Evaluating the use of local knowledge in species distribution studies – A case study of Saiga antelope in Kalmykia, Russia.

Jenny Leon

Supervised by: E.J. Milner-Gulland and Navinder Singh

September 2009

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science and the Diploma of Imperial College London

Contents

List of Tables

List of Figures

List of Pictures and boxes

List of Acronyms

CBD Convention on Biological Diversity

CMS Convention on Migratory Species

CZBR Chernye Zemli Biosphere Reserve

GIS Geographical Information System

GLM General linear model

GPS Geographical Positioning System

IUCN International Union for the Conservation of Nature (World Conservation Union)

NDVI Normalised Difference Vegetation Index

SCA Saiga Conservation Alliance

SDM Species Distribution Model

SR Stepnoi Reserve

Word count: 15,870

Abstract

Species distribution modelling (SDM) is a rapidly growing field, with modellers looking for fast and cost effective methods of recording species occurrence data. Participatory monitoring using local ecological knowledge (LEK) to collect data cheaply, rapidly and over a wide spatial and temporal scale presents a good alternative to more traditional data collection methods. The use of such data broadens species distribution studies into multi-disciplinary research requiring an understanding of anthropological techniques. It also brings risks in terms of data quality, reliability and interpretability. In the current literature there are no direct examples evaluating the use of LEK in species distribution studies to assist and complement SDMs.

A case study of the saiga antelope in Kalmykia, Russia has been used to highlight the merits and shortcomings of utilising LEK. From participatory monitoring data collected using LEK, the current overall saiga distribution has been identified, as well as seasonal distributions within this. These data suggest that species typical mass migrations may no longer be occurring to the same extent as in the past. Finally, data was collected to investigate people's perception of the factors controlling current saiga distribution, this raised important information specifically about water availability that will complement future SDMs produced for the region. This study provides an example of how the reliability of participatory monitoring data can be tested, using GLMs to evaluate the factors affecting the probability of a respondent reporting a saiga occurrence. This is achieved by evaluating the relative importance of three different categories of explanatory variables; biological, observational and attitudinal in determining whether respondents report a saiga sighting. The results demonstrate that this probability varies over time. Biological variables and time people had lived on their farm best describe the probability of reporting having seen saigas prior to 1991, whereas for the last 12 months attitudinal variables become the significant factor, suggesting that reliability may be compromised by misreporting. This type of study is useful for guiding participatory monitoring towards SDMs.

Acknowledgements

This project has been an amazing experience both academically and personally and I would like to first thank Prof. E.J Milner-Gulland and Dr. Navinder Singh for all their supervision and guidance along the way. Anna Lushchekina provided invaluable help translating communications to our partners in Kalmykia and organising logistics for our trip. Thanks to Kerry Waylen for helping to find a translator and advice on other aspects of the trip. I would also like to thank the Ministry of Environment in Kamykia for supporting our project, showing so much interest in it and assisting us in getting our visas.

Spasiba Olga Obgenova and Yuri Arylov. The trip was such a success and although we joked that it was due to all the good luck signs and Buddha Shakyamuni, the main reason was your careful planning and organisation. To Ilyana – you were my 'Russian mouth and ears' and great friend, I could not have begun to do this research without your help translating, thank you. Thanks also to Chingis and Gilyana for driving around the steppe and making the expedition so enjoyable.

I would also like to thank the respondents of the survey, for their willingness and helpful answers and for inviting us into their houses for much needed 'tea'. Thanks also to the villages, which kindly helped us to find a bed; be it in a host house, a medical centre or school. Thanks to Anatoli and Larisa, we always loved coming back to the Breeding Centre and Larissa's cooking! Thanks to Svetlana, who so kindly hosted me whilst in Elista.

Finally thanks to my parents for supporting me in every way possible through this MSc. And to Maurice and all my friends at Silwood for providing daily support

1 Introduction

Species distribution modelling (SDM) is being increasingly used as a tool to inform management decisions in conservation (Guisan, 2000). Species distribution maps provide an accessible visual representation of high suitability areas that can be used by practitioners and stakeholders at all levels (Abbitt et al. 2000; Treves et al., 2004). A cost effective and practical method for collecting occurrence data for use in SDMs is participatory monitoring which can utilise local ecological knowledge (LEK) to collect data covering a wide geographic area and temporal scale (Pattengill-Semmens & Semmens, 2003). Local knowledge is a cautiously used tool in conservation (Huntingdon, 2000). Researchers are right to be careful when using such approaches. However, on the condition that attention is paid to the complexities of using social data, LEK can offer invaluable information and benefits to research.

Despite the increasing amount of literature researching SDM, only find one paper discussing the use of LEK in species distribution studies could be found (Ban et al., 2009). In addition to providing occurrence data, LEK can supply many additional benefits to support SDMs such as social engagement, and should thus be promoted as a useful approach to be used by species distribution researchers. Moreover, if models are going to be produced based on monitoring data collected through using LEK it is imperative that researchers are aware of the limitations of such data and have examples of rigorous scientific testing to evaluate the reliability of the underlying monitoring data. This study fills this gap in the scientific literature by evaluating the use of LEK in species distribution studies, using a case study of saiga antelope distribution in Kalmykia.

Saiga antelope are a migratory antelope that inhabit the steppes and deserts of Central Asia. This study focuses on the pre-Caspian population of *Saiga tatarica tatarica* in Kalmykia, Russia. Saigas have suffered a severe population decline of around 90% since the collapse of the Soviet Union (Milner-Gulland, 2001). As a result they were listed as Critically Endangered on the IUCN Red List in 2002 and maintained this listing in the 2008 evaluation (Mallon, 2008). The main cause for the population crash is the hunting of males for their horns, which are used in traditional Chinese medicine (Milner-Gulland, 2001). The meat is also consumed by local communities. The total current range of the pre-Caspian population is unknown (Lushchekina & Struchkov 2001). Saigas are known to exist in the neighbouring protected areas of Chernye Zemli Biosphere Reserve (CZBR) and Stepnoi Reserve (SR), however their seasonal movements and the extent of the range outside the reserves are unknown.

