

**The Where and Why  
of saiga antelope distribution in West Kazakhstan**

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*September 2011*

*A thesis submitted in partially fulfillment of the requirements of Master of*

*Science and the Diploma of Imperial College London*

## **DECLARATION OF OWN WORK**

I declare that this thesis:

**The where and why of saiga distribution in West Kazakhstan**

Is entirely my own work and that where material could be construed as the work of others, it is fully cited and referenced, and or with the appropriate acknowledgement given

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## 2. LIST OF ACRONYMS

ACBK	Association for the Conservation of Biodiversity in Kazakhstan
AUC	Area under the curve
CITES	Convention of International Trade of Endangered Species of wild flora and fauna
GIS	Geographical information system
GPS	Geographical position system
HSM	Habitat suitability model/modelling
NDVI	Normalised difference vegetation index
ROC	Receiver Operating Characteristic curve
SCA	Saiga Conservation Alliance
USSR	Union of Soviet Socialist Republics

### 3. ABSTRACT

Effective and economical monitoring methods are required in biodiversity conservation. Monitoring of migratory species can be especially costly. A participatory monitoring scheme, as an economical monitoring technique, is initiated in West Kazakhstan for the monitoring of the Ural population of Saiga antelope, *saiga tatarica*. The presence data collated from the participatory monitoring scheme is evaluated and analysed alongside presence data from wildlife rangers in the region and an annual aerial survey using a maximum entropy habitat suitability modeling approach. The participatory monitoring data performs well with an improved model fit than the ranger data and of similar fit to the aerial survey data. Additionally the deterministic value of the environmental variables impacting saiga habitat selection, are analysed. The normalized difference vegetation index (NDVI) is shown to have the greatest effect on saiga habitat selection. Human factors and distance to water are also demonstrated to have deterministic value. Improvements to the monitoring techniques covered are discussed. Participatory monitoring is found to be an effective tool for monitoring the saiga antelope.

## 4 INTRODUCTION

### 4.1 Problem Statement

#### 4.1.1 Conserving migratory species

The phenomenon of animal migration particularly those of vast numbers covering large distances is a truly awe inspiring sight. These seasonal mass movements of animals is not only captivating to the human eye but also an important ecological process that facilitates the perpetuation of both the migratory species and the ecological interactions resulting from the migration. To that note the conservation of migration is not just the conservation of the migratory species but the preservation of the phenomenon itself which plays an important part in the function of the involved ecosystems (Shuter et al., 2011)

Migration has developed as a life history strategy throughout the animal kingdom including many species of mammals, birds and insects (Wilcove & Wikelski, 2008). Debates over exact definitions of migration may be interesting but can bottleneck the research of a phenomenon which takes countless forms. Fryxell, E. J. Milner-Gulland, & Sinclair (2011) outline the various angles by which migration is characterized and conclude that acknowledging the wide range of variations within migration theory, will lead to a better understanding of the underlying processes.

As a valuable ecological process animal migration can provide many ecosystem services including nutrient transfer, seasonal predation and seasonal disturbance (Olson, 2005; Shuter et al., 2011). The famous salmon (e.g. *salmo salar*) migration is a classic example of nutrient transfer between ecosystems. Having been born upstream in a river, salmon spend 1-2 years feeding in the ocean before returning to spawn upstream in their natal rivers. After spawning the adults die, leaving their bodies to decompose and release nutrients, acquired from their marine growth environment, into the river systems (B. Jonsson & N. Jonsson, 2003)

Although migratory animals are adapted to a variety of ecosystems, this does not

mean they are better equipped to adapt to changes or threats in their environment. Severe declines in both migratory species and migratory behaviors have been demonstrated over the past decade (Joel Berger, 2004; Joel Berger, Young, & K. M. Berger, 2008; Bolger, Newmark, Morrison, & Doak, 2008; Harris, Thirgood, Hopcraft, Croomsight, & J Berger, 2009; Shuter et al., 2011; Wilcove & Wikelski, 2008). Although it is the loss of huge flocks of migrating birds (e.g. passenger pigeons), swarms of bats and herds of ungulates that is most noticeable to us, the declines are also occurring across all migratory species including insects and amphibians.

This decline seen in migratory animals is due to the large number and variability of threats to which they are exposed. The threats facing migratory species fall into four general categories: habitat loss and degradation, overexploitation, interruption of migration, and climate change (Bolger et al., 2008; Shuter et al., 2011; Wilcove & Wikelski, 2008). Migratory animals are more vulnerable than resident animals to habitat loss and degradation due to the multiplied risk of relying on more than one habitat type. Similarly migratory animals require a larger area of habitat than their sedentary counterparts (Bolger et al., 2008; Harris et al., 2009; W. J. Sutherland, 1996; William J. Sutherland, 1998). The predictability and large aggregation sizes commonly seen in migratory animals lends them to be easily overexploited (Bolger et al., 2008), an occurrence which has been well documented in causing severe declines and extinctions, particularly in marine species (Mollmann, Muller-Karulis, Kornilovs, & St John, 2008; West, Dytham, Righton, & Pitchford, 2009). Overexploitation is of particular concern where the migration crosses institutional and political boundaries due to the requirement of coordinated hunting laws, quotas and enforcement (Epstein et al., 2009). Often migration occurs along spatially and temporally narrow pathways, making them vulnerable to obstruction and interruption, for example Mongolian saiga and Pronghorn in Western Wyoming (Joel Berger, 2004; Joel Berger et al., 2008). This can include anything from degraded habitat to physical barriers, such as dams in river system (Wilcove & Wikelski, 2008). Lastly global changing climate is challenging species worldwide, and we are already seeing its impacts in the reduction in number of returning migratory birds from Africa to Europe (Sanderson, Donald, Pain, Burfield, & van Bommel, 2006). Migratory species may be unable to respond to these changes in climate due to their



migration being stimulated by an innate and/or learned behaviour to specific variables, not a generally increased ability to detect and respond to change in all climatic variables.

Conservation of migration, both as a behaviour and of the species involved is a problematic discipline. Although some rough patterns have been described (e.g. Olf, Ritchie, & Prins, 2002), each instance is case specific and requires a full understanding of the complex processes and large areas involved. In order to undertake any conservation action a clear account of the species habitat usage both spatially and temporally is required, alongside an understanding of the drivers behind the migration, i.e. the where and why of endangered migratory species.

Habitat suitability models (HSM's) are a useful tool in this circumstance, providing the ability to investigate unobserved areas for species presence and evaluate what variables determine the migratory patterns (Austin, 2007; A Guisan & N E Zimmermann, 2000; Hirzel & Le Lay, 2008; Store & Kangas, 2001). The use of HSM's however requires data on species known presence and absence, which involves monitoring the species of interest. Monitoring can be both time and money consuming and requires careful consideration of the aims and objectives of the data it will provide (Nichols & Williams, 2006; W. Sutherland, 2000). Therefore evaluation of monitoring techniques in order to increase the efficiency and efficacy of monitoring schemes is essential. Migratory species exacerbate this problem further due to their wide ranging and highly itinerant behaviour.. The data required for HSM's is therefore often scarce in migrant animals living within developing countries due to a lack of capacity and funding preventing the establishment of suitable monitoring schemes. Many of the remaining migrations fall into these regions due to the reduced anthropogenic impact found in less developed countries, upon the habitat types (Reardon, 1995).

#### **4.1.2 Saiga antelope: an endangered migratory ungulate**

The saiga antelope (*saiga tatarica*) is an example of a highly migratory species inhabiting developing countries with a deficiency in understanding of its ecology and

threats, necessary for conservation initiatives. Historically undergoing vast migrations and populating the expanse of the Eurasian steppe, the species underwent a 95% population decline between 1991 and 1998, due largely to a rise in poaching after the collapse of the Soviet Union (E.J. Milner-Gulland et al., 2001). The last 20 years has seen an increase in international interest and research on the species but one of the five remaining populations still lack the basic data on distribution and ecological drivers. The population, sub species *saiga tatarica tatarica*, in question is located in the Ural region of West Kazakhstan. An up to date spatial and temporal distribution of saiga within this population has yet to be documented and the movement patterns described. Monitoring techniques used in Kazakhstan are limited due to lack of capacity and funding. It is therefore a key location for the establishment and evaluation of effective and efficient monitoring schemes.

## **4.2 Aims and Objectives**

### **4.2.1 Project aims**

This study aims to add to the knowledge base of saiga antelope distribution and the ecological drivers behind it. This is achieved by implementing a participatory monitoring scheme in the believed range of the Ural population of saiga antelope. This data will be used alongside data from aerial surveys and wildlife rangers, in a habitat suitability model. The current distribution of saiga in the Ural and further potentially suitable habitats are illustrated. The use of three sources of monitoring data allows for the cross-evaluation of the monitoring techniques used and assessment of the newly established participatory monitoring scheme.

### **4.2.2 Project Objectives**

1. A description of the current and potential distribution of the Ural population of saiga antelope
2. Illustrating the deterministic factors involved in saiga habitat selection in the Ural population
3. Analysis of how the habitat use predictions vary between monitoring techniques and times of year

4. Evaluation of participatory monitoring as a suitable conservation tool in this region

## **5 BACKGROUND**

### **5.1 Habitat selection**

#### **5.1.1 Habitat selection and Niche theory**

Ecological niche theory describes the position held by living organisms within their ecosystem (Hirzel & Le Lay, 2008). It functions at the species, population or individual scale. The fundamental niche illustrates the role played by the organism in relation to the affect of the physiological and mechanistic processes and limitations occurring within the ecosystem, therefore describing the potential position (geographically and ecologically) for its existence (A Guisan & N E Zimmermann, 2000; A. Guisan et al., 2007). This does not take into account the biotic interactions and limitations played between species/populations/individuals, which results in the realized niche due to the impacts of interactions such as predation pressure and competitive exclusion (Ellenberg, 1953; Malanson et al., 1992; Malanson, 1997).

Habitat suitability modeling (HSM) is the application of habitat selection as determined by niche theory, providing a prediction of potential habitat (A Guisan & N E Zimmermann, 2000; Hirzel & Le Lay, 2008). This is achieved by the evaluation of known species presence data against a series of environmental variables, and can again be applied at any scale; species, populations or individuals. The species is derived from field observations and according to the modeling technique used can be simple presence data, presence-absence data or abundance data (Antoine Guisan & Thuiller, 2005). As habitat suitability models use field derived observations, rather than theoretical, of environmental variables under analysis, a description of the realized ecological niche can be formed (A Guisan & N E Zimmermann, 2000). However this is often limited to a simple ecological niche by a lack of information on species dispersal activity and evolutionary history (S. J. Phillips & Dudík, 2008)(Phillips et al 2008).

### **5.1.2. Habitat selection in biodiversity conservation**

Biodiversity conservation requires foresight into the impacts of environmental and managerial change upon an ecosystem and the organisms within it (Ferrier, 2002; Funk & K. S. Richardson, 2002; Rushton, Ormerod, & Kerby, 2004) The ability to predict the affects of this change is imperative due to the often irreversible nature of conservation actions. It requires a full and quantified understanding of the interactions both within and between the ecosystems components, both biotic and abiotic. Quantifying these relationships has historically played a part in ecological research, and constant improvements in analytical and predictive tools is ever increasing our understanding of evolutionary habitat selection (Rushton et al., 2004)

### **5.1.3. Determining factors of habitat selection**

Factors influencing habitat selection can be categorized in two ways. Firstly they fall into the following three categories; Physical environment, abiotic (e.g. topography); biological environment, biotic (e.g. parasitism); and anthropogenic, biotic or abiotic (e.g. hunting and roads). Additionally they can be classified as direct or indirect according to how they influence the decision making process. The direct factors often comprise several casual indirect factors, such as precipitation, topography and temperature affecting vegetation productivity factors (e.g. NDVI), a direct influence on herbivore habitat selection.

The choice of determining factors (variables) selected for habitat suitability modeling is dependant on the level of detailed quantification required by the study. The use of an indirect determinant will account for the causal, direct determinants behind the indirect factor, and this may be enough for a scoping study on the general influences of habitat selection; for example if investigating whether anthropogenic or environmental factors are more influential on the species habitat selection. In contrast when planning conservation management it is often necessary to have a deeper understanding of the exact direct determinants most valuable to the decision of species habitat selection, such as prioritizing between areas of variable levels of indirect factors according to which has the greatest influence on the direct habitat preference determinant.

