argali	F	810.2307	100.2126	1412.662	98.74255	21.54225	24.1462	846.6417
Lauren2	Argali	F	832.9808	114.8942	1201.522	79.4355	1.0659	39.2916	1225.531
Lisa2	Argali	F	1656.006	443.9278	2975.568	202.0676	26.8426	163.6107	3359.582
Mandakh	Argali	F	889.26	238.3592	1453.909	145.6537	18.10712	89.35018	1917.953
Onon	Argali	F	747.4641	175.4374	1370.068	134.7503	5.6426	129.8541	2165.589
Otgoo	Argali	F	1495.879	164.3759	2240.393	129.8584	10.6691	72.6078	2561.772
Sue	Argali	F	1272.243	132.2206	1921.914	110.5546	5.6038	38.28045	1817.585
Tonimaa	Argali	F	1190.683	256.6912	2095.801	195.4508	15.8717	126.4706	2285.219
Tuya	Argali	F	906.2432	290.8264	1491.972	151.4881	19.50884	116.1427	1920.927
Vicky	Argali	F	1090.297	556.5807	1725.317	256.3317	24.6773	189.9838	1613.218
Zulaa	Argali	F	1204.447	175.923	1805.039	133.0864	3.713233	82.81457	2108.778
Bataa	Argali	M	1154.257	247.8409	1789.552	122.2	28.11353	61.72947	1935.814
Batorshik	Argali	M	1303.119	144.2081	2331.936	149.6871	0.4105	40.5969	1886.427
Bayanaa	Argali	M	633.9168	109.9992	1134.054	108.1797	3.5713	76.015	1345.404
Brian	Argali	M	628.8624	226.3296	983.771	107.7807	24.3793	94.2658	1744.677
Buya	Argali	M	795.9546	603.8175	1509.221	242.7394	40.16005	217.2076	1839.035
Dale	Argali	M	1323.414	312.4284	1965.049	214.7166	23.36285	61.42655	1569.49
Harlan	Argali	M	1063.008	786.2048	1971.388	365.1637	29.5354	255.0694	2273.414
Jed	Argali	M	1086.637	173.7359	1529.861	136.1091	0.5916	47.921	1474.878
Khokh	Argali	M	1024.118	304.9518	1802.109	132.6524	17.5036	150.043	2031.536
Khongilt	Argali	M	1097.321	137.5496	1187.058	140.7525	2.0059	29.3575	1223.954
Mike	Argali	M	637.2792	113.8647	1200.127	123.0653	0	39.063	1030.83
Namshir	Argali	M	960.8902	114.1921	1419.367	88.4709	1.1318	50.4095	1366.396
Purev	Argali	M	916.2743	82.842	1283.685	102.599	1.144	34.2971	1625.758
Scott	Argali	M	567.7474	61.2045	671.2384	64.3052	0.9066	9.193	485.6653
Toogii	Argali	M	958.1377	49.731	1473.559	62.3823	0.0812	20.9437	1496.377

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub

Table 2: Argali mean percent of vegetation use by years 2003-2008 for 50% home range kernel, measured in hectares.