In 2008, two monitoring projects were established in the region by two Imperial College MSc projects, in collaboration with two researchers from the Kalmyk State University, researching two methods of monitoring; ranger based monitoring (O'Neil, 2008) and participatory monitoring by local villagers (Whitbread, 2008). Both of these projects urged the need for further collection of year round data and its analysis to identify the seasonal ranges used by saiga. This monitoring is an important element of the conservation work being carried out in Kalmykia, not only to provide information on the population size but also the location of saigas at different times of the year. Currently this monitoring is restricted to the two protected areas due to finance and feasibility, and the participatory monitoring started in 2008 in 6 nearby of the villages was a 6 month pilot study, now awaiting further funding. Understanding of the current saiga range is essential to inform conservation decision-making and management. Local knowledge data can be used to identify a range boundary and to populate a species distribution model to predict high suitability regions within the range. Before SDMs can be built however, the reliability of the data must first be assessed.

There are 3 factors which can potentially explain the variance in the probability of a local observer reporting a saiga sighting; biological variables (i.e. whether the animal is present), observational variables (i.e whether they report it when they see it). This study will test all three in a binomial generalised linear model (GLM) showing the probability of reporting saigas. The type of variable that best explains the data provides information as to the reliability of the data for use in an SDM.

Nomadic and migratory species are particularly difficult to conserve. With no fixed home range protected areas only offer limited protection as individuals are free to move in and out of these reserves. With limited funds for conservation and range sizes covering relatively large areas it is impossible to protect the species comprehensively. This problem is compounded by those species whose movement patterns are not clear, as protection cannot even be provided along their migration corridors. These are species for which local knowledge may be particularly useful, and for which the difficulty of collecting scientific knowledge is high. Such species that have a large range are also more vulnerable to habitat loss and human impacts such as poaching. Saiga antelope are one such species.

1.1 Aims and Objectives

The aim of this project is to evaluate the role of local knowledge in species distribution studies. To achieve this aim, the objectives are to:

- ❖ Use local knowledge to establish a current range boundary for the pre-Caspian population of saiga antelope.
- ❖ Identify the seasonal ranges within the overall distribution
- ❖ Investigate the reliability of occurrence data obtained from local knowledge, through the use of a binomial GLM assessing which variables best describe the probability of farmers reporting a saiga sighting, now and in the past.
- ❖ Explore local people's perceptions of saigas; population changes since 1991, reasons for the change, and factors controlling current distribution.

The binomial GLM with test the following hypotheses:

- ❖ Social factors have a more significant influence on people's probability of reporting saigas than biological factors.
- ❖ In known poaching areas people will be less likely to report saigas, and as such will show greater variability than other areas.

1.2 Overview of thesis structure

To begin this thesis will provide a review of the current literature to place the research into context. It will cover the background to species distribution modelling, the limitations of modelling, the background to the monitoring data that models are based upon, the benefits of using participatory monitoring approaches, and the theory behind the use of local knowledge in scientific research. Following this is the case study of saigas in Kalmykia, introducing the species, the study area and people and providing a background to the monitoring work that has been carried out there already.

Having established the context of the project, the specific methods of this research will be outlined. The results are split into three sections; current saiga distribution identified in this study with comparisons to past range boundaries, reliability of the questionnaire data through analysis of two binomial GLMs, and finally local people's perception of saiga distributions in Kalmykia.

The results will then be discussed in relation to the implications of for future species distribution research, and subsequent conservation action.

2 Background

This section will describe the background to species distribution modelling, the methods used to collect monitoring data and the potential of using local knowledge as a soure of data. The relationship between these factors is shown in Figure 2.1. This is followed by the background to saiga antelope in Kalmykia, Russia.

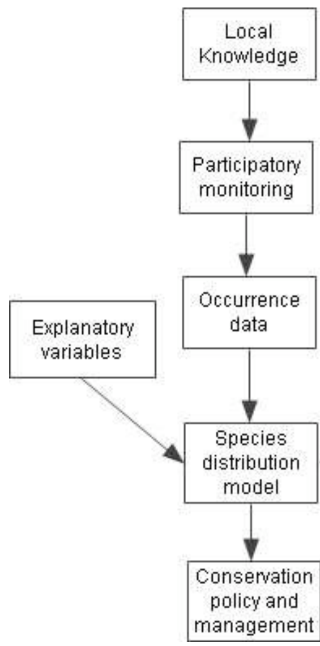


Figure 2.1 Diagram representing the relationship Relationship between local knowledge, monitoring and species distribution modelling.

2.1 Species Distribution Modelling

Species distribution modelling (SDM) is a rapidly growing area in ecology and conservation. Models relate observation data collected in the field, through monitoring programmes, to environmental variables and then use a specific algorithm to extrapolate out these features, to form predictions of high suitability areas for the focal species (see reviews and comparisons of modelling methods: by Elith, 2000; Ferrier and Guisan, 2006; Ferrier *et al*. 2002a; Franklin, 1995; Guisan & Zimmermann 2000; Guisan & Thuiller, 2005; Scott et al., 2002; Zaniewski *et al*. 2002). The mapped output of these models can be used for prioritisation of management actions (such as anti poaching patrols and allocation of protected areas) as well as to direct and improve the efficiency of future monitoring (Abbitt et al. 2000; Treves et al., 2004).

SDMs are based on the ecological niche concept (Hutchinson, 1957). The fundamental niche parameterises the potential range of climatic conditions in which a certain species could persist, but does not take into account biotic interactions, which may prevent individuals dispersing to that suitable habitat. More commonly used in modelling is the realised niche concept, which describes the actual areas in which a species is found. Realised niche models are based on field observations and take into account factors such as competition (Guisan, 2000).

2.1.1 Determinants of habitat selection

Habitat selection at the simplest level is the process or behaviour by which a species chooses an area in which to live. Habitat selection is primarily determined by the availability of a habitat to an individual, and subsequently by the abiotic and biotic factors that characterize the habitat. All species have a range of environmental and physical variables that they can tolerate and survive. Species distribution is ultimately determined by the process of habitat selection, which works in a hierarchical manner at a series of spatial and temporal scales. Spatial scales include such factors as selection of diet, feeding-area and home range (Senft et al., 1987). Temporal scales include seasonal dependence for food availability, and snow cover (Boyce, 2006).