#### 5.1.4. Maxent

Maxent is a maximum-entropy methodology developed for the use of presence only data in habitat suitability and species distribution modeling. It is typically more difficult to achieve presence-absence data than presence only data, particularly when the species in question is rare, migratory and/or endangered, such as the case of saiga antelope. Having seen major advances in statistical and computational power in relation to species distribution modeling, the creation of the maximum-entropy approach has filled a gap with a robust technique for presence only data (Phillips et al, 2006). The Maxent approach uses the occurrence data to set constraints used to find a probability of presence distribution over the study area. The distribution requiring the least constraints is then selected, as this represents the closest to uniform fit of the model and data, i.e. maximizing entropy (Phillips et al, 2006; S. J. Phillips & Dudík, 2008). Although the Maxent approach is a general machine learning methodology, it is now commonly used and appreciated in the ecological research of species distributions (Phillips et al, 2006; S. J. Phillips & Dudík, 2008). The usefulness of the model created can be evaluated using the area under the curve, AUC, value, which tests the fit of the test data to the model created by the training data. Pearce & Ferrier (2000) suggest an AUC value 0.7 portrays a good model and AUC 0.9 an excellent model. Similarly (Jane Elith et al., 2006) suggest a model with an AUC > 0.75 provides useful information. Evaluations of the Maxent approach illustrate the model as performing consistently above average or best in relation to other presence only data species distribution models currently in use in ecological literature (S. J. Phillips & Dudík, 2008)

### 5.2 Monitoring techniques

#### 5.2.1. Why monitor?

Monitoring is the systematic measurement of variables and processes over time. It is essential within ecology for quantifying changes seen in populations, communities or ecosystems. Quantification is required for disseminating patterns for a greater understanding of changes observed within the subject being monitored (Spellerberg, 1995). Additionally quantification is particularly important in ecological conservation as it provides

numerate evidence for persuading and informing policy change. Monitoring can answer numerous conservation relevant questions such as: what are the habitat requirements of a species? How does a given management strategy affect a species, community or ecosystem? What and where are the most important habitat types for an endangered species (W. Sutherland, 2000)? A common pitfall in monitoring techniques is a lack of clear objectives. This leads to time and money consuming monitoring schemes being implemented and resulting in information that is unable to be used for the required research or management questions (Spellerberg, 1995). An example of this in terms of conservation ecology is a need for agreed monitoring techniques across a species range in order for the results to be used together. Additionally when answering questions of habitat selection and response to management changes, the environmental variables associated should also be monitored.

#### 5.2.1.1 Techniques available for mammal monitoring

Monitoring species, communities or ecosystems usually requires some form of sampling due to entire counts being either impossible, too costly or too time consuming. There are three main classes of sampling technique: random, systematic and stratified (W. Sutherland, 2000). Random sampling is the first step in avoiding bias during monitoring and can be used where little is previously known about the ecological requirements of the monitoring subject. Importantly for this to be a valid sampling method site selection must be randomly generated to avoid bias (W. Sutherland, 2000). Following from this stratified sampling requires previous knowledge of the general range of the monitoring subject. Systematic sampling or interval sampling is generally faster than random sampling and provides a better coverage of the variation within a site (Mueller & Ellenberg 1974). This sampling technique is carried out by randomly selecting a starting point and sampling in a previously defined systematic manner. Analysis of systematic sampling is more straightforward than with a random sampling technique and performs better when identifying patterns. Finally stratified sampling is usually the optimal sampling method as it allows for weighting according to known differences in subject density and dispersal within its range (W. Sutherland, 2000)

Most monitoring methodologies will result in bias and inaccuracies at some level. In order to reduce these problematic factors acknowledgment followed by standardization of the methodology used across the population of interest is essential. Monitoring of mammals can be achieved in multiple ways, with the optimal strategy dependant on species life history, size and ecology (W. Sutherland, 2000):

a) Direct counts; used for easily located, visible species. Best for species who can be counted without causing disturbance, for example bats during hibernation (W. Sutherland, 2000). The problem with disturbance can in some situations be counteracted using photography.

b) Transects; a popular methodology used alongside distance sampling theory to estimate species abundance and densities.

c) Mapping; best monitoring method for territorial species, where territories can be determined according to vocalizations and/or nest or den site.

d) Trapping; commonly used for small mammals with mark recapture technique. However the marking procedure used must not hinder the animals fitness. This method also now includes photo or video trapping where the mark-recapture technique can be applied using distinctive phenotypic characteristics.

e) Dung Counts; excellent for elusive or rare animals. Climate is an important factor in determining suitability of this method due to its affect on rate of dung decay.

## **5.2.2 Techniques used in this study**

### **5.2.2.1 Aerial surveys**

The aerial survey design used in this study is an example of systematic transect sampling. While this methodology will be a good predictor of abundance and densities within the area covered, a bias caused by differing levels of detectability at distance according to saiga herd size of will exist (McConville, 2006; Navinder J. Singh & E.J. Milner-Gulland, 2011). The survey coordinators, the Oohotzooprom wildlife rangers, part of the committee for forestry and hunting in Kazakhstan, have attempted to minimise this by surveying in April, when the saiga will still have their white winter coat, but the snow will have melted to reveal brown – green landscape therefore increasing the visibility

(detectability) of small herds of saiga.

#### 5.2.2.2 Oohotzoprom Wildlife Rangers

The Oohotzoprom wildlife rangers are a division of the Committee for Forestry and Hunting of the Ministry of Agriculture of the Republic of Kazakhstan. The rangers patrol the steppe surrounding the areas used by saiga in an anti-poaching capacity. When they sight saiga it is recorded (pers. comm. Steffen Zuther). This is therefore a very biased monitoring technique with no randomness or stratification involved. However as a source of presence points within its own HSM model, this data can help describe habitat selection determinants.

#### 5.2.2.3 Participatory monitoring

Participatory monitoring is an ideal monitoring technique where long term datasets and where spatial and temporal variations are of interest – due to their sedentary state. It is both cost effective (Whitebread, 2008) and bias is usually easily disseminated. In the case of this study there are two potential sources of bias. Firstly if poaching pressure is an important determinant on habitat selection, saiga are likely to avoid human settlement. Secondly participatory monitors tend to herd livestock. The type of livestock herded by the monitor will effect the level of livestock – saiga competition and therefore influence the selection of that habitat by saiga.

### 5.3 Saiga Antelope

The saiga antelope is an endangered migratory ungulate of the steppe, semi-arid and desert ecosystems of Central Asia. An ancient ungulate the saiga antelope has been evolutionary diverse from other hoofed mammals for thousands of years and has therefore hold valuable genetic diversity (Bekenov et al , 1998). It has a sandy colored coat in summer and a thicker white coat during the winter months. At roughly the size of a goat, with males sporting horns, both sexes have a characteristic protruding nose. A culturally important species to the nomadic tribes of central Asia the saiga has been



hunted for hide and horn for centuries. Margulan et al 1966 report cave paintings in central Kazakhstan of saiga from the 7-5th centuries BC. The males horn is highly valuable in traditional Chinese medicine. Due to the soviet rule limiting international research much of the early studies on saiga ecology and distribution are in the Russian language and have not been translated. Bekenov et al 1998 wrote a review of this literature in English on which much of the recent international literature reflects.

### **5.3.1 Current and historical distribution**

The current distribution of saiga antelope can be found in five populations. Four of these populations are the nominate sub species *saiga tatarica tatarica*, with three populations in Kazakhstan and one in pre-Caspian Russia. The final population is of the sub species *saiga tatarica mongolica* of which very few (only hundreds) remain is phenotypically distinct with smaller head and horns (Bekenov et al 1998).

Fossil remains have been found of saiga right across the Eurasian continent from southern Britain to east China (Preston, Pearman, & Hall, 2004). A major climate shift resulted in a mass reduction in the range of saiga and other steppe species from the Pleistocene era 10-12000 years ago (Vereshchagin, 1975 from Bekenov et al 1998). In the more recent history however the antelopes are described as being common throughout Kazakhstan and the surrounding steppe region during the fourteenth to seventeenth centuries. This range appears to have slowly fragmented throughout the following two centuries, with the northern most extent moving south considerably (Sludskii, 1955, from Bekenov et al 1998). Further fragmentation to the final populations occurred throughout the twentieth century as nomadic lifestyles were abandoned and large scale land transformation for agricultural purposes, The Virgin Lands Campaign, took place under the rule of the Soviet Union (Bekenov et al 1998).

### **5.3.2 Saiga antelope population decline**

As a historically hunted game species in central Asia and an important prey species for predators in the region, the saiga antelope population has seen many fluctuations over

the past four centuries. However in the early twentieth century the population was nearly hunted to extinction (Bekenov et al 1998). A ban on hunting in 1919 had little affect due to the civil wars causing both instability on livelihoods and increasing the availability of fire arms. Population recovery was not seen until the 1930's, further hindered by a series of bad dzhuts (extremely heavy snow episodes) in the 1920's, and hunting was legalized again in the 1950's (Bekenov et al 1998). This recovery was due both to management and protection by the Soviet Union within the USSR and also the related border closure with China.

Since the collapse of the soviet union in 1991, the saiga population has undergone another dramatic decline. Milner-Gulland et al 2001 reported a 95% decline, in the proceeding 10 year period. During the Soviet period regular, annual censuses had been undertaken by the Oohotzoprom Wildlife Service, part of the Governments Forestry and Hunting committee. However these ceased due to a lack of funding post Soviet Union collapse and censuses became irregular and lacking in national coordination (Bekenov et al 1998) . A handful of causes have been attributed to the severe population decline since 1991. Firstly loss of economic stability and poverty ran through the former soviet states, leading to a marked reduction in livestock numbers, resulting in an increased reliance on saiga meat as a food source. The instability also lead to a lack of state protection and increased availability of firearms during the initial post soviet years, increasing the ease and efficiency of saiga poaching. Lastly the reopening of the border with China and high value of saiga horn for traditional Chinese medicine caused a steep rise in demand for the saiga horn. As an aggregative species with an increased risk of mass mortality by disease and stochastic events, saiga populations historically have recovered quickly from severe declines due to a high fecundity. The lack of a bounce back response to the recent drop in saiga numbers is of great concern. (E. J. Milner-Gulland et al., 2003)suggest the cause for this to be a high level of poaching of male saiga, for their horns, and a consequent reproductive collapse as the ratio of males to females becomes too high. The resulting diminished saiga population was categorized as critically endangered on the IUCN red list in 2002 (IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <[www.iucnredlist.org](http://www.iucnredlist.org)>. )

### **5.3.2 Ecology (habitat, food, herding, reproduction & life history)**

The saiga antelope has demonstrated mass migratory movement for thousands of years (Bekenov et al 1998). The migratory patterns were also followed by nomadic tribes in the region, up until the last century, driven by rich fodder in the northerly regions in the winter, followed by migration southwards in the winter to avoid harsh cold weather conditions and snow levels (Olcott, 2008).

Saiga habitat stretches over the steppe, semi desert and desert regions of Central Asia. Habitat requirements include even terrain, access to water and ground vegetation. Diet consists of grasses and shrubs such as *poa* and *Calligonum* species respectively. Productivity of semi-desert regions can vary from 200 to 700kg per hectare (Bekenov et al 1998).

There is a female biased sex ratio found in saiga populations similar to other aggregative ungulates. The females can fall pregnant at 9 months old, usually twin from 2 years old and can reproduce until the age of 10 (Bekenov et al). This high fecundity is an evolutionary trait complimenting the mass herding behaviour of the species due to the associated increased risk of mass mortality due to disease. The formation of aggregations of thousands of individuals during migratory periods and within the females during calving is a response to predation risk and a harem based social structure (Bekenov et al 1998, Kühl, 2008).

### **5.3.3 Current threats**

Three main threats face saiga populations presently. First and foremost is the poaching of male saiga for the traditional Chinese medicine market, although poaching for meat and hide is also a problem the high level of demand for saiga horn in China provides the greatest pressure (Kühl, 2008). This pressure not only removes individuals from the population but has additionally lead to a skewed sex ratio causing a reproductive collapse in the species (Milner-Gulland 2003). The increase in poaching of saiga antelope since the collapse of the soviet union is held responsible for the dramatic decline in numbers, with a saiga horn held as a valuable commodity in China (E.J.

Milner-Gulland et al., 2001). In November 1994 the species was added to Appendix II of CITES due to the international concern.

The second major threat to saiga antelope is the blocking, disturbance and destruction of migration routes and habitats (Joel Berger et al., 2008). The virgin lands campaign during the latter half of the twentieth century saw the conversion of saiga habitat to agriculture (Bekenov et al). Additionally vast reductions in livestock numbers since the end of soviet rule has lead to a reduction in steppe management. Without the grazing pressure of the livestock ( a pressure which would formally have been provided by the saiga themselves) indigestible vegetation types outcompete the saiga fodder species.