Name	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Alison	F	71.6415	3.2213	68.4616	2.2224	0	0.0444	25.1381
Amaraa	F	208.9476	7.81905	146.3769	8.78805	0	5.58645	212.5443
Bataa	M	384.6535	19.229	453.7651	17.13857	0.081233	9.826267	348.9375
Batbold	F	257.6182	19.0332	293.7794	16.524	0	19.6369	580.5678
Batorshik	M	497.6968	18.6069	698.9724	40.139	0	6.6965	340.3894
Bayanaa	M	198.7023	9.6849	121.0291	6.089	0	6.9113	268.1637
Bayasaa	F	264.5084	21.48725	441.1061	45.8072	0	5.1304	157.77
Brian	M	232.0213	10.6698	147.6302	4.7345	0	5.0793	339.4623
Buya	M	268.1691	88.2985	327.2736	49.08435	0.48735	32.26085	587.0381
Dale	M	392.5965	35.33125	594.4406	59.38325	0.12185	12.2076	361.0205
Debmaa2	F	321.0086	18.5698	234.9388	18.6052	0.1625	11.8283	399.6999
Diane	F	400.0345	29.3849	696.6824	52.6824	0	16.519	304.5769
Dot	F	213.1214	9.8099	226.1108	11.26225	0.12185	1.8785	175.0263
Eggnog	F	199.6129	11.3866	229.0351	8.42745	0	1.6854	135.7815
Ganaa2	F	360.6863	14.79158	518.7044	22.87384	0.80352	3.93402	239.8261
Harlan	M	396.8312	82.9959	618.1201	109.8753	0.5666	29.5114	527.2921
Janice	F	186.1029	14.6636	267.5276	18.1938	0.1812	2.8808	96.1111
Jargal	F	325.9326	30.8531	378.6928	30.70825	0.09865	7.18925	245.9652
Jed	M	368.1986	15.9451	423.4331	22.4012	0	3.0032	253.4426
Jerry	F	314.0432	17.83967	338.4545	19.19623	0.081233	2.3359	173.0053
Jill	F	256.1464	13.5225	370.0002	32.64795	0	5.9937	196.0785
Khatan	F	228.1252	13.80475	321.185	33.99945	0	4.87915	167.8322
Khokh	M	412.1061	17.5834	422.6776	18.3342	0	6.1527	449.7947
Khongilt	M	266.4056	43.4187	295.4761	41.317	0.2437	11.4623	286.3592
Lauren2	F	261.425	7.8322	187.8432	6.1907	0	5.6711	261.5338
Lisa2	F	499.5279	58.9059	957.6118	28.3543	2.9467	20.1989	1082.911
Mandakh	F	292.5647	28.38067	333.422	34.781	0.022683	14.90142	433.0417
Mike	M	215.0043	15.1759	300.4722	29.4042	0	5.1713	214.8108
Namshir	M	266.8908	10.6371	232.6971	14.3892	0	6.3141	292.9793
Onon	F	266.379	16.3324	283.7825	15.2125	0	7.1041	568.8268
Otgoo	F	471.8143	30.0627	692.6044	39.4374	0	16.5813	912.8696
Purev	M	313.1899	16.1028	325.518	28.4813	0	6.7613	275.4688
Scott	M	197.2209	11.6398	193.7587	18.9312	0.2437	2.5669	65.3042
Sue	F	423.6738	25.5998	574.2483	22.27435	0.737125	9.38795	322.5885
Tonimaa	F	375.5496	27.5767	352.4236	48.1046	0	11.6021	543.577
Toogii	M	323.1068	13.6916	280.2171	16.4908	0	5.767	289.1508
Tuya	F	318.9845	35.9739	336.617	24.9592	2.46016	17.42926	574.5933
Vicky	F	387.1893	38.2652	433.1029	32.4065	0.0957	17.5216	497.5149
Zulaa	F	379.8224	23.76437	477.925	19.9105	0	12.0213	516.2075

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 3. Argali mean percent of vegetation use by years 2003-2008 for minimum convex polygon, measured in hectares.