A set of species-specific (typically environmental) variables is therefore used to construct a SDM (Guisan, 2000). These variables must be chosen with a priori thought to their relevance to the focal species and scale at which they act (Johnson et al., 2002).

The factors that influence species distribution and habitat use, can be categorised into three ecological gradients; direct, indirect or resource (Austin 1980,1985;

Austin et al., 1984 and Austin & Smith, 1989). Direct gradients describe environmental variables that influence physiology such as temperature. Indirect gradients are those that affect the direct and resource gradients, such as precipitation which in turn controls plant growth and thus food availability for herbivores. Resource gradients refer to the availability of food and water (Guisan, 2000).

Commonly data is acquired from open access databases on the internet or official data sourced from the countries concerned. Remote sensing, using satellite imagery, is frequently used to collect data on climatic variables and global data sets are available for factors such as precipitation. Preference is often given to the use of remote sensing data, as fieldwork has further practical and financial limitations. In some circumstances however specific layers must be collected locally, in which case fieldwork can directly gather information on specific variables. The need for this is often dependent on the scale at which the variables act, for example, local disturbance is not easy to get from global databases.

2.1.2 Species occurrence data

Occurrence data can be obtained from a variety of sources including direct field observations, participatory monitoring, or from museum or herbarium collections. The data is heavily influenced by the sampling technique used, and is subject to biases and inaccuracies. The type of data collected dictates the modelling method chosen. Wintle et al. (2005) provide a practical explanation of the five main categories of data type, with collection method and modelling technique for each type.

Data for each of the explanatory variables are extracted for each occurrence point. SDMs use a specific algorithm which characterises the conditions at occurrence points. Once the suitable range for each of the environmental variables has been defined, this information can be extrapolated over the area of interest to highlight other locations that have suitable combinations of explanatory features, thus making predictions of species distribution or suitable habitat. The accuracy of the model predictions is dependent on the reliability of the occurrence data. Therefore the data collection methods have a pivotal role in the overall accuracy of a SDM.

2.1.3 Scope of SDMs

Modelling is just one tool that can used to investigate species distribution. Although many modelling studies successfully predict distribution and thus can be used to aid monitoring (Peterson, 2003), there are others where attempts at finding the species in the predicted habitat failed to locate any individuals (Jiménez-Valverde et al, 2008). To provide the most accurate results SDMs need to be used within a framework of other approaches. Uncertainties in predictors are another common problem with SDMs where high suitability areas predicted by the model, in reality would never have the species present. This is due to other determinants of distribution such as distance from source population (the habitat is suitable but too far from source population for the species to ever reach). Incorporating local knowledge of the area can reduce these inaccuracies.

There is a risk with such a promising new tool, of creating SDMs without critically analysing the data the model is based on; it is important to understand the limitations of the techniques as well as the strengths. A large source of error in spatial modelling occurs when models are based on biased data, from poorly designed monitoring.

2.2 The role of Monitoring in SDM's

Monitoring is at the centre of all species distribution models providing the most commonly used source of occurrence data. The output of a SDM then provides a feedback loop to the decision makers improving future management of habitats and species through adaptive management and the efficiency and effectiveness of monitoring programmes (Yoccoz et al, 2001). It is imperative to understand the general theory of monitoring and the background to the specific monitoring programme used, to understand the strength, weaknesses and overall scope of the data, before using it to build a model.

Monitoring programmes are usually established as a first step in conservation work, to gain a basic understanding of the focal species; through monitoring of its population size, status and dynamics, distribution, movement patterns, life history and habitat requirements.

Spellerberg (2005) defined monitoring as *"the systematic measurement of variables and processes over time" and "assumes that there is a specific reason for that collection of data, such as ensuring that standards are being met".* Monitoring has a wide range of applications which Legg and Naggy (2006) broadly divided into three main functions; to highlight changes in a system's state, to measure success of management and/or policy, and to determine the effect of perturbations and disturbances. SDM are a tool that allow conservationists to carry out these functions.

With increasing attention being paid to the conservation of endangered species, habitats and ecosystems the number of monitoring programmes has increased in recent decades. This increase, in addition to the shift towards more hard-line, rigorous 'evidence-based conservation' (Sutherland el al., 2004), has inevitably brought the design and implementation of monitoring programmes under scrutiny.

2.2.1 Using pre-established monitoring data

In reality monitoring data often come from monitoring programmes which have been established without rigorous a priori thought. The design of a monitoring programme is pivotal; if it is not designed correctly at the start, the data derived will be unreliable. Insufficient finances, manpower, time and restricted areas to be monitored, cause biased sampling areas and incomplete coverage of species' range. Many programmes also have poor sampling strategies and no measure of effort. Unreliability caused by bias invalidates any application benefits of a model.

Where species have not been previously monitored or where monitoring programmes are severely limited, ideally a new monitoring programme would be established, complementing existing programmes. Due to time and financial limitations researchers are most often left with no choice but to work with imperfect data, requiring them to take extra care to account for and work within the limitations of the data.

2.2.2 Designing new monitoring programmes

For monitoring to be successful and efficient at achieving its aims, it must be carefully designed with a priori hypotheses and clear objectives and implemented with close links to its application and adaptive management. Yoccoz et al. (2001) highlight the need to address three basic questions "*Why Monitor? What should be monitored? And how should monitoring be carried out?*" To this end, scientists have been calling for improved integration of monitoring, management and research (Noss, 1999). Monitoring should be one element of a larger process of either conservation science or management (Nichols and Williams, 2006). Krebs (1991) stated "*Monitoring of populations is politically attractive but ecologically banal unless it is coupled with experimental work to understand the mechanisms behind system changes*". Monitoring should focus on precisely the information needed to make conservation decisions (Nichols and Williams, 2006). Thus monitoring should be designed with the aim of making the resulting data as useful to conservation and science as possible i.e. efficient, cost effective and targeted.