## 6.0 METHODS

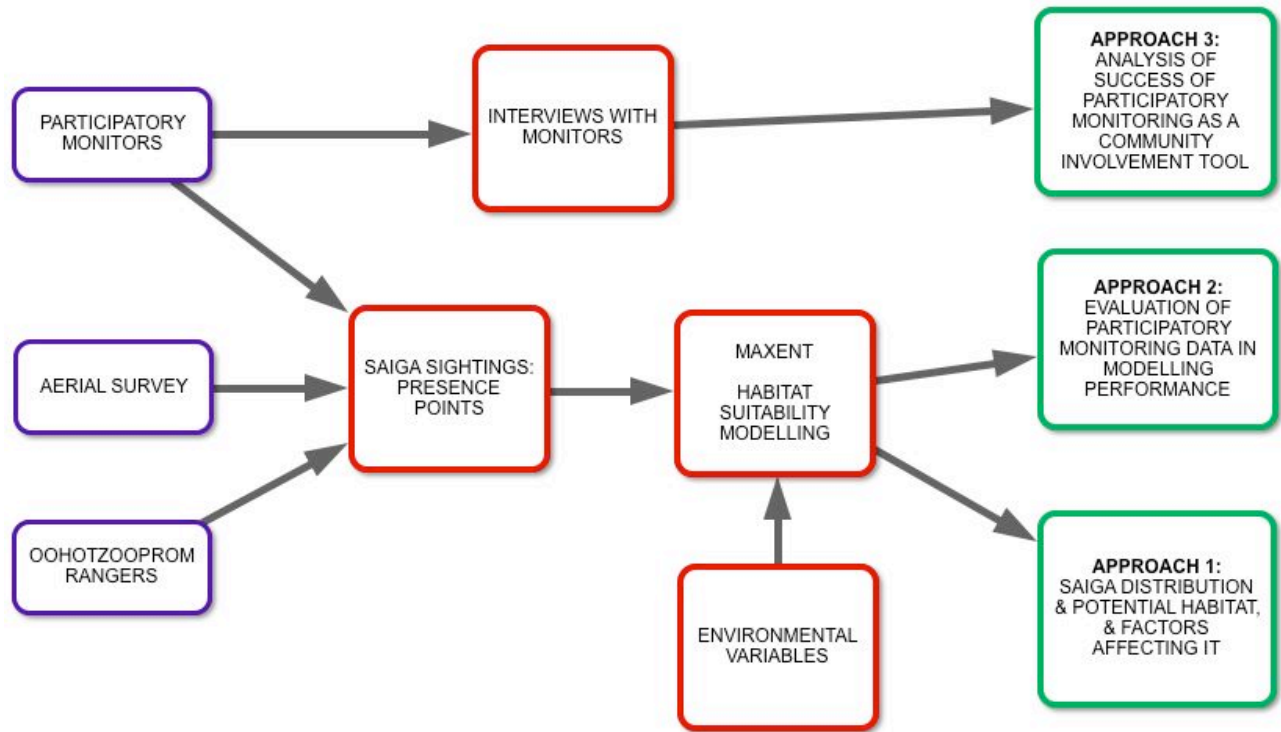
### 6.1 Framework of methodology

The aims of this project require a three fold approach.

1. Execution of a habitat suitability models to establish potential saiga habitat and distribution
2. Comparative analysis of participatory monitoring against other monitoring techniques in terms of its ability to disseminate determinants of seasonal habitat use.
3. Qualitative analysis of participatory monitoring both as a monitoring and community involvement tool in conservation.

Presence data from recorded saiga sightings was compiled from 1<sup>st</sup> January 2011 to 15<sup>th</sup> June 2011, from three monitoring techniques: participatory monitoring, aerial surveys and from the Oohotzoprom wildlife rangers. The presence points were then used in a habitat suitability model with a selection of environmental variables, chosen by a hypothesis driven approach. Due to the differences in sampling design and the therefore resulting differences in bias and detectability between the three monitoring techniques, separate models were applied to the data from each technique. Additionally the presence data was split into two seasonal sets Spring and Winter, due to the extreme change in climate in the Eurasian steppe expected to lead to differing habitat selection determinants between these seasons. As a result 5 habitat suitability models were created. The aerial survey was carried out in April so no presence data from this monitoring technique was available for the winter months. The habitat suitability models will contribute to approach 1 and 2 described above, and interviews of participatory monitors facilitated approach 3, as illustrated in figure 6.1.

Figure 6.1: Framework of methodology



## 6.2 Data Collection

### 6.2.1 Participatory monitoring

#### 6.2.1.1 Identifying and preparing participatory monitors

The participatory monitoring was set up with the help of the in country partner ACBK. Initially an inception workshop was held involving central figures of ACBK, regionally based Oohotzooptom team, members of Institute of Zoology, Ministry of Education and Science, Kazakhstan and two external advisors from SCA. The focus area was chosen using the following indicators: information on frequency of saiga sightings, poaching level, poaching causes, information on social and economic infrastructure, availability of remote farms, attitudes of local people to saiga and saiga poaching, and availability of saiga related information and knowledge. The same indicators were used in identifying 7 target villages from the focus area. Following this 20 monitoring points were chosen and mapped (figure 6.2) using five indicators: A top priority was to ensure coverage of both the location of mass mortality in 2010 and areas with poaching reports supported by the villages. Second

to this was coverage of areas where saiga are frequently observed, where remote farms are located and maximum coverage of the Ural saiga population's range (Olga Klimanova & E.J Milner-Gulland, pers. comm.)

The inception workshop was followed by a field trip by local collaborators on 20th January 2011 where the participatory monitoring concept was explained to members of the 7 target villages and the intended monitoring points contacted. The farmers/ herders at each of the proposed monitoring points were contacted and their participation confirmed. Only a few monitoring points were changed due to unwillingness or lack of capacity to participate. The confirmed participatory monitors (one at each monitoring point) were given record sheets, maps of their local area and binoculars. Monitors were asked to record the date, time, total number of saiga, number of males, females and young or unidentified, and the weather conditions. Additionally they were asked to mark on the map where any sightings took place. The monitoring commenced immediately

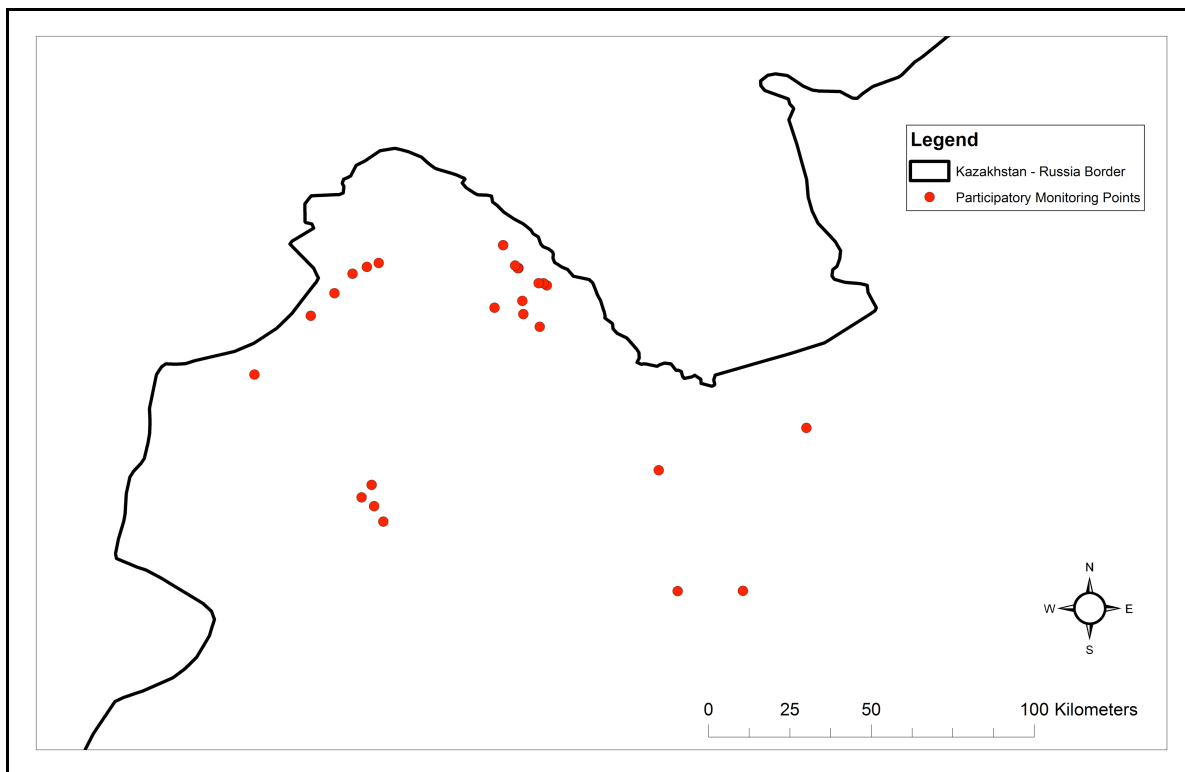


Figure 6.2: A map illustrating the location of the 20 monitoring points confirmed for use in the participatory monitoring scheme. Please see appendix X for detailed version of this map due to legality issues of publishing saiga distribution.

### 6.2.1.2 Collecting data from participatory monitors

Interviews with the participatory monitors were held during a field trip to the focus area in early June 2011. The interviews were semi-structured around a pre-designed format, allowing for an informal and open conversation to take place but ensuring the required data was obtained. The interviews were undertaken in Kazakh by the regional project coordinator. The Kazakh response was translated via Russian and a translator from the Eurasia Academy in Uralsk, to English. Unfortunately we were unable to get in touch with 2 of the 20 participatory monitors. One had reportedly moved away and the other could not be located.

The design of the interview questions focused on three main elements. Firstly collecting the data on saiga sightings made by the participatory monitors and ensuring all necessary details were completed. This mainly consisted of confirming the locations on the maps where any sightings were made. Secondly were some questions on any changes in saiga occurrence observed by the monitors. These questions used landmark events such as before and after the collapse of the Soviet Union in order to aid in memory recall (Leon, 2009). The final element to the interview concerned attitudes towards the participatory monitoring scheme. The questions were carefully phrased using guidance from , so to avoid suggestions of answers and as leading questions (E. Milner-Gulland & Rowcliffe, 2007). The interviews were of variable length from 30mins to 1.5 hours, depending on the monitors enthusiasm for discussion.

### 6.2.2 Aerial Surveys

The aerial survey was undertaken by Oohotzooprom who enlisted the help of the Institute of Zoology, Ministry of Education and Science, Kazakhstan and ACBK as technical advisors. The survey was part of an annual monitoring programme undertaken by the Forestry and Hunting committee, using standard methodology as described in Zuther, 2009. An Antonov an-2 plane was used, flying at 150km/hr at 120m altitude (Zuther 2009). The survey design consists of transects at 10 km intervals (fig 6.3), followed using a predesigned map of transects, on a GPS installed in the plane. The counting strip, marked using tape on



the wings, was 600m either side of the plane. Four people are involved in the observations, two counters and two recorders. The recording pair additionally noted the time and GPS location of each sighting.