Name	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Alison	F	366.4099	28.7128	637.9615	23.2974	0	4.1051	343.398
Amaraa	F	773.2511	243.7386	1412.182	174.8658	1.3278	80.5504	1814.4
Batbold	F	953.7972	96.726	1615.572	123.9045	0.9156	38.2501	2050.85
Bayasaa	F	1015.731	660.6424	1990.795	411.6244	3.6146	226.158	1303.1
Debmaa2	F	802.578	264.9722	1452.867	171.5287	1.1372	105.472	1881.05
Diane	F	1792.061	689.17	3633.232	447.4479	4.6453	229.37	3849.99
Dot	F	621.0162	102.954	1116.19	111.7227	1.5045	19.3613	623.071
Eggnog	F	807.4976	112.5676	1077.222	80.92875	0.212	12.8337	948.559
Ganaa2	F	1336.769	374.5438	2832.638	264.2454	2.3566	117.092	2301.1
Janice	F	1580.221	187.0112	2796.309	163.5454	1.6245	16.2451	1573.34
Jargal	F	1599.948	181.0773	2611.271	167.9816	2.031	17.9967	1815.43
Jerry	F	1022.872	126.4689	1436.386	106.7958	0.592	7.47405	930.384
Jill	F	1982.027	1033.039	4121.793	496.2237	7.4526	350.066	3867.14
Khatan	F	950.3528	176.6094	2139.464	144.9248	3.3572	93.5394	1849.89
Lauren2	F	1476.368	317.9854	2787.551	255.1739	2.9234	62.9692	2722.83
Lisa2	F	1221.471	640.2173	2512.7	435.0302	4.3133	196.278	2192.43
Mandakh	F	1019.977	455.959	1997.981	237.6872	6.3357	161.421	2372.96
Onon	F	947.9363	186.1468	1732.028	112.9406	0.1625	98.4669	2612.84
Otgoo	F	1273.823	75.9879	2326.416	120.4515	0.1625	26.7972	2251.46
Sue	F	1304.038	249.7212	2416.719	210.5567	1.8518	59.1026	2105.68
Tonimaa	F	1290.517	354.1298	2670.241	215.2818	1.2896	101.222	2818.49
Tuya	F	1316.001	656.4129	2712.28	317.2103	14.572	243.529	2694.51
Vicky	F	886.5075	343.4496	1539.844	248.708	1.7784	86.6017	1399.35
Zulaa	F	1268.532	364.2695	2250.89	255.8564	1.9387	129.045	2325.88
Bataa	M	1226.406	554.7116	2396.756	310.0943	14.285	171.211	1556.34
Batorshik	M	896.5737	86.2868	1898.438	124.479	0.2777	26.0875	1947.54
Bayanaa	M	577.2437	163.9803	1005.141	79.0363	0.1625	92.9776	1800.22
Brian	M	588.6214	245.4375	993.1845	178.8108	1.1977	67.1847	1600.42
Buya	M	1272.714	353.7167	3125.086	255.2965	3.3584	101.765	1676.58
Dale	M	1865.453	544.6453	3561.46	415.6346	5.5251	127.239	2314.98
Harlan	M	1124.944	1161.793	2435.592	596.9107	5.2796	419.899	3319.86
Jed	M	1111.277	296.9225	1920.759	263.1286	2.9829	61.0655	1340.61
Khokh	M	975.4492	582.2381	1974.256	338.629	6.8644	178.421	2072.48
Khongilt	M	995.3786	190.4557	1889.083	189.8685	2.7617	35.7016	1212.92
Mike	M	580.9336	42.7126	1215.829	79.3922	0.1625	21.0733	1018.46
Namshir	M	1053.931	812.8983	2154.99	397.5866	15.916	273.835	2256.06
Purev	M	1083.103	247.2769	2058.673	205.5815	1.6306	51.0897	2088.5
Scott	M	524.8231	64.6163	788.3691	58.2817	0.2437	12.8846	581.667
Toogii	M	998.2769	50.2857	2063.423	82.7802	0.1625	22.7418	2102.83

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 4: Ibex mean percent of vegetation use by years 2003-2008 for 95% home range kernel, measured in hectares.

Ibex Name	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Amber	F	632.1381	194.2964	955.8459	107.5913	1.6091	40.3418	630.6959
Cecile	F	425.164	76.576	732.9971	79.7236	0	16.656	271.3886
Chris	F	422.5098	34.4331	526.6343	41.5537	0	7.292	279.8102
Gerda	F	484.994125	52.860575	621.825625	61.25975	0.494	11.0901	889.42445
MaryJo	F	411.3538	78.76055	612.2302	70.1173	0.6049	22.5388	408.2916
Saikhanaa	F	660.2101	80.38725	854.7258	68.5529	1.77945	20.7994	581.50275
Tony	F	402.0583	71.6139	548.0911	68.99195	38.48125	20.41485	394.06655
Tsomoo	F	798.0726	176.23235	1064.5902	120.3899	1.78115	30.81185	780.11355
Anand2	M	404.0932	43.4478	522.1762	41.079	0	9.9576	394.0441
Baagii	M	1141.3201	123.1026	1348.96	117.5103	0.9747	23.8069	1378.4555
Bold	M	560.5604	108.1806	780.9942	81.4114	0.4873	15.7929	614.4536
Borkhuu	M	562.5236	55.9961	766.3804	63.7771	0.0812	10.7978	414.8496
Dagii	M	932.9216	140.5706	1097.5602	135.984	1.462	21.4131	994.0629
Fisher	M	427.6053	29.0159	757.2	51.5209	0	7.5366	285.176
Guy	M	323.8508	9.495	258.9342	19.0228	0	4.2485	301.9401
Malcolm	M	442.2975	48.6215	617.0073	57.072	0.2437	10.9704	358.3397
Nasaa	M	1067.18155	158.72415	1601.5643	172.2127	1.51495	24.4362	889.53955
Randy	M	437.1421	44.27815	577.21055	61.4126	0.3682	10.18705	299.5476

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 5: Ibex mean percent of vegetation use by years 2003-2008 for50% home range kernel, measured in hectares.