2.2.3 Participatory Monitoring as a solution

Participatory monitoring is a useful approach providing dual benefits of species conservation as well as local awareness and engagement. There is a continuum of how participatory such programmes are; ranging from those in which local people are involved from design to implementation, to those that record local knowledge through interviews. The former has long term benefits for community engagement however the latter gives immediate access to retrospective information collected through participants experiences (Danielsen et al., www.monitoringmatters.org).

Public participation methods are relatively cheap, as they often reduce the dependence on paid researchers (Pattengill-Semmens & Semmens, 2003). Those involved either volunteer their time for free, or small payments are made as an incentive, meaning that a greater number of monitors can be used. Participants that have lived in the same house or area for a long time are able to provide information on population changes over time. Participatory monitors are capable of collecting data quickly covering a large geographic area (Pattengill-Semmens & Semmens, 2003), and un-restricted by time thereby the project benefits from a larger sample both spatially and temporally. Whereas the practicalities and cost of using paid professionals could prevent surveys going ahead. Participatory monitoring programmes are also less affected by inconsistent funding so can therefore help improve longevity of a study, providing data over a much longer time frame than would be possible for a researcher, allowing long term trends to be detected (Whitelaw et al., 2003). This can help to pick up early warning signals (Pattengill-Semmens & Semmens, 2003).

As well as these practical benefits there are additional benefits of increased education and awareness (Sharp, A. & Conrad, C. (2006); Stokes et al., 1990). The sense of personal involvement that is gained through participation in such projects means respondents are more likely to engage with conservation. This increased knowledge can also provide a social benefit by aiding community-based informed decision-making (Sharp, A. & Conrad, C. (2006); Stokes et al., 1990).

Although there are many limiting factors with this method which control the level of input volunteers should/could have (see section 2.3), "*with the proper* *caution and appropriate design, the use of volunteer involvement in monitoring schemes should be given a great deal of attention and support*" (Stokes et al., 1990).

2.3 Local Ecological Knowledge

Local Ecological Knowledge (LEK) in rural conditions has been defined as "knowledge held by a specific group of people about their local ecosystem … a mix of scientific and practical knowledge, being site specific" (Olsson & Folke, 2001). Local ecological knowledge can be obtained from any person that has knowledge about their local environment, as such this approach can be applied to a wide variety of studies for example from management of mistletoe and Alma harvesting in India (Rist, 2009) to sustainable urban planning in Finland (Yil-Pelkonen & Kohl, 2005). There is a distinction between LEK and traditional ecological knowledge (TEK), the latter more specifically investigates the knowledge that a person accrues through their culture, such as through story telling, customs, and songs. Although it is important to recognize the difference between them there are also many similarities that can allow some transferability. In the literature they are often confused, with papers referring to both approaches interchangeably (Gilchrist and Mallory, 2005). Examples of research using LEK is even harder to find in the literature than papers specifically relating to TEK.

In both cases the use of such knowledge in conservation research is an often over looked source of information, this is due to an amalgamation of factors few of which relate to the quality of the data. Arguably the most significant aspect in deterring scientists is the fact that these approaches require the use of social science methods to gather biological data, with the implication being that LEK and TEK research and application becomes a multidisciplinary undertaking (Huntingdon, 2000). There has been strong debate over the scientific merit of such approaches (Brook & McLachlan, 2005; Gilchrist & Mallory, 2005). Huntingdon (2000) provides a rare evaluation of the use of TEK in science, in this paper he theorises that the reticence of scientists to use TEK is 'a continued inertia in favour of established scientific practices and the need to describe TEK in Western scientific terms', equally this reason explains the underrepresentation of the use of LEK in the literature.

2.3.1 Benefits of using LEK

In addition to the benefits of participatory monitoring, there are many further benefits associated with the use of local knowledge in SDMs. Local people that coexist with a focal species and have a strong connection to, and interest in, the environment provide a useful source of information about the main factors that influence the ecosystem.

If they have lived in the same area for any period of time residents are able to provide data covering a large temporal period and can explain the subtleties of how a specific species' population my have changed over time, both in overall size and structure, including age and sex ratios. To complement this species data they can provide their direct opinion of what has caused these changes, such as overharvesting or poaching, or indirect environmental changes that can be tested in a model to analyse their effects on species distributions.

2.3.2 Factors to consider when using local knowledge data

LEK refers to the knowledge built up by a person over numerous local observations of a system, this means that every person's LEK is subjective and is formed through their specific and unique experiences (Yil-Pelkonen & Kohl, 2005), a potential source of inconsistency. Some of this inconsistency can be explained by factors such as detectability of a species, the daily routine of the person interviewed and chance. It is important however to also critically analyse the information provided as some people may have incentives to report certain and possibly inaccurate answers.

The difficulty in assessing and ensuring the reliability of LEK data is a major limitation of the approach. Social data is prone to bias and error, especially if those being interviewed are possible 'users of the resource', whether this be direct harvesting for subsistence means or poaching as a supplementary livelihood activity. Careful questionnaire design, in addition to having, awareness of the main causes of error are the most effective ways of reducing the inaccuracies of the data.

In addition to untruthful reporting the questionnaire design can be a further source of error. Subtle differences in question phrasing can significantly alter the answers given. Differences include asking typical questions versus actual values, for example "*what's the average size of a fish that you catch*" versus "*what was the size of the last fish you caught*" (Jones et al., 2008). Asking question about actual values introduces variability. Furthermore, it can be understandably difficult for people to accurately recall information especially if asked specific questions about a period many years ago. Therefore it is important to minimise these effects again this is achieved through careful design of the questionnaire, an using tools such as timelines to aid memory recall.

Bernard identifies four reasons why people are inaccurate recording their own behaviour:

1. Once involved in the questionnaire participants have a personal stake and may try to provide answers to questions they do not fully understand.

2. The strength of peoples memory can vary, some people have stronger memory than other, some events are easier to remember than others, and variety of other factors can contribute to how easily a memory can be recalled. If memories cannot be recalled the risk is that participants will estimate the answer (Estimation rules)

3. Interviews are a form of social encounter which people are likely to manipulate to what they perceive as their advantage (for review of social desirability – see deMaio, 1984).