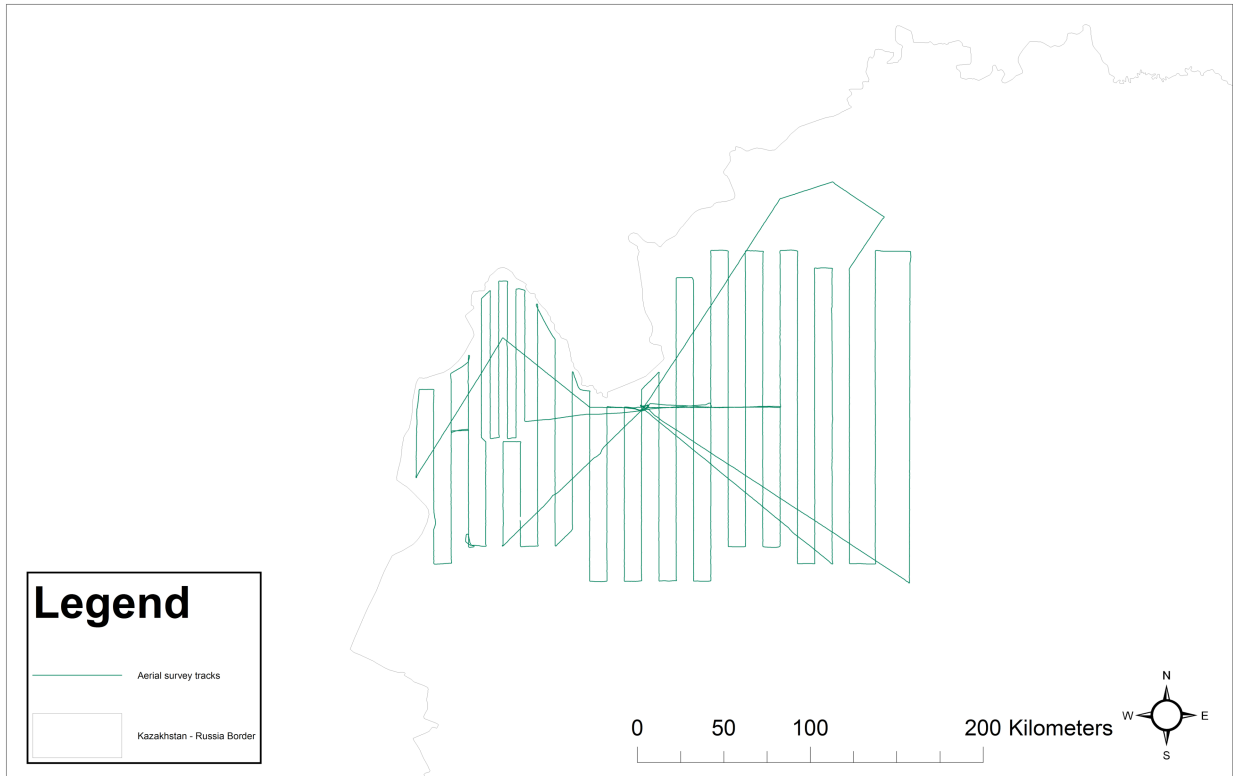


Figure 6.3 A map illustrating the transects flown in the aerial survey 2011

### 6.2.3 Oohotzoprom Ranger data

The Oohotzoprom rangers patrol the Ural population of saiga antelope to aid monitoring and prevent poaching. There are usually about 10 rangers in 3 groups in the field at any one point of time surrounding the Ural saiga population in a roughly 200km circle throughout the year (pers. comm. Tazhgaliev Nurlan Magdanovich). They provide year round protection and monitoring of saiga of distribution and shared two teams of rangers' records over the study period from January to June. The rangers use vehicles to patrol the steppe and are equipped with binoculars and GPS units. The patrol routes are chosen according to current information on saiga distribution and movement patterns and/ or any information on potential poacher activity (pers. comm. Tazhgaliev Nurlan Magdanovich). This movement pattern creates problems of bias in the dataset due to the non random,

systematic or stratified technique. Each ranger team records the following every time saiga are sighted: Date, time, GPS point, total number of saiga seen, number of males, number of females, number of young and weather at time of sighting.

## 6.3 Habitat Suitability Modeling

### 6.3.1 Data preparation in ArcGIS 9.3.1

#### 6.3.1.1 Presence data

The raw presence data obtained from the participatory monitoring interviews was converted from paper maps (from each monitor) to a single raster layer by creating point features using the sketch tool in ArcMap (ArcGIS 9.31). Electronic forms of the maps used by the monitors in ArcMap provided the referencing required. The feature layer was converted to raster format and the total number of saiga sighted at each point added as field to the attribute table. The raw presence data from the Oohotzoprom ranger monitoring and aerial survey was provided as GPS locations which were used to create two further raster layers of presence point data. Similarly the total number of saiga sighted at each point location was added as a field in the attribute table of each of these raster layers. Exporting the three attribute tables to Microsoft Excel provided each point with a longitude and latitude under the same geographic coordinate system, GWS 19834 zone 39N . Following this each point was replicated according to the number saiga sighted at each point, using coding in R. The result was returned to excel and converted to csv format as required by the Maxent software.

#### 6.3.1.2 Environmental variables

The environmental variables were chosen according to literature and expert suggestion of the most deterministic factors of habitat selection in saiga antelope, as detailed in table 6.1. Due to the concern of both anthropogenic (overexploitation, habitat loss/degradation & migration interruption) and ecological (climate change) threats to saiga antelope it was key to include representatives of both influences when choosing the environmental layers.

The climate in the Ural region undergoes extreme seasonal variation from -40°C to +40°C. The presence data was therefore split into winter and spring sightings utilizing 30/03/2011 as the dividing date, due to Bekenov et al 2008 accepted approximation to the timing of snow melt as the end of march. The environmental variables used for spring and winter data differed due to the extreme climatic variation between the seasons. Precipitation levels were chosen for use alongside winter data, as this would give an indication of snow levels, a likely influential factor on saiga habitat selection. Normalized Difference Vegetation Index (NDVI) was used alongside the spring data as a surrogate for plant biomass (Hirzel & Le Lay, 2008). NDVI is a measure of infra-red reflectance of leaf cells measured by satellites, where the more leaves a plant has the more near visible infrared light will be reflected. This is utilised in the following equation to create an index, indicating plant growth, greenness or biomass.

$$\text{NDVI} = (\text{NIR}-\text{VIS})/(\text{NIR}+\text{VIS})$$

NIR = near visible infrared regions

VIS = visible infrared regions

In addition to the environmental variables described above the importance of surface water to saiga antelope a crucial resource is likely to influence habitat selection and was therefore chosen as a possible determinant. The variables chosen to examine habitat selection by anthropogenic disturbance, were roads and settlements due to the key influence these factors will have on the movement of poachers. These latter three variables, surface water, roads and settlements all refer to the habitat selected in reference to the distance from the variable. Furthermore although surface water is a vital resource for saiga antelope it also attracts competitors, predators and parasites saiga antelope. The result of this is an expectation for the saiga to select for habitat at intermediate distances from the surface water, therefore by squaring this distance the impact of the intermediate distances will be magnified.

The environmental variables were prepared in ArcGIS 9.3.1 using the data management and spatial analyst toolboxes and raster calculator. This primarily involved the reprojection of all rasters into the Geographical Coordinate System GWS 1984 zone 39N, with cell size set at the equivalent of 500m<sup>2</sup>. The use of the Modis terra NDVI data layers required the use of the Modis Reprojection Tool ([https://lpdaac.usgs.gov/tools/modis\\_reprojection\\_tool](https://lpdaac.usgs.gov/tools/modis_reprojection_tool)). The distance to surface water, roads and settlements layers raster layers were created using the Euclidean distance tool. The Maxent software required the environmental variables to be in ASCII format.

This preparation of the environmental layers within ArcMap and Arc Catalog enabled qualitative analysis of the variables to be used. It was noted in ArcMap that there were polarized differences in the NDVI data between early spring (April – mid May), and late spring (mid May-mid June). The NDVI data was therefore further split into early spring (spring A: dates) and late spring (spring B; dates), and mean and peak values within these ranges taken and used as additional variables within the habitat suitability models. This action was taken in order to assess if saiga distribution is more affected by NDVI levels during early or late spring and disseminate any further details in habitat determination by NDVI. Due to the correlation between the various NDVI environmental layers a further 9 HSM's were run to allow each variation of NDVI variables to be compared. Three additional HSM's for each monitoring technique were run with the base environmental variables of distance to water, distance to water squared, distance to roads and distance to settlements and then the NDVI layers used were differed for each one: Total spring mean & peak NDVI, Early Spring (A) mean & peak NDVI, Late Spring (B) mean & peak NDVI.

Variable	Where used	Expected effect	Why variable was chosen	Source
Distance to roads	Winter & Spring	Avoidance of roads	Due to evidence of considerable levels of poaching, it is predicted that saiga would avoid interaction with anthropogenic activity; these variables were chosen to represent proximity to anthropogenic activity. (Milner Gulland et al 2001,1995 Bekenov et al 1998)	Navinder Singh
Distance to Settlements	Winter & Spring	Avoidance of settlements		Navinder Singh
Distance to water	Winter & Spring	Prefer intermediate distance	Surface water (rivers and lakes) are an essential water resource for saiga. However prey species do not remain around water supplies for prolonged periods as they are also an essential resource for their predators (e.g. wolves). As the intermediate distance is therefore predicted to be preferred habitat, squaring this distance clarifies the effect of intermediate distance (H Olf, M. Ritchie, & H. Prins, 2002).	Navinder Singh
(Distance to water) <sup>2</sup>	Winter & Spring	Prefer Intermediate distance		Navinder Singh
Peak NDVI (28/03 - 15/06)	Spring	Prefer areas of high NDVI	Evidence from literature suggests saiga antelope demonstrate resource driven habitat selection. NDVI represents vegetation biomass and is therefore chosen to represent the essential vegetations resource levels. (N. J. Singh, I. A. Grachev, A. B. Bekenov, & E. J. Milner-Gulland, 2010)	(Leon, 2009)
Mean NDVI (28/03 - 15/06)	Spring	Prefer areas of high NDVI		
Cumulative Precipitation (01/01-30/03)	Winter	Avoid areas of high cumulative precipitation	The winter months in the saiga range are extremely cold, -40°C with continuous snow cover. Therefore levels of precipitation were chosen to represent snow levels. Cumulative precipitation was used to represent ground snow depth throughout the winter months.	<a href="http://www.worldclim.org/">http://www.worldclim.org/</a>
Mean Precipitation (01/01-30/03)	Winter	Avoid areas of high mean precipitation		

Table 6.1 A table describing the decision mechanisms behind each variable chosen.

### 6.3.2 Maxent

The maxent software was obtained from the following Princeton website: <http://www.cs.princeton.edu/~schapire/maxent/>. A cross validation run was performed using 20% test and 80% training data, with four replicates for each run. A regularization multiplier of 1 was used with a maximum of 10,000 background points allowed and a maximum of 500 iterations allowed; the recommended default values. Eleven models were run in total as detailed in figure 6.4. As the data lacks information on dispersal ability and evolutionary history it is impossible to predict a realized niche, therefore the results are

expected to illustrate an ecological niche (Phillips et al 2008)

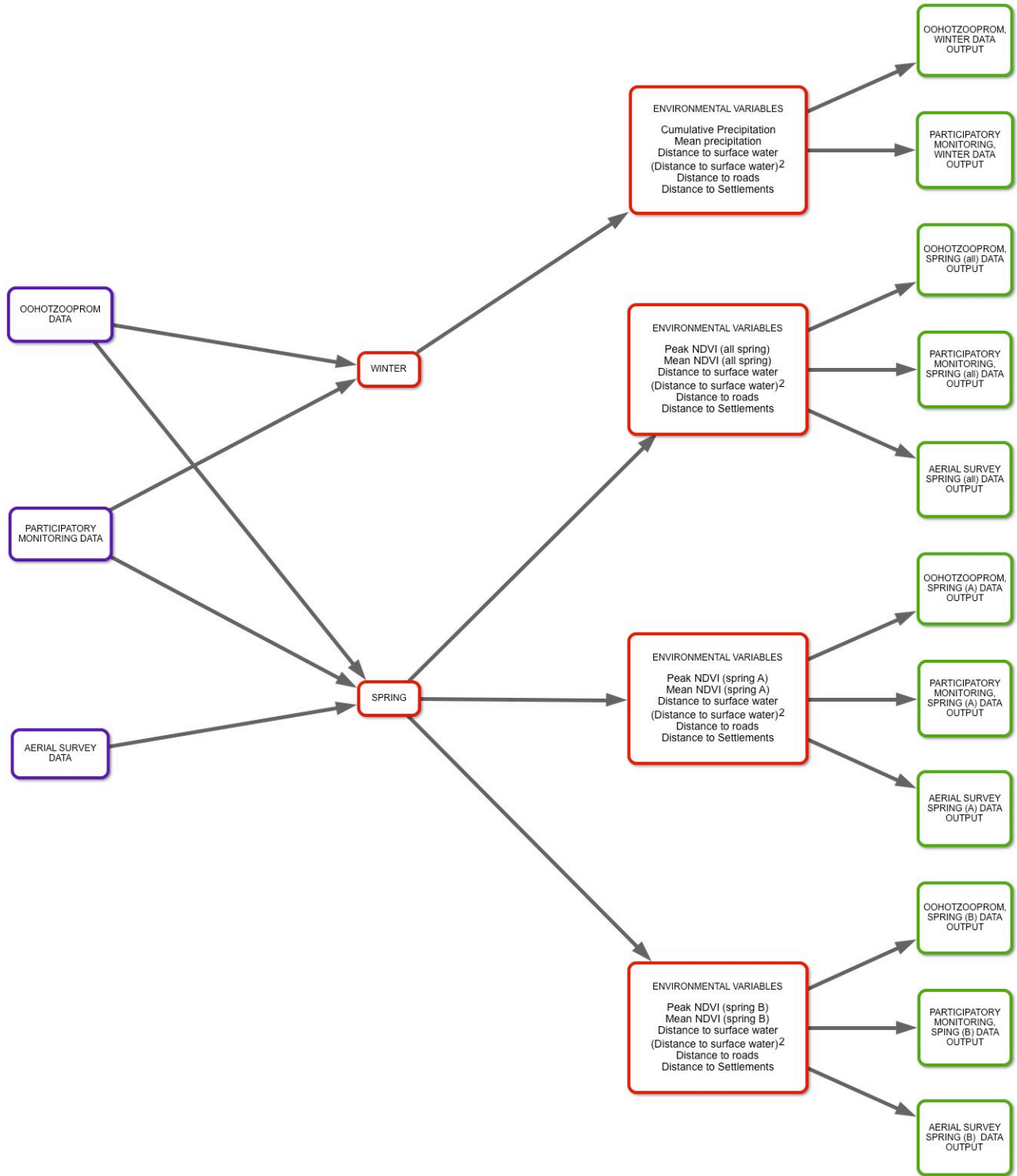


Figure 6.4: Framework of Habitat Suitability Models run

## 7 RESULTS

### 7.1 Presence Data

A total of 263 presence locations were obtained from the three data sources, with a counting of 95,161 saiga. The breakdown of these between the three data sources can be seen in Table 7.1. The number of individual saiga sighted are not mutually exclusive as a sighting of each saiga, may and is likely to be replicated. Mapping of the presence locations in figure 7.1, illustrates the coverage of the participatory monitoring area over regions of higher presence density from the two other monitoring techniques.