Ibex Name	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Amber	F	180.4531	11.5617	268.8356	22.0498	0	4.3763	107.1085
Anand2	M	116.2005	13.7595	125.7881	16.0601	0	2.6131	66.2808
Baagii	M	179.8245	26.4303	184.9606	37.8184	0.2437	9.5098	173.8491
Bold	M	189.5957	17.1308	164.4997	18.7924	0	0.5708	151.4731
Borkhuu	M	168.4502	16.4793	151.1405	20.1254	0	4.235	75.1043
Cecile	F	77.5206	1.1965	131.6686	13.2354	0	0.0717	8.0106
Chris	F	145.2462	8.6713	150.4443	9.419	0	0.1624	60.6477
Dagii	M	217.7426	28.0706	240.4579	35.0913	0	6.9642	162.9848
Fisher	M	77.2476	1.3253	125.6015	11.1387	0	0	8.7778
Gerda	F	135.5032	11.63658	163.751	16.2869	0.06093	3.07835	71.2477
Malcolm	M	111.8556	9.5073	113.067	12.7032	0	1.9271	64.2081
MaryJo	F	133.667	9.85785	150.7651	17.8626	0	4.44155	80.7382
Nasaa	M	325.0853	22.72355	388.6278	39.6691	0.004	6.0846	191.71195
Randy	M	149.1703	5.6513	174.8749	12.3264	0	1.90115	47.75235
Saikhanaa	F	173.1895	12.14025	194.5087	14.1957	0	1.9126	77.038
Tony	F	70.3616	6.0994	87.7719	14.9062	0	2.9095	72.5955
Tsomoo	F	189.4641	21.73145	209.2988	28.70335	0.12185	6.3813	137.89665

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 6: Mean percent of vegetation use by years 2003-2008 for minimum convex polygon for ibex, measured in hectares.

Ibex Name	Sex	DR*	HDS	SGF	TV	W	SS	LDS
Amber	F	1094.8172	255.2717	2274.72	196.599	2.6662	50.2975	1146.104
Cecile	F	1655.542	225.7372	3458.57	187.656	0	25.3458	1234.298
Chris	F	973.3212	114.4823	1266.58	88.3898	0.731	11.6306	1250.132
Gerda	F	733.97455	84.4797	1294.65	71.0093	0.0766	12.0885	737.5769
MaryJo	F	656.34775	108.2747	1175.87	95.6852	1.3875	18.2086	901.4367
Ochoo	F	1626.468	169.1149	2879.64	140.92	0.4874	18.8483	1918.642
Saikhanaa	F	921.6694	339.1654	1446.14	233.171	2.3988	81.9792	1049.152
Tony	F	829.8646	123.8843	1677.17	104.898	1.4693	17.9916	1035.829
Tsomoo	F	1721.96655	252.6783	2421.45	170.864	2.0381	29.9424	1839.253
Anand2	M	432.8734	63.1804	542.088	52.5307	0.2437	12.3944	566.8895
Baagii	M	1084.03563	173.6951	1655.28	162.444	1.7328	27.2236	1264.753
Borkhuu	M	851.5841	114.2242	1176.88	76.9528	0	10.246	745.4931
Dagii	M	1490.2286	200.7004	1804.91	184.838	2.5472	28.0565	1835.312
Guy	M	394.6341	18.3014	521.157	35.9745	0	7.8755	284.1252
Malcolm	M	470.9324	55.6058	781.949	52.5437	0	11.4527	437.0387
Nasaa	M	1502.20205	165.5104	2317.87	141.768	1.2895	16.4882	1668.673
Randy	M	517.85865	90.1457	789.628	65.0014	0.6895	12.4193	537.3891

*DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

APPENDIX II: SYSTAT tables 1 – 30 measuring 95%, 50% home range kernels and minimum convex polygons compared to Argali and ibex use, further divided by individual species, and sex. DR = dense rock; HDS = high density shrub; SGF = short grass forb; TV = tall vegetation; SS = semi shrub; LDS = low density shrub.