4. It is difficult to count a lot of behaviours, instead they use rules of inference and report what they presume happened.

Linked to the problems of memory recall is the theory of 'shifting baseline syndrome' that was first observed in the marine conservation literature (Pauly, 1995; Sheppard, 1995; Jackson, 1997) and has now been recognised in mainstream conservation (Papworth, 2009). Shifting baselines refers to the subconscious change in people's perceptions over time (either over a person's lifetime or between generations), resulting in an inability to 'appreciate the extent of past environmental modifications by humanity' (Saenz-Arroyo, 2005). Papworth (2009) provided the first conclusive evidence to prove the existence of shifting baseline syndrome and thus the challenge for researchers using human perceptions of change to inform conservation policy-making or management. As such it is an essential factor to consider when analysing data obtained about population changes over time from LEK. Triangulation of the results with data collected through other means, is one method of identifying potential shifting baselines.

Participatory mapping is a useful process to focus discussions and visualise the information people are providing (Chambers, 2006). The use of this tool can take many forms, most typically participants are asked to draw maps of certain areas marking specific places of interest such as water sources. Alternatively, pre-prepared maps can be provided that participants can annotate. If maps are not used in a certain society, they can prove a difficult concept to understand. Participatory mapping should only be used if the respondents already understand mapping or if you're able to successfully explain it to them (Milner-Gulland and Rowcliffe, 2007). If implemented successfully maps can supply a useful extra source of information, enabling a wider understanding of the study site.

2.4 Case study of the Saiga antelope (Saiga tatarica tatarica)

2.4.1 Conservation status

Saiga antelope are small nomadic ungulates that inhabit the Central Eurasian steppe. Once widespread across Europe and Central Asia (Bekenov et al., 1998) the species is now restricted to 5 populations (figure 2.4.2) found in Russia, Kazakhstan, Uzbekistan, Turkmenistan (only in extremely cold winters) and Mongolia (Milner-Gulland, 2001). This study focuses on the Pre-Caspian population, found in the Russian Federation States of Kalmykia and Astrakhan.

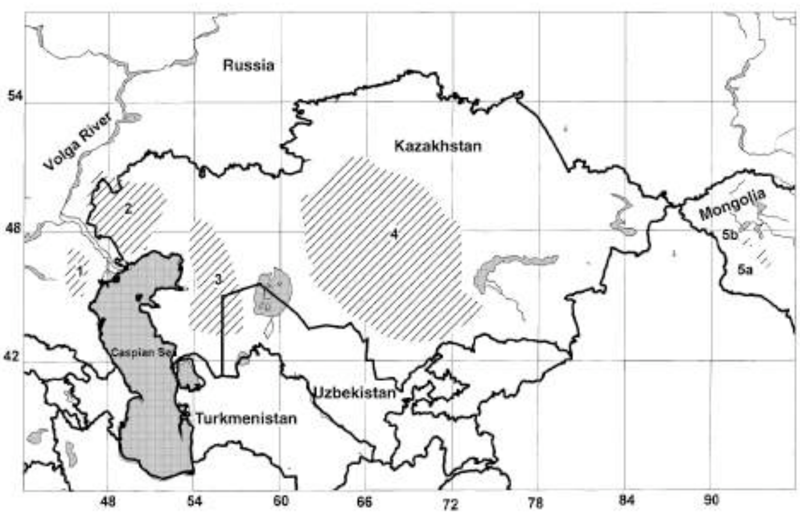


Figure 2.2 The approximate current ranges of the Saiga Antelope Saiga tatarica. The four Saiga tatarica tatarica populations are depicted by 1) Kalmykia, Russia 2) Ural, Kazakhstan 3) Ustiurt, Kazakhstan migrating into Uzbekistan 4) Betpak-dala, Kazakhstan. The two saiga tatarica mongolica population are shown in 5a) Shargyn Gobi population, Mongolia and 5b) Mankhan population, Mongolia. Reproduced from Milner-Gulland et al., 2001 with kind permission

Saigas have been hunted for centuries for their meat and also the males horn for use in Chinese Medicine (Milner-Gulland, 1994 referenced Kirikov, 1966). As with many 'Soviet Species' political changes have had direct effects on their exploitation and population size (Milner-Gulland, 1994). The Soviet Union collapsed in 1991, leaving many rural people without jobs, with the subsequent reopening of the border with China, saiga poaching reached an all time high. A reduction of the ratio of males to females, caused many females to remain barren (Milner-Gulland et al., 2003), further exacerbating the population crash. The 90%

decline in population size (Milner-Gulland, 2001) resulted in saigas being up-listed to 'critically endangered' on the IUCN Red List (2002), and included in Appendix 2 of the Convention on Migratory Species (2002), and Convention for International Trade in Endangered Species (1995).

2.4.2 Saiga Ecology and migration patterns

Saigas require access to freshwater, but will travel up to 40km a day to find them (Bekenov, 1998). The species is adapted to flat terrain with low-lying vegetation, and little snow cover. Records show them crossing rivers but current opinion is that they might not be able to cross steep-sided artificial canals and other forms of human infrastructure (Singh, pers omm.).

Saigas migrate seasonally between northerly summer ranges, which have the most productive feeding grounds, and southerly winter ranges, which have less snow cover and sparse but accessible vegetation. These migrations are thought to be driven by environmental conditions (Singh, in review). Figure 2.2 depicts the seasonal movements of the pre-Caspian saiga population in the past, when the population was large and exhibiting typical behaviour.

The population crash has caused alterations in the saiga population; a reversal in reproductive behaviour (Milner-Guland, 2003) and a reduction and disbanding of birthing aggregations. A further effect has been to severely disrupt migrations meaning that now neither the overall distribution nor the summer and winter ranges of the pre-Caspian saigas are known precisely. The last depiction of saiga distribution was presented by Lushchekina comparing the distribution in 1950s with the distribution from 1990-2000 (Lushchekina & Struchkov, 2001). Experts are keen to establish the current saiga range and use species distribution models to predict high suitability areas to assess the current population status and inform future policy and management decisions.