Table 7.1

Monitoring technique	No. of presence locations	% of total presence locations	No. of saiga counted	% of total saiga counted
Total	263	100	95161	100
Aerial Survey (Spring data only)	73	27.76	5201	5.47
Participatory Monitoring (spring & winter data)	84	31.94	13655	14.35
Participatory Monitoring (spring data)	64	24.33	13111	13.78
Participatory Monitoring (winter data)	20	7.60	544	0.57
Oohotzooptom Rangers (spring & winter data)	106	40.30	76305	80.19
Oohotzooptom Rangers (spring data)	64	24.33	49859	52.39
Oohotzooptom Rangers (winter data)	42	15.97	26446	27.79

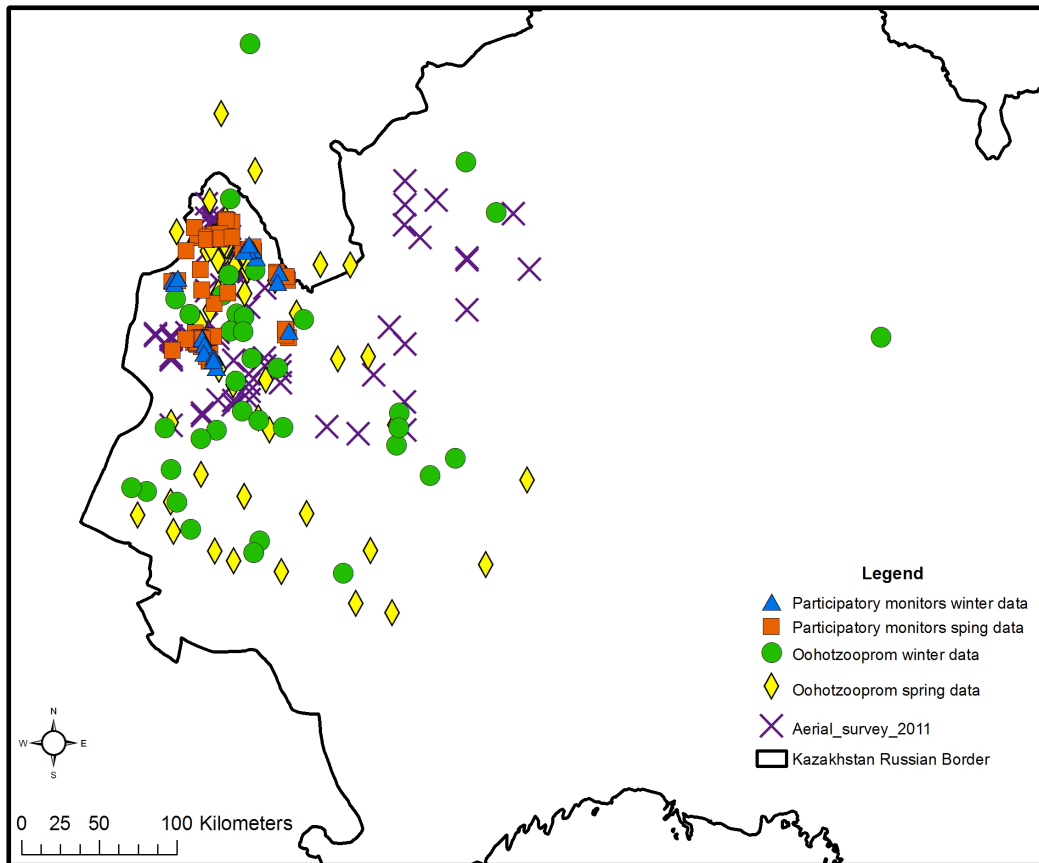


Figure 7.1

## **7.2 Maxent predictions of suitable habitat.**

### **7.2.1 Strength of models**

The Maxent output includes ‘receiver operator curves’ (ROC’s) with ‘area under the curve’ (AUC) values for both the training and test data. Here I report on the AUC values of the test data, which was used in cross-validation of the models to describe their predictive strength. All these AUC values illustrate a better than random,  $AUC > 0.5$ , fit for the five HSM models run (Phillips et al 2006). Additionally four of the models achieved  $AUC > 0.75$ , so can be deemed useful predictive models (Elith et al 2002). The data from Oohotzoprom rangers during the spring did not achieve this approval,  $AUC < 0.75$ . The data obtained from participatory monitoring performed equally well if not better than the data from other



monitoring techniques. Looking at the AUC values, in figure 7.3, from data collected during both winter and spring (for the total spring period), the fit of participatory monitoring data performs better, i.e. has a higher AUC value, than the models using Oohotzooptom ranger data. Comparing these sets of AUC values also illustrates the better fit of winter data than spring data to their respective models. The HSM using aerial survey data, obtains the highest AUC value at 0.872 of all the models from spring data.

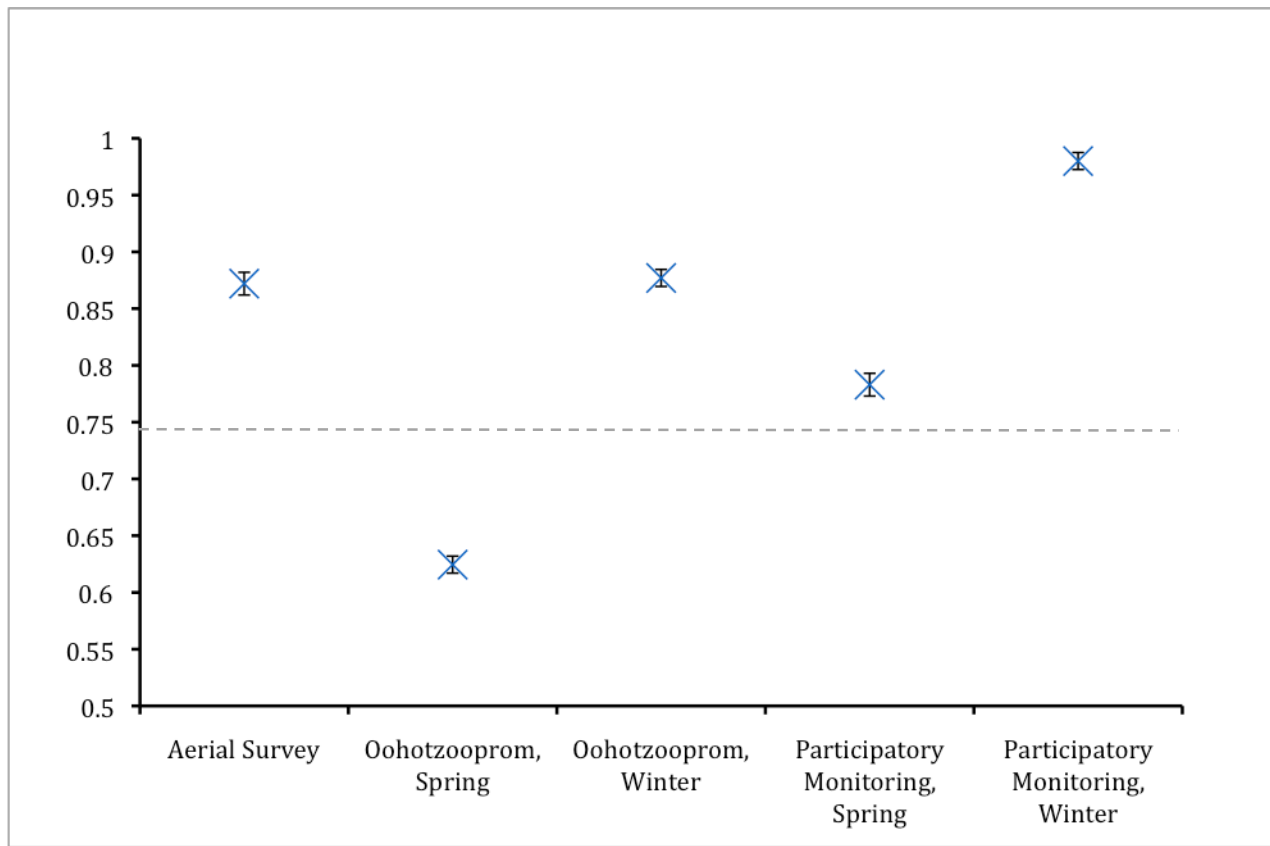


Figure 7.3: A scatterplot depicting AUC values from the ROC curves from the initial five Maxent HSM models. The spring datasets refer to those including the NDVI for the whole spring period. The dashed line represents the useful  $AUC > 0.75$  threshold level.

## 7.2.2 Effects of environmental variables on Saiga Distribution

### 7.2.2.1 Winter

The jackknife tests on the HSM models from both participatory monitoring and Oohotzooptom ranger data during winter, suggest cumulative precipitation to be the most important variable in describing saiga distribution; the tests illustrate the training gain is

greatest with only this variable used and a distinct reduction in training gain if the variable is removed from the model (figure 7.4). However although a 54.9% permutation importance of cumulative precipitation on the participatory monitoring model, also supports this, the permutation importance of mean precipitation is greater than that for the cumulative precipitation in the model from Oohotzoprom ranger data. Due to the correlation between these two variables, overlap is to be expected, however the removal of mean precipitation from both jackknife tests shows little to no loss in training gain of the models.

Interestingly the permutation importance of 30.5% of the variable 'distance to roads' in the participatory monitoring model is much greater than the 8.6% found in the Oohotzoprom model, but both jackknife tests illustrate a loss in training gain after its removal. Comparing this to the lack of training gain loss when mean precipitation and the water variables are removed illustrates that the distance to roads variable gives valuable extra information towards habitat determination that other variables do not cover. This possession of extra valuable information is similarly depicted in the jackknife test for distance to settlement for Oohotzoprom data. Participatory monitor locations will be correlated with settlements the evidence for the 'distance to settlement' variable within this model and are therefore likely to be biased. 'Distance to settlement' appears to be the least deterministic variable when used alone for saiga habitat selection in both models.

No difference is shown in the jackknife tests between the distance to water and the distance to water squared, variables. Conversely the permutation importance of distance to water in the participatory monitoring model lies at only 1.9% in comparison to the 15.7% in the Oohotzoprom model. This pattern is reflected with values of 10.7% and 0.8% in participatory monitoring model and Oohotzoprom model, respectively with the distance to water squared variable. Removing either form of 'distance to water' variable from the model has no affect on training gain, suggesting its provides no extra valuable information to the model that the other variables do not cover. However this is probably due to the high correlation between these two valuables, imparting the same data to the model and

therefore evaluation of its individual importance to the model is difficult to ascertain.

The decision direction in which the formerly discussed variables effect habitat determination by saiga is illustrated by response curves (figure 7.5). Preference for peaked, low to intermediate levels of cumulative precipitation, roughly 45-60mm is illustrated in both models. A similar but broader preference is depicted by the response curves for mean precipitation. Finally the models show preferences for short distance to roads, settlements and water.