Table 1: Argali and Ibex Mean 95% kernel vegetation Percentages compared to the core zone, Ikh Nart, and the study site

	DR	HDS	LDS	SGF	SS	TV	Total
AR	21.399	4.912	34.888	33.883	1.776	3.142	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	27.018	4.520	26.982	37.358	0.288	3.834	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	**92.761**	**51.523**	**146.826**	**166.626**	**19.381**	**22.883**	**500.000**

Table 2: Argali and Ibex Mean 50% kernel vegetation percentages compared to the core zone, Ikh Nart, and the study site.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	29.788	2.097	30.737	34.099	0.808	2.471	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	33.907	2.679	18.627	39.733	0.673	4.381	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	**108.038**	**46.866**	**134.320**	**169.217**	**18.798**	**22.759**	**500.000**

Table 3: Argali and Ibex Mean Minimum Convex Polygon vegetation percentages compared to the core zone, Ikh Nart, and the study site.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	16.672	16.672	29.642	31.904	1.627	3.482	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	24.974	3.762	27.174	40.476	0.578	3.036	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	**85.990**	**62.524**	**141.773**	**167.766**	**19.522**	**22.425**	**500.000**

Table 4: Comparison of Argali and Study Site Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	21.399	4.912	34.888	33.883	1.776	3.142	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	**30.490**	**26.641**	**62.752**	**58.673**	**11.519**	**9.926**	**200.000**

Table 5: Comparison of Argali and Study Site Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	29.788	2.097	30.737	34.099	0.808	2.471	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	38.879	23.825	58.601	58.889	10.551	9.255	200.000

Table 6: Comparison of Argali and Study Site Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	16.672	16.672	29.642	31.904	1.627	3.482	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	25.763	38.400	57.507	56.694	11.371	10.265	200.000

Table 7: Comparison of ibex and Study Site Mean 95% kernel Vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	27.018	4.520	26.982	37.358	0.288	3.834	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	36.109	26.249	54.846	62.148	10.031	10.617	200.000

Table 8: Comparison of ibex and Study Site Mean 50% kernel Vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	33.907	2.679	18.627	39.733	0.673	4.381	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	42.998	24.407	46.491	64.523	10.417	11.164	200.000

Table 9: Comparison of ibex and Study Site Mean minimum Convex polygon percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	24.974	3.762	27.174	40.476	0.578	3.036	100.000
SS	9.091	21.728	27.864	24.790	9.743	6.783	100.000
Total	34.065	25.490	55.038	65.266	10.321	9.819	200.000

Table 10: Comparison of Argali and Ikh Nart Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	21.399	4.912	34.888	33.883	1.776	3.142	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	32.185	22.848	63.412	63.086	8.864	9.605	200.000

Table 11: Comparison of Argali and Ikh Nart Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	29.788	2.097	30.737	34.099	0.808	2.471	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	40.574	20.032	59.261	63.302	7.896	8.934	200.000

Table 12: Comparison of Argali and Ikh Nart Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	16.672	16.672	29.642	31.904	1.627	3.482	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	27.458	34.607	58.166	61.108	8.715	9.945	200.000

Table 13: Comparison of ibex and Ikh Nart Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	27.018	4.520	26.982	37.358	0.288	3.834	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	37.804	22.456	55.506	66.561	7.376	10.296	200.000

Table 14: Comparison of ibex and Ikh Nart Mean 50% kernel Vegetation.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	33.907	2.679	18.627	39.733	0.673	4.381	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	44.693	20.614	47.151	68.936	7.761	10.844	200.000

Table 15: Comparison of ibex and Ikh Nart Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
IB	24.974	3.762	27.174	40.476	0.578	3.036	100.000
IN	10.786	17.935	28.524	29.204	7.088	6.463	100.000
Total	35.760	21.697	55.698	69.680	7.666	9.499	200.000

Table 16: Comparison of Argali and Core Zone Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	21.399	4.912	34.888	33.883	1.776	3.142	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000

	DR	HDS	LDS	SGF	SS	TV	Total
Total	45.866	7.339	63.456	75.275	2.262	5.803	200.000

Table 17: Comparison of Argali and Core Zone Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	29.788	2.097	30.737	34.099	0.808	2.471	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
Total	54.255	4.523	59.305	75.491	1.294	5.132	200.000

Table 18: Comparison of Argali and Core Zone Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
AR	16.672	16.672	29.642	31.904	1.627	3.482	100.000
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
Total	41.139	19.098	58.210	73.297	2.113	6.143	200.000

Table 19: Comparison of ibex and Core Zone Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	27.018	4.520	26.982	37.358	0.288	3.834	100.000
Total	51.485	6.947	55.550	78.750	0.774	6.494	200.000