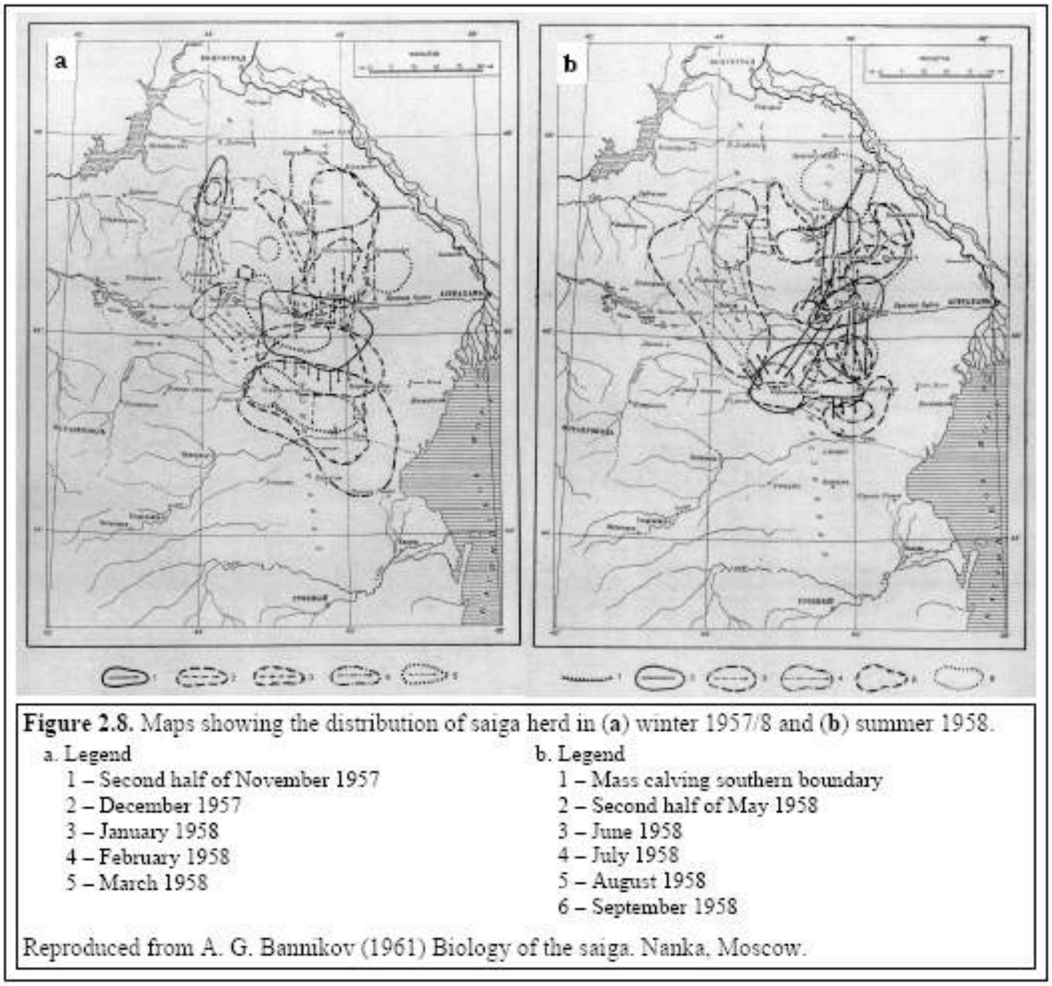


Figure 2.3 Maps showing the past seasonal movements of saigas in Kalmykia in a) winer 1957/8 and b) summer 1958.

2.4.3 Study area and People

Located in the southwest of the Russian Federation, the autonomous Republic of Kalmykia and its neighbouring state of Astrakahn, are situated in the steppe and semi-desert region of the Precaspian. Kalmykia is one of the poorest regions of Russia; the percentage of people living below the subsistence level exceeded 60% and income per capita was only 32.8% of the national Russian average in 2005 (UNDP 2007). The economy is primarily based on livestock and agriculture, with about 70% of agricultural land serving as pasture and 14% as arable land (Orichova 2004). In 2002 the rural population made up 55.7% of the total population in Kalmykia (UNDP 2007). Kalmykia is the only Buddhist state in geographic Europe, and the temple in the main square of the capital Elista depicts a statue of God with a Saiga at his side.

The Kalmyk people were traditionally nomadic herders migrating with their flocks from the overwintering grounds in the south to the richer pastures of the north. This lifestyle provided strong links with the environment (Grin, 2000), and Kalmyk people had great respect for saigas which mirrored their nomadic existence. As a result the saiga was protected under cultural law, by having no-take zone and limited off take areas. Under the Soviet regime the Kalmyk people were exiled, and new groups moved into the area settling on the collective farms of the communist regime. This shift from nomadic to settled farming meant that prime areas were over grazed. Overgrazing caused the steppe ecosystem to degrade and great swathes turned to desert, the only desert in Europe.

In 1991 the Soviet Union collapsed and the financial support for the collective farms dried up almost over night, leaving thousands of people unemployed and starving. At this time the border with China was also opened and poaching became rife. Although poaching levels have reduced since their peak in the 1990s poaching is still carried out today.

The known poaching villages in Kalmykia today are Khulkhutta (Kühl, 2008), Utta (Siaga News, Issue 8), Komsomolskiy (Saiga news, Issue 9), Yashkul' (Issue 8), Chernozemelskiy region (Saiga News, issue 8).

2.4.4 Public Participation in saiga conservation

A series of different conservation interventions have been used to try and engage the local population in saiga conservation with the aim of reducing poaching. The Centre for Wild Animals and the Centre for Ecological Projects have been the two in country partners that have facilitated this work. An ongoing media campaign is used to increase awareness in the general public about the severity of the threat that saigas are facing and the importance of this in the government and international conservation community. All projects being conducted in the region are regularly reported in the local newspaper and news. To engage children art competitions have been organised across the state with a theme of saigas and the steppe habitat. School 'saiga clubs' have also been established. Talks are regularly given to different groups, there is a presentation discussing the threat to saigas in a more scientific context and a cartoon made for children about saiga poaching. Kh. Manzhiev has written the lyrics for a song which has been produced in traditional Kalmyk style to be broadcast around the area to further raise awareness. Support is provided for rangers at the reserves and training to young scientists in Kalmykia. Efforts are made to partner up students from the Kalmyk State University with students coming to study saigas from abroad, so that the two sides can learn from each other.