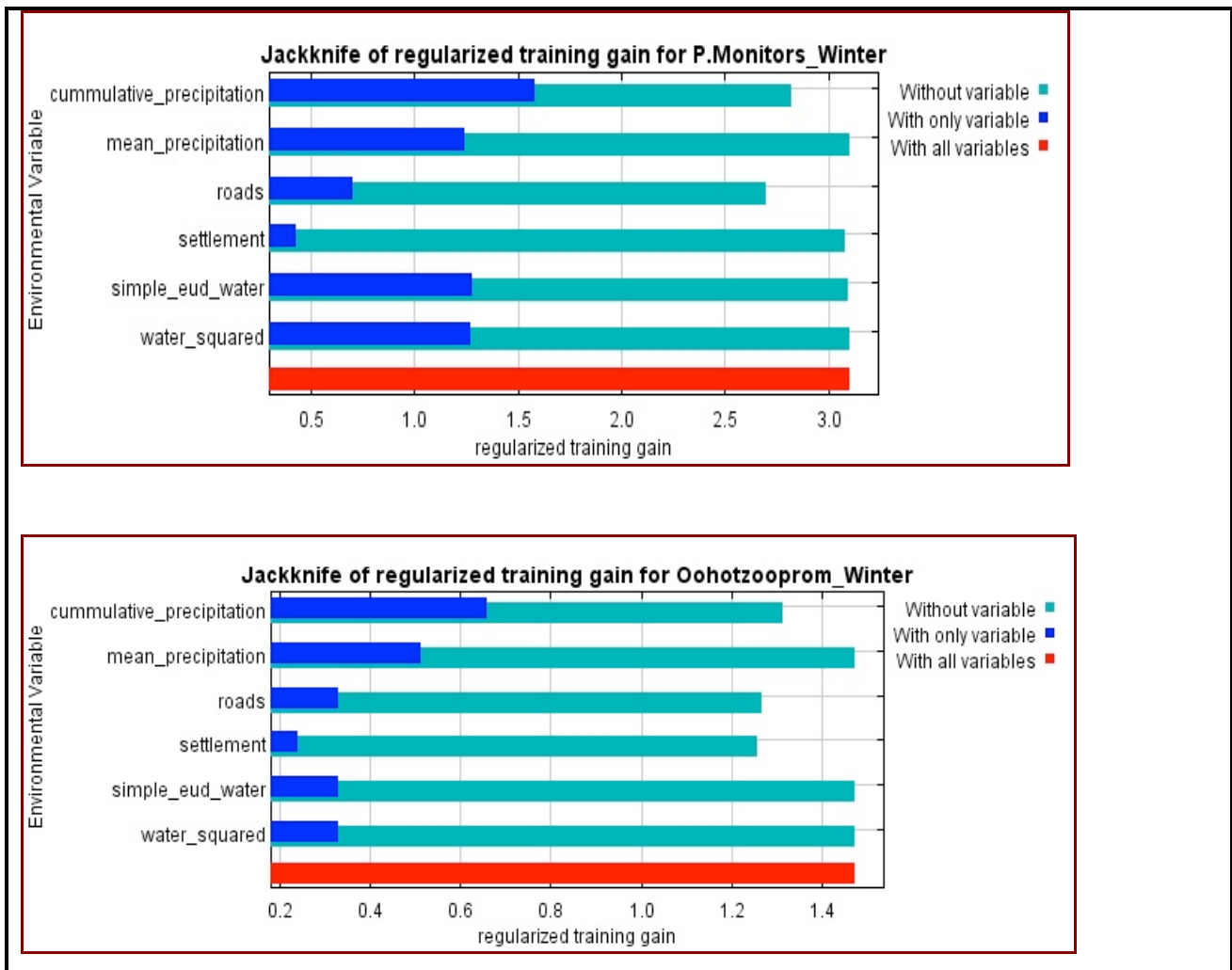


Figure 7.4: Jackknife of training gain from both HSM models of winter data, participatory monitoring and Oohotzoprom rangers.

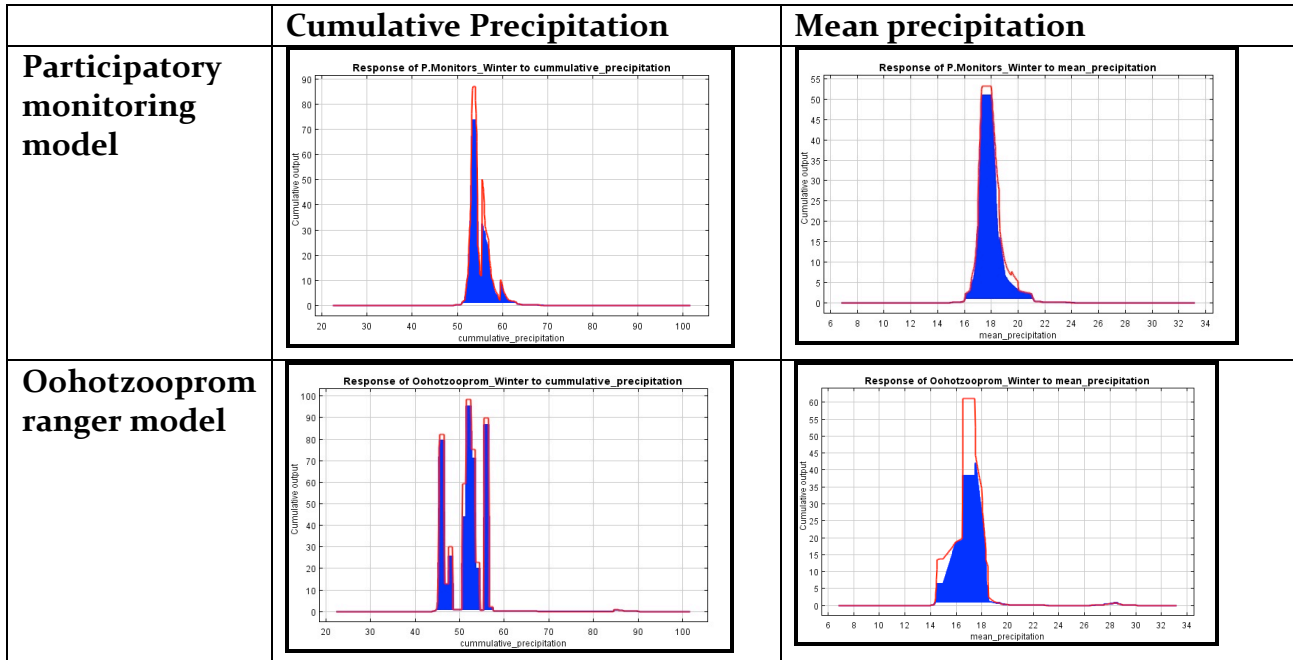


Figure 7.5 response curves of precipitation related variables in HSM for Participatory monitoring and Oohotzooprom winter data

### 7.2.2.2 Spring

The initial three broad HSM models run for the three spring datasets illustrated that NDVI was more deterministic in saiga habitat selection than the anthropogenic and surface water variables. The jackknife test depicting this from the participatory model as an example, is illustrated in figure 7.6. The high level of correlation between the NDVI variables in this jackknife test is illustrated by the lack of any substantial loss of training gain when any of these variables are removed. Similarly the lack in loss of training gain when either of the anthropogenic variables are removed suggests the environmental variables have a greater significance in habitat determination.

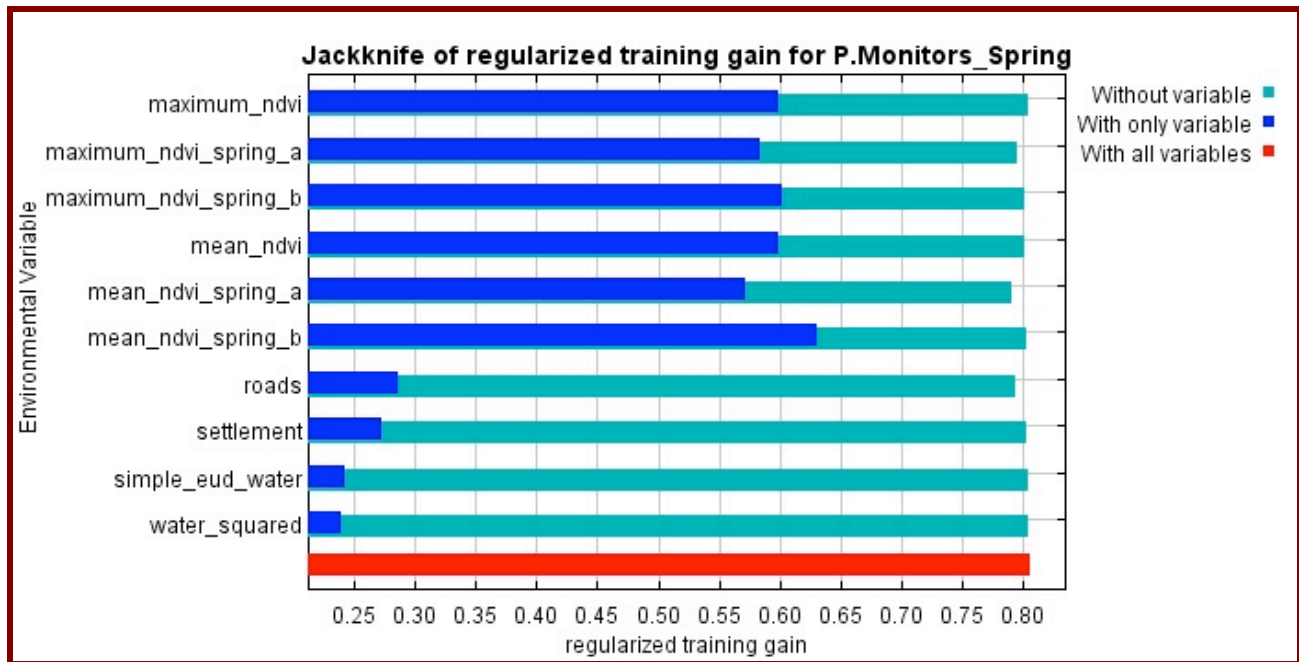


Figure 7.6: The jackknife test on the spring data from participatory monitors

Nine further HSM models were run to disseminate the effect of each of the environmental variables on saiga habitat determination. The AUC values for the models from aerial survey and participatory monitoring data (six models – three for each data type) were greater than 0.75 and therefore considered useful (elith et al 2002) . The 3 further models created from Oohotzooptom data did not however exceed this 0.75 AUC value, so their results are considered with caution.

The permutation importance for the environmental variables for the nine extra models are shown and ranked in table 7.2. where maximum NDVI is shown to contribute considerably to habitat selection. This is supported by the greatest loss in training gain in the jackknife tests of all nine models when the maximum NDVI variable is removed. The aerial survey models suggest distance to water is more influential on saiga habitat selection than distance to roads or settlements. The participatory monitoring models rank the deterministic importance of distance to roads considerably higher than the aerial survey predicts. The models from aerial survey data and participatory monitoring data predict similar patterns in the difference in deterministic ability of the environmental variables

between early and late spring, e.g. the permutation importance of maximum NDVI increases across this temporal gradient, whilst it decreases for both distance to roads and distance to water squared. The jackknife tests show little loss in training gain of the data when distance to roads, distance to settlements or distance to water variables are removed from the model. However although small the jackknife tests for the six models from aerial survey data and participatory monitoring data illustrate the greatest loss in training gain to occur when the distance to water variable is removed from the HSM.

All response curves concerning maximum NDVI and mean NDVI (at any time period during the spring) illustrate a preference for NDVI levels of 0.6 to 0.9 and 0.35 to 0.75 respectively. The curves illustrate a peaked response for distance to roads and distance to water, in contrast to the backwards S shape function depicted in the distance to settlement response curves.