Table 20: Comparison of ibex and Core Zone Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	33.907	2.679	18.627	39.733	0.673	4.381	100.000
Total	58.374	5.105	47.195	81.125	1.159	7.042	200.000

Table 21: Comparison of ibex and Core Zone Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
CZ	24.467	2.426	28.568	41.392	0.486	2.661	100.000
IB	24.974	3.762	27.174	40.476	0.578	3.036	100.000
Total	49.441	6.188	55.742	81.868	1.064	5.696	200.000

Table 22: Comparison of Argali and Ibex Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
Argali	21.399	4.912	34.888	33.883	1.776	3.142	100.000
Ibex	27.018	4.520	26.982	37.358	0.288	3.834	100.000
Total	**48.417**	**9.433**	**61.870**	**71.240**	**2.064**	**6.976**	**200.000**

Table 23: Comparison of Argali and Ibex Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
Argali	29.788	2.097	30.737	34.099	0.808	2.471	100.000
Ibex	33.907	2.679	18.627	39.733	0.673	4.381	100.000
Total	**63.695**	**4.776**	**49.364**	**73.831**	**1.481**	**6.852**	**200.000**

Table 24: Comparison of Argali and Ibex Mean minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
Argali	16.672	16.672	29.642	31.904	1.627	3.482	100.000
Ibex	24.974	3.762	27.174	40.476	0.578	3.036	100.000
Total	**41.646**	**20.434**	**56.817**	**72.380**	**2.205**	**6.518**	**200.000**

Table 25: Argali comparison of male and females for Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	21.537	4.606	34.716	34.338	1.768	3.036	100.000
M	21.264	5.212	35.056	33.437	1.784	3.247	100.000
Total	**42.801**	**9.818**	**69.772**	**67.774**	**3.552**	**6.282**	**200.000**

Table 26: Argali comparison of male and females for Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	29.401	1.926	30.734	34.884	0.764	2.291	100.000
M	30.408	2.371	30.742	32.843	0.877	2.760	100.000
Total	**59.809**	**4.297**	**61.476**	**67.727**	**1.642**	**5.051**	**200.000**

Table 27: Argali comparison of male and females for minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	19.202	5.510	33.834	36.041	1.728	3.685	100.000
M	18.166	6.592	32.839	36.004	2.031	4.367	100.000

	DR	HDS	LDS	SGF	SS	TV	Total
Total	37.369	12.102	66.674	72.045	3.759	8.051	200.000

Table 28: Ibex comparison of male and females for Mean 95% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	26.785	4.838	26.777	37.409	0.283	3.908	100.000
M	27.269	4.179	27.203	37.302	0.293	3.753	100.000
Total	54.054	9.017	53.980	74.712	0.576	7.661	200.000

Table 29: Ibex comparison of male and females for Mean 50% kernel vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	29.401	1.926	30.734	34.884	0.764	2.291	100.000
M	30.408	2.371	30.742	32.843	0.877	2.760	100.000
Total	59.809	4.297	61.476	67.727	1.642	5.051	200.000

Table 30: Ibex comparison of male and females for minimum convex polygon vegetation percentages.

	DR	HDS	LDS	SGF	SS	TV	Total
F	24.061	3.941	26.178	42.155	0.627	3.037	100.000
M	26.497	3.463	28.836	37.676	0.496	3.033	100.000

APPENDIX III.

DIRECTIONS FOR CREATING PERCENT AND AREA OF POLYGONS in 9.3.1.

- Open ArcMap
- Choose existing animal map
- Open attribute table (95/50 season 10 or mcp season)
- Highlight attribute you wish to summarize (95% season 10)
- Run model using highlighted attribute

Model set up:

- Clip attribute from vegetation layer
- Input is vegetation layer
- Features to clip are attribute you've selected (season 10/95%)
- Calculate area for each vegetation layer, in hectares
- Add percent field (name=pct; precision=5; scale decimal values=3)

- After running model, summarize vegetation layers
    - Open clipped file
    - Right click on gridcode
    - Choose summarize
    - Check hectares, standard deviation, and variance
    - Check pct, standard deviation, and variance
- Obtain sum of hectares
    - Open sum table
    - Right click on hectares
    - Choose stats
    - Record sum of hectares
- Calculate percent of vegetation
    - Right click on pct column
    - Use field calculator
    - Type in Pct=(click on sum-hectar) and use '/' by, type in the sum of hectares obtained in previous step
- Record area and percent in excel table