The Centre of Wild Animals breeding centre has a captive population of saigas and a visitor centre exhibiting information on conservation work carried out in the region.

The biggest project dedicated to public engagement has been the 'rotating cows' programme. The project targets poor families in the area north of the reserve, who are most likely to poach, providing them with a dairy cow and support to look after it. The first heifer born to this cow goes back to the reserve heard at the breeding centre of the Centre for Wild Animals.

Previous research has shown those who have received some form of social engagement about saigas were significantly more likely to feel more positive about saigas than those that have not (Howe, 2009).

2.4.5 Current available data for modelling

Two monitoring programmes have been used to record data on saiga antelope in the pre-Caspian region of Russia; ranger based monitoring (O'Neil, 2008) and public participatory monitoring (Whitebread, 2008).

Within the Chernye Zemli Biosphere Reserve (CZBR) and Stepnoi Reserve (SR) 'surveillance' monitoring is carried out by rangers (Nichols and Williams, 2006).

The rangers patrol the reserves by vehicle and record observations of saiga, collecting information on the group size, age / sex structure and location. The rangers also constitute the anti-poaching patrols. To increase the efficiency of patrols it is important to gain a better understanding of where the saigas are located throughout the reserve and their movement patterns in different seasons.

To successfully conserve the population it is also necessary to understand saiga distribution outside the reserves, as a result a public participatory monitoring programme was piloted for 6 months in 2008 (Whitebread, 2008). This functioned as a 'targeted' monitoring programme collecting specific data to discover where, when and how the saiga move outside the nature reserves (Nichols and Williams, 2006). The programme also aimed to engage the local people, hopefully increasing awareness and the value assigned to saigas in the region.

This provides a good basis of presence data from which to create a model however it is spatially limited and biased towards certain areas within the saiga range (O'Neil, 2008; Whitebread, 2008). Therefore further data is required before a reliable model can be created.

2.4.6 Future approach

Combining formal monitoring by paid staff and participatory monitoring by local members of the community may give a better picture of species distribution within and outside protected areas, as a wider regions will be sampled. The data can be used to map out the year round distribution of the species and identify threat areas or specific factors which negatively impact saiga movements and distribution, this information can then feedback into conservation action and policy making. This approach may also lead to an increase in efficiency and possible reduction of survey effort (Guisan et al. 2006, Singh et al. 2009). A priori thought and planning maximises the efficiency of management and monitoring, this is particularly important in the face of limited resources and plentiful conservation need.

2 Methods

3.1 Outline

The methods are divided into two parts; firstly the data collection process is outlined, starting with the choice of social survey technique and subsequent development of a questionnaire (section 3.2.1), followed by the plan for the expedition (section 3.2.2). Secondly the data analysis methods are described for producing the boundary data (section 3.3.1) followed by explanations of the choice of statistics performed on the social data along with details of how they were applied (section 3.3.2).

3.2 Data Collection: Questionnaire Survey of Kalmykia

A questionnaire survey was used as it provided a fast and cost effective method of collecting a large spatial sample of presence points, whilst also providing additional contextual information about local perceptions of saiga distributions and how their population has changed over time (see sections 2.2.3 and 2.3 for further background to using participatory monitoring and local knowledge). This participatory monitoring programme was designed in accordance with the best practise guidelines such as clear a priori objectives and not collecting excess data as described in section 2.2.1.

3.2.1 Questionnaires

The questionnaire survey used face-to-face questionnaires in a semi structured interview framework (Milner-Gulland and Rowcliffe, 2007; Bernard, 2006), to collect information on saiga distribution and the perceived factors that influence this. The benefit of using a semi-structured approach is that while answers given to set questions provide consistent and comparable data for the whole study area, the informal nature of the interview allowed the researcher or respondent to develop specific aspects as seemed appropriate. The interviews were carried out in Russian, through a translator from the linguistics department of the

Kalmyk State University, on the respondents' farm, to try and minimise the formality of the process. The questionnaire itself took approximately 20 minutes to complete however often the respondent would expand on certain topics.

The questionnaires were developed from previous questionnaires that had been successfully piloted and implemented in the region (Kühl, 2003; Howe 2009; Whitebread, 2008) in conjunction with expert opinion (E.J. Milner-Gulland, N. Singh and A. Lushchekina, pers comms).

Reference was made to 'timelines' used in participatory rural appraisals (PRA, see Milner-Gulland and Rowcliffe, 2007), to provide a locally relevant memorable date, in this case the collapse of the Soviet Union in 1991, from which people could make comparisons. For example rather than asking "how many saigas did you see in this area in the past compared to now" or even "how many saigas did you see 20 years ago compared to now", this fixed point in time allows an easy and memorable time in people's history from which to make comparisons. The collapse of the Soviet Union had further relevance to this study because not only did it cause a significant change to the daily life of all Russians but the collapse also had a direct impact on the saiga population (as described in section 2.4). Observing saigas has become a relatively rare event and therefore it is likely that to be more memorable, however other factors will also influence this for example, a how much of a personal interest in saigas the person has.

The structure of the questionnaire provided an order, which the interview could be loosely based around; starting with general, closed questions to allow the interviewer and respondent to become familiar with the process and build a rapport between themselves. The more sensitive, open questions focusing on changes in the saiga population were positioned at the end by which time respondents would feel more comfortable discussing these matters.

When asked about why the population had declined, many respondents were naturally reticent to talk openly about poaching so, a technique was developed which provided participants a safe space to open up. I showed them on the map the route that the expedition had visited previously and told them the number of questionnaires already carried out, and then said (truthfully) that most of the previous people had talked about poaching in their interviews. I then asked whether this person thought that was something that might have affected the saiga population in this region now and/or in the past. An accepted problem with such an approach is that the researcher can impose their preconceptions on the respondents. This situation is clearly vulnerable to such a difficulty however, it was felt that the technique used enabled respondents to give their honest opinion rather than a false answer. Comments such as '*any fool knows there's poaching*' which were made after showing the respondent the map, suggest that the participant was being truthful and had simply been too cautious to share this information before.