Permutation Importance	Aerial Survey data					
	All spring		Early Spring (A)		Late Spring (B)	
	%	rank	%	rank	%	rank
Maximum NDVI	32.48	1	36.38	1	49.28	1
Mean NDVI	25.33	2	23.50	2	15.90	3
Distance to Roads	3.90	5	2.03	5	4.25	5
Distance to Settlements	17.80	4	18.48	4	14.40	4
Distance to water squared	20.53	3	19.60	3	16.18	2
	Participatory Monitoring data					
	All spring		Early Spring (A)		Late Spring (B)	
	%	rank	%	rank	%	rank
Maximum NDVI	20.23	3	40.70	1	56.73	1
Mean NDVI	42.85	1	14.00	3	8.13	3
Distance to Roads	24.33	2	24.78	2	23.53	2
Distance to Settlements	4.38	5	8.43	5	4.03	5
Distance to water squared	8.20	4	12.13	4	7.60	4
	Oohotzoprom Ranger's data					
	All spring		Early Spring (A)		Late Spring (B)	
	%	rank	%	rank	%	rank
Maximum NDVI	18.53	3	24.25	2	57.45	1
Mean NDVI	33.20	1	24.68	1	12.93	3
Distance to Roads	11.68	5	10.98	5	7.33	5
Distance to Settlements	22.03	2	21.88	3	13.30	2
Distance to water squared	14.53	4	18.18	4	9.03	4

Table 7.2: A table illustrating the nine further HSM's run and their output permutation importance and its ranking.

### 7.2.3 Predicted Suitable Habitat

The best 5% of suitable habitat predicted by the five initial HSM's run portray a considerable overlap, illustrated in figures 7.7 and 7.7. The predicted winter suitable habitat is narrower in the latitudinal direction than that of the spring habitat. Additionally the areas of the best 5% of habitat are more fragmented in the spring predictions than in winter.

The winter habitat predictions show a smooth and continuous possible habitat along

a latitudinal gradient. The participatory monitoring data resulted in a considerably narrower and more northerly positioned potential distribution than that of the Oohotzooprom ranger data set.

The spring data sets produced a fairly fragmented distribution of suitable habitats. Considerably more habitat fell into the >5% suitable habitat in the prediction from the HSM using Aerial survey data. Notably all three of these HSM's illustrate potential saiga habitat in the south west of the region along the Caspian sea, coast line.

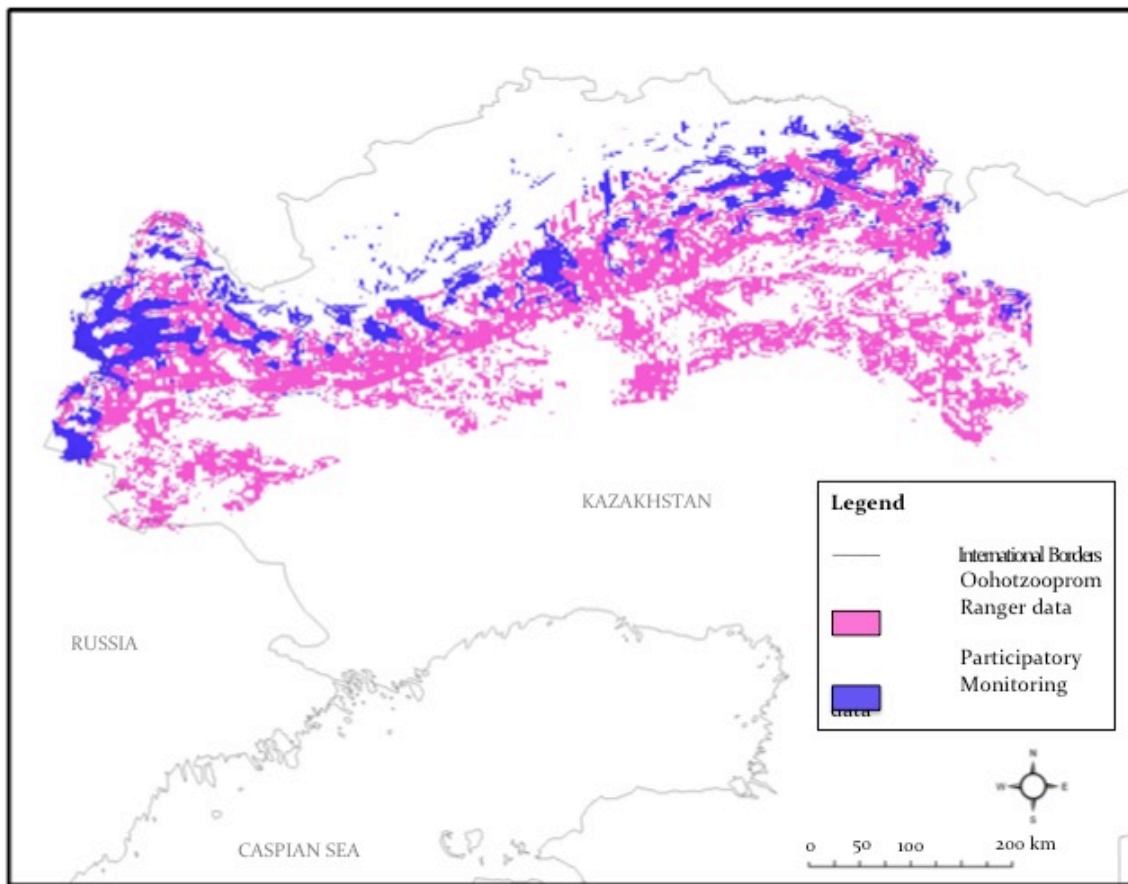


Figure 7.7: The most suitable (top 5%) habitat as predicted by the HSM during the winter months, according to the monitoring data used.



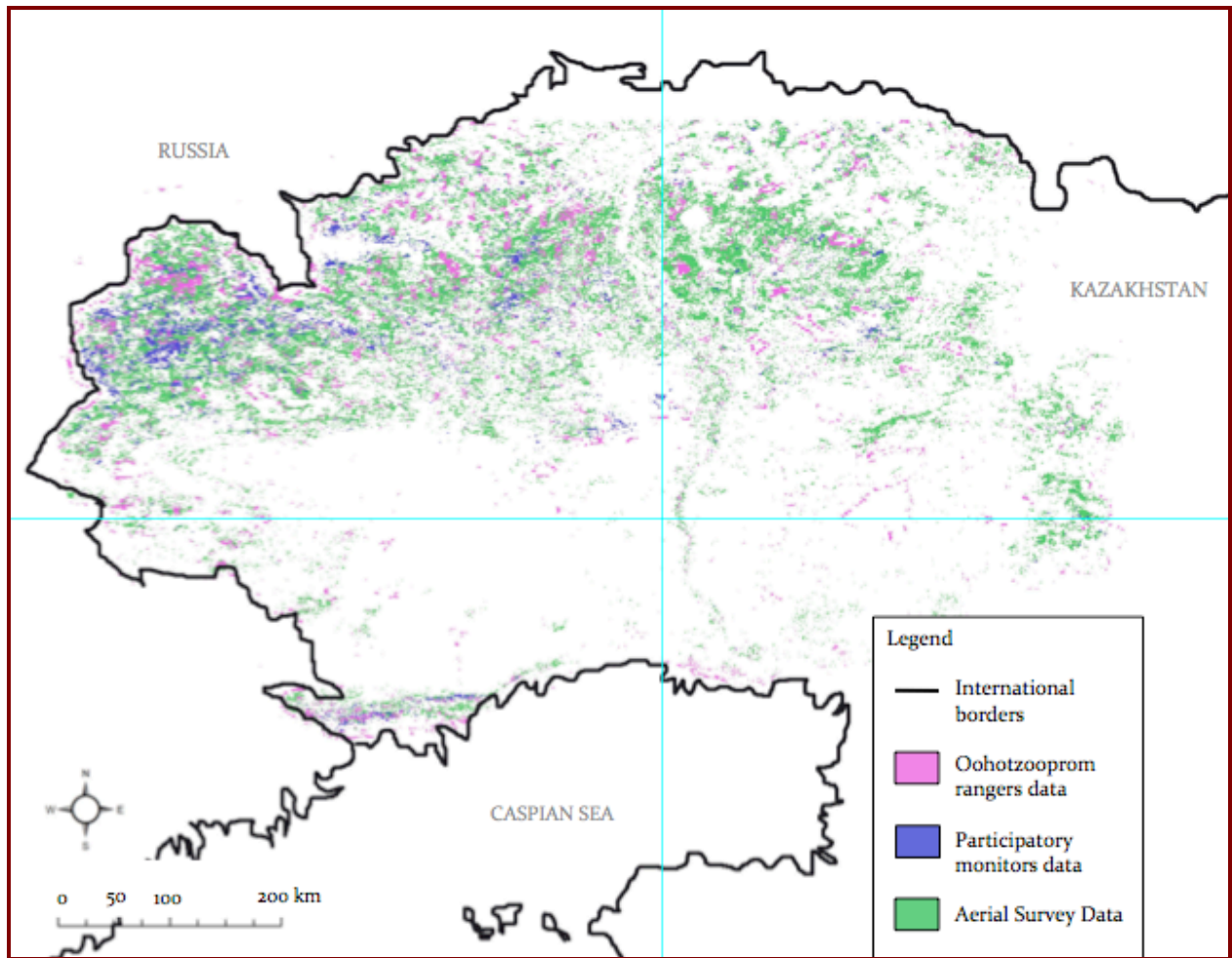


Figure 7.8: The most suitable (top 5%) habitat as predicted by the HSM during the spring months, according to the monitoring data used.

### 7.3 Interview results

The Interview results shed a very positive light on the participatory monitoring scheme. Only 18 of the 20 monitors were contacted but 17 of those were extremely enthusiastic about the scheme. When asked what parts and why they enjoyed the scheme 61% confessed to saiga watching being a favorite hobby and delight in having binoculars with which to continue this. A couple of monitors remarked on how interesting it was to learn and practice mapping skills. Concern over the noted reduction in saiga sightings over the past couple of years was a common observation. Trends in reduced numbers and smaller group sizes were reported in comparison to last year, table 7.3. 94% of participants were

extremely enthusiastic about the participatory monitoring scheme and keen to continue as a monitor. The remaining 6 % accounts for an individual who is moving from the area. Few (n=4) of the participatory monitors had lived in the area for over 20 years and were therefore able to comment on any changes seen since the collapse of the Soviet Union. Additionally for those who had lived in the area over the past 10 years a pattern was described of many saiga sightings 8 -9 years ago, followed by a sharp decline in sightings until 3-4 years ago, since when another yet more dramatic decline is reported.

<b>Participatory monitor ID</b>	<b>In 2010 were there more or less saiga seen in comparison to 2011?</b>	<b>Time of year sightings occurred in 2010</b>	<b>In 2010 were the group sizes bigger or smaller than in 2011?</b>
A	more	Summer	bigger
B	more	summer	bigger
C	more	summer	bigger
D	less	Spring, Summer & Autumn	same
E	more	Spring & Summer	bigger
F	more	summer	bigger
G	more	summer	bigger
H	more	summer	bigger
I	more	summer	bigger
J	more	Spring & Summer	same
K	more	summer	bigger
L	same	spring	same
M	more	summer	Constantly fluctuating
N	more	summer	same
O	more	summer	same
P	more	summer	same
Q	more	summer	bigger
R	more	summer	bigger

Table 7.3: A table illustrating the participatory monitor interview results.

## 8 DISCUSSION

Evaluating the distribution of species is a crucial first step in the conservation of biodiversity. We also need an understanding of why habitats are selected to enable effective prioritization of habitat. This information is particularly key for migratory species as the drivers and indicators of migration need to be understood (Antoine Guisan & Thuiller, 2005; Hirzel & Le Lay, 2008). Habitat suitability modeling (HSM) is a tool used to establish the potential and likely range of a species. Additionally further analysis of the model enables the importance of different environmental variables used in the habitat prediction process to be identified. Presence data of the species in question is required by HSM's and is obtained through monitoring.

Monitoring is an essential part of every conservation program, it not only gives us more information regarding the species of conservation concern, but allows us to assess the effectiveness of any conservation intervention in achieving its goals (Nichols & B. K. Williams, 2006). Often multiple monitoring schemes are implemented so as to account for unavoidable error, bias and uncertainty inherent in many of the methodologies. Therefore establishing robust, effective and efficient monitoring systems which produce data that can be utilized alone or alongside data from multiple sources of monitoring, is a key part of any conservation initiative. Achieving this is particularly problematic when the species being monitored is migratory due to the increased distances covered, variation in habitat and climatic factors, and covering regions of differing jurisdiction (nationally and/or internationally) (N. J. Singh et al., 2010; N.J. Singh & E.J. Milner-Gulland, 2011; Navinder J. Singh & Eleanor J. Milner-Gulland, 2011).

In this research three commonly used monitoring techniques were compared in their ability to produce useful data for habitat suitability modeling using Maxent. Following from this the predictive models were used in establishing the predictive power of individual environmental variables in determining habitat selection. The Ural population of saiga antelope in west Kazakhstan was studied in this instance due to a 95% population decline in the last two decades. Political will for saiga protection is currently prominent and there is

therefore an urgent need to provide the relative authorities with sound scientific data on the species distribution and effective and efficient monitoring techniques. The Ural population in West Kazakhstan is the least studied population and due to mass mortality (c.12000 individuals) in May 2010. There is a high level of local concern and interest, which is valuable for any conservation initiative, especially participatory monitoring. In addition plans to create a reserve to protect the Ural population have been initiated, requiring a robust understanding of distribution and habitat selection (<http://www.saiga-conservation.com/news.html>).

### **8.1 Evaluation of monitoring techniques**

The three monitoring techniques all provided a better than random response (AUC >0.5) when utilised with environmental variables in Maxent's HSM. This allows a degree of trust in the three monitoring systems, however 'better than random' is not informative enough as a measure of a model's ability to predict. Therefore the use of a 0.75 AUC threshold for model usefulness as suggested by Elith et al 2002 was applied to the data, resulting in the models from both the aerial survey and participatory monitoring data being declared as producing useful predictions.

The aerial survey has been used in Kazakhstan for the census of saiga for 40 years (N. J. Singh & E.J. Milner-Gulland, 2011; S. Zuther pers comm..) and is therefore a well practiced technique. The survey has a history of bias and detectability problems but effort has been put into correcting these to differing levels of success over the past 5 -10 years. The resulting 2011 survey provides the best data yet, but some forms of uncertainty such as those owing to detectability issues associated with weather conditions and herd size in aerial surveys are difficult to eliminate and therefore must be taken into account. However aerial surveys are understood to be the best method available for the monitoring of migratory ungulates in open habitat such as saiga antelope (N.J Singh & E.J. Milner-Gulland 2011). As a valid technique, the predictive power (AUC value) of the aerial surveys data in the HSM is a useful reference for the verification of the 0.75 utility threshold and a base from which to compare other monitoring techniques ability in Maxent HSM's. This comparison portrays

the data collected from the participatory monitoring to be equally useful in its predictive capacity. The data from the participatory monitoring during the spring has an AUC value lying between the 0.75 threshold and the aerial survey value, however the winter data exceeds the aerial survey value therefore illustrating an excellent predictive capability. This suggests that the initial participatory monitoring scheme holds a great deal of potential for effective monitoring of saiga antelope as credible data is achieved. Nevertheless participatory monitoring is susceptible to bias, for example the inherent nature of its methodology leads to a unavoidable correlation of sightings with anthropogenic activity. Selection of remote monitoring points mitigates this bias as much as possible, but the total removal of anthropogenic affects are impossible using this method of monitoring.

The Oohotzoprom ranger data produced HSM's with less reliable outputs as the AUC values were lower than those of the participatory monitoring models. The winter model produced a useful model according to the 0.75 threshold, however the spring data was considerably beneath this and so its output predictions are considered with caution. The uncertainty surrounding the Oohotzoprom ranger data is difficult to account for due to the lack of records on effort and sampling design. The Oohotzoprom rangers' job is two fold, both to protect saiga from poaching, by policing the area, and to record sightings of the antelope. These overlapping aims however result in the rangers lacking strategy and randomness in their monitoring methodology, preventing effective analyses from being drawn from the data (O'Neill, 2008). Small improvements can be made to make the ranger's saiga sightings more useful for further analyses: recording the when and where of their patrols, recording of presence or absence of saiga at regular intervals and strategic planning of patrols so the region is covered representatively.

The three techniques used all induce varying levels of error from differing sources of uncertainty and bias. The challenge ahead not only includes the need to find cost efficient, effective monitoring strategies but also to establish ways to utilise the data collected from different sources of monitoring, to determine trends and changes seen within populations

and influence policy changes respectively.

## **8.2 Saiga distribution and habitat determinants**

The results of this study suggests that the Ural population of saiga antelope experiences resource driven habitat selection, although anthropogenic activity also influences their distribution. Both the winter and spring HSM's described the environmental variables, cumulative precipitations and NDVI respectively, as having the most deterministic power upon saiga distribution in West Kazakhstan.

The predicted winter habitat lay in a latitudinal strip across the area studied, for both HSM's run. The models suggest that cumulative precipitation has the greatest deterministic power, supported by both the high permutation importance and top jackknife scores which due to the below freezing temperatures at this time of year, can be taken to signify snow depth. The response curves illustrate a preference for 45 to 65mm, which supports evidence from previous literature that saiga winter habitat selection leads to areas with low snow depth (Bekenov et al 1998). Anthropogenic activity appears to be affecting habitat selection throughout the winter months by saiga antelope with both distance to settlement and distance to roads causing a decrease in training gain of the model when removed. This supports the theory of high and influential levels of poaching activity is occurring in the region. Furthermore from personal experience and reports the negative impact of anthropogenic activity on saiga is demonstrated as they flee at the first sight of a vehicle. This is in contrast to stories of the antelope appearing to play with the vehicles, dodging and racing them across the steppe, reported by several participatory monitors and their families. However conflicting with this evidence is the demonstration of preference for intermediate distance from these activities by the response curves. Due to both forms of monitoring in the winter months consisting of bias of an increase in sightings towards anthropogenic activity – as influential anthropogenic activity is occurring by those undertaking the monitoring – the results of a preference for intermediate distance to roads and settlements

cannot be fully relied upon. Due to the evidence of continuous snow cover throughout the saiga winter range, as illustrated above, it is unsurprising that surface water does not influence saiga habitat selection during the winter months. This can be explained by the resource need for water being provided by the snow and the cold temperatures likely to cause freezing of most surface water.

The distribution of saiga through the spring months is strongly resource driven. The results of the HSM demonstrate that peak levels of NDVI drive habitat selection followed by mean NDVI, followed by distance to water. This has been reported in previous studies of saiga habitat selection (N. J. Singh, I. A. Grachev, et al., 2010). Anthropogenic activities appear to be considered in the habitat selection process but do not overwhelm the affects of resource abundance. Migratory behaviours are thought to have evolved due to high variability in resource abundance across regions (Alerstam, Hedenstrom, & Akesson, 2003). Therefore resource driven habitat selection is expected. Additionally it is positive to see that anthropogenic activities do not appear to have a great influence on saiga. However this evidence is opposing to recent studies of saiga habitat selection being increasingly determined by anthropogenic activity (N.J. Singh, I.A. Grachev, A. B. Bekenov, & E.J. Milner-Gulland, 2010).

### **8.3 Participatory Monitoring in west Kazakhstan**

The implementation for participatory monitoring for the Ural population of saiga antelope has been a successful on several levels. Firstly the monitoring produced useful data as evaluated against aerial survey data and wildlife ranger data in the Maxent HSM. There is a great need for effective and efficient monitoring techniques in Kazakhstan and the ability to use data obtained by rural farmers is an exciting break through in the monitoring of these endangered ungulates. Further from this, the data obtained has aided towards an understanding of current determinants of saiga habitat selection in west Kazakhstan. This evidence can be utilized in policy formation concerning saiga antelope conservation, such as

in the positioning of the reported planned reserve in the region. Lastly the participatory monitoring scheme was met with high levels of enthusiasm. Integrating the local community in conservation initiatives has shown to increase the success of management plans and conservation efforts (Cooper, Dickinson, T. Phillips, & Bonney, 2007). General feedback from the participatory monitors included appreciating learning how to use maps, enjoyment of interest from national and international sources and pleasure in being able to help saiga conservation. The families were keen to participate in a continued program and no faults were reported by participants with the current methodology. Four of the eighteen monitors interviewed suggested improving the scheme by providing cameras to increase the accuracy of group counts. Seven monitors liked the suggestion of compasses to aid in their mapping skills, but only one was comfortable with the idea of using a GPS after having had the tool demonstrated. While meeting the participatory monitors and their families it was clear that saiga are seen as an integral part of the steppe and the Kazakhs nomadic heritage, while stories and information were passed through the family and across the generations. Concern and theories regarding the 2010 and 2011 mass mortality events were at the forefront of discussion. This successful involvement of the local community reflects the reports from the concurrent attitudinal survey towards saiga and their conservation where 91% of those asked in 2011 expressed a wish to help with saiga conservation (pers. coms. Carlyn Samuel).

## **8.4 Limitations and recommendations**

### **8.4.1 Monitoring techniques**

Limitations of this study mainly lie in the monitoring protocols. Each monitoring method has a degree of bias and uncertainty attached, however quantifying these for the Oohotzooptom and participatory monitoring data is not possible without a clearer lack of movement patterns and effort records. Detection problems are inherent in any monitoring strategy using human observation and is therefore found in all three of the monitoring techniques in this study. An increase in likelihood of sighting animals with an increase in group size, could result in an underrepresentation of presence of smaller herds of saiga.



Although very keen, the participatory monitors appeared to have forgotten to record the positions where the saiga sighted on the map and sometimes the sightings at all. This resulted in a process of recall and map work during the interview, to record the saiga sightings. Relying up human recall for data results in more me moral events being remembered more readily. In this situation this could lead to a sighting of a large herd of saiga being remembered and several sightings of smaller herds forgotten. The lack of consistent recording of saiga sightings by participatory monitors could either have been caused by forgetfulness, or a misunderstanding of the level of detail required from the data.

Small improvements to the monitoring techniques used in this study would facilitate a deeper analysis of the data. Oohotzoprom rangers suffer a common issue when both monitoring and policing and area is undertaken, where by policing and therefore tracking the animals being monitored a lack of randomness or stratification occurs. By recording effort, where exactly they go and absence data, more robust analyses can be made.

Recommendations for the continuation of the participatory monitoring scheme concern providing more up to date maps, and requesting effort and or absence data to be recorded. This could be achieved simply by noting the following each time they are out on the steppe for a period of 2 hours or more; period of time spent out on the steppe, direction and distance taken, presence or absence of saiga. Following from this monitors could be asked to take part in a 'control' search for saiga on a regular basis (fortnightly possibly), covering their range. Suggestions have also been made

#### **8.4.2. Cross border population**

The data obtained for this study came from Kazakhstan based sources. Although the Ural population of saiga antelope mainly inhabits West Kazakhstan, individuals have been seen over the border in Russia on a fairly frequent basis (pers comms S. Zuther). Only the west Kazakhstan region was included in the model so as to avoid increased inaccuracies and

bias, from a lack of monitoring effort, that would be included if the environmental variables extended over the border.

Future work needs to establish when and how the saiga move through the Russian regions of the populations range. Monitoring schemes that cover the full area across both Russian and Kazakh territory are required to establish a better understanding of the populations movements and distribution.

### **8.4.3 Translation**

The two fold translation process that was undertaken during the interview has limited the detail of information obtainable from the participatory monitors. The presence data acquired from the participatory monitors will not have been badly effected by translation limitations. However during the interview process I felt a lot of detailed information was missing from the translations. In West Kazakhstan the rural community speak Kazakh as their first language and Russian is often not understood. Therefore international researchers not only need to learn Russian to communicate in the regional capital but also Kazakh. Minimizing translation limitations may be done by using well informed translators, who are able to understand the scientific theory and therefore translate at the necessary detailed level. Additionally I recommend future studies including translators create a formal methodology and approach to the translation process when in an interview situation.

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## 10.0 Appendices





## Appendix 2: Interview guidelines

### Interview for farmers

1. When and where did you last see a Saiga?
  - Males/females/young?
  - How many?

After the interview please can you take me to the points where you have seen saiga.

2. What animals or plants do you farm?
3. How often do you walk around your area? (A day /A week)
4. How far do you walk on each trip out around the area?
5. Which direction do you usually go in?
6. How often do you go out and not see saiga?
7. Do you see Saiga all year round or only at certain times of year?
8. How many Saigas in a group do you see most often?
9. Do you see the Saiga in single sex groups or are the males with females?
10. How long have you lived in the area?

Soviet Union broke down in 1991, Kazakh Independence

11. How often did you see saiga before 1991?
12. How many Saiga in a group before 1991?
13. Did you see males and females together or separate before 1991?
14. Have you noticed any change in Saiga numbers or behaviour since 1991?

Future help with monitoring

15. Do you mind participating in our monitoring programme?
16. Would you be happy to continue?
17. What are the good and bad points of your job as a participatory monitor?
18. What would improve the monitoring for you?

19. Would a compass be useful?

20. Would a GPS be useful?

21. Would you be happy to spend more time helping with monitoring the saiga? If yes how much more would you like to be paid?

22. Would you be happy to go out on a certain day every fortnight, as a control measure?

23. Can you tell the difference between saiga pellets and those of other animals?

Show pellets.

24. Which one of these is saiga pellets?

25. Would you be willing to use saiga pellet counts as a method for monitoring saiga numbers?