It is also important to note at this stage that many of the people interviewed will have been involved with saiga poaching at some stage, and some will still be connected with poaching today. This does not necessarily mean that they will provide inaccurate answers but is an important consideration to take into account when analysing the results.

A 'Don't Know' category was included in all questions to provide a category for people who genuinely had no knowledge or interest in saigas so that they did not bias results by just answering 'yes' or 'no' to fit in with a poor questionnaire design. However, it was often found that respondents would start by using the 'don't know' options either because they were not 100% sure of the answer, or because some respondents (especially women) lacked the self-confidence to give an opinion. Further discussion often brought out a definite answer.

There were cultural considerations to take into account when conducting the survey, namely that as the majority of the inhabitants of the farms originated from the Caucasus and were Muslim in whose culture it was courteous for men to speak first. On the advice of the Kalmyk driver and translator, on arrival at each new farm the male driver got out first to explain briefly about the project and introduce the female researcher and translator. Once the inhabitant had agreed to take part there were never any problems with the men not responding well to a female interviewer.

One person was interviewed per household in general. If there was a group of people keen to input into the interview process, the answers of the person most likely to see saigas were recorded (see section 3.2.2 for discussion of demographic groups), whilst still listening to the whole group to make sure there was agreement. If there were differences of opinion a separate interview was conducted with those individuals. For current location data the most recent observation of saigas was used, and the more outdated response was excluded from the analysis.

All respondents were given a Saiga Conservation Alliance pen, postcard or badge (for their children) or a combination of these items, in appreciation for their help and to fit with local custom of present giving, this often also prompted a further discussion about the international work and interest that surround saiga conservation.

A form of participatory mapping was used to clarify specific features that were talked about in the interview, because we wanted specific answers participants annotated individual copies of printed maps of their locality. This method was suitable for use in Kalmykia as the population is well educated and have a sufficient level of understanding of maps to feel comfortable referring to them.

3.2.2 Survey Plan

Questionnaires were conducted across the Russian Federation States of Kalmykia and Astrakhan during June and July 2009 to determine the outer boundary of saiga distribution and wider geographic range of previous sightings. The general area to be surveyed within Kalmykia was identified using a combination of the most recent range data (Lushchekina & Stuchkov, 2001) and local expert knowledge of current saiga distribution (Iu, Arylov, pers omm.), with specific routes being determined by the results of the questionnaire (explained further below). The survey lasted two weeks, which gave enough time to cover the entire saiga range. Time was spent at either end to liaise with our in country partners, government officials including the Minister of the

Environment and journalists to ensure the project had good support and publicity.

The original objectives negate the need for representative sampling of demographic groups and locations. Instead, the aim was to cover as large an area as possible to get a good spatial coverage of presence /absence points for future modelling and to get data covering the complete boundary of the range. It was important to get true positive and negative recordings of saiga presence / absence therefore the survey used a purposive sampling method (Milner-Gulland & Rowcliffe, 2007) targeting shepherds and older generations who had lived in the area prior to 1991 as this demographic group spent the most time out on the steppe and would be able to provide information on saiga population changes in a specific area over time. This demographic group mainly live on "tochkas", single farms in the middle of the steppe which have livestock that are taken out on to the steppe everyday by the shepherds.

The route of the survey responded to information given during previous interviews. It extended out until people stopped reporting sightings of saigas, once this occurred a 'zig-zag' route was taken along the boundary of the saiga range, with people reporting saiga sightings on one side and not on the other. The selection of farms was made on an opportunistic basis; the steppe is sparsely inhabited with steppe roads linking the farms. Steppe roads varied from well made up dirt tracks to hard to detect tyre lines through the grass. Each household was allocated a number and geographic coordinates were recorded using a Garmin eTrex® H Handheld GPS Navigator (with a maximum horizontal accuracy of <33 feet and an enhanced position accuracy of <10 ft).

If there were many houses in an area and interview results were showing clear consistent answers, rather than continuing with full questionnaires after it was felt that enough farms were reporting an overall trend was clear (3 farms in a row reporting the same answer), a 'quick questions' mini interview was carried out just to check that the trend was continuing without wasting time conducting a full interview on each farm. The 4 'quick questions' included how long the person had lived at the farm, how often they went out on the steppe, when they last saw saigas, what time of the year was it usual to see saigas here. In addition to this information the GPS location was recorded. These mini interviews provided useful information for directing the expedition, as well as providing supplementary presence points, however as they did not include full answers they were excluded from much of the data analysis. When the answers in the mini interviews started changing then full interviews were resumed.

3.3 Data Analysis

3.3.1 Boundaries

The data collected was recorded in a 97-04 compatible workbook in Excel. Maps were produced using ArcMap GIS software, using the Utm WGS 1984 40N projection to match previous research conducted in the saiga range (Singh et al. in review). These data were overlaid onto a state boundary layer, obtained from http://wagda.lib.washington.edu/data/geography/world/russia/index.html. A minimum convex polygon was fitted to the data to represent an approximate current range. An alternative boundary was also constructed in GIS using the same background state boundary layers but instead overlaid with a boundary recreated from an original hand drawn boundary (Honya, pers omm.). Although this boundary will obviously not be exact it does show the overall picture of saiga distribution. These boundaries were compared to past distribution range boundaries which were again recreated in GIS, this time from Lushchekina's original work (Lushchekina & Struchkov, 2001).

The presence data was sub-divided by season to analyse the current seasonal ranges. Seasons were defined as Spring – March, April, May; Summer – June, July August; Autumn – September, October, November and Winter – December, January, February. This fits with the saiga migration information described in section 2.3.2

3.3.2 Modelling

The reliability of the data for use in a SDM was analysed using binomial generalised linear models (GLM), which unusually tested 3 different types of explanatory variable within a single model; biological, observational and attitudinal. Two models were built; one to analyse the reported occurrence data for the last 12 months, and the other to analyse whether people had ever reported seeing saigas in their area. The latter allows a comparison to highlight any changes over time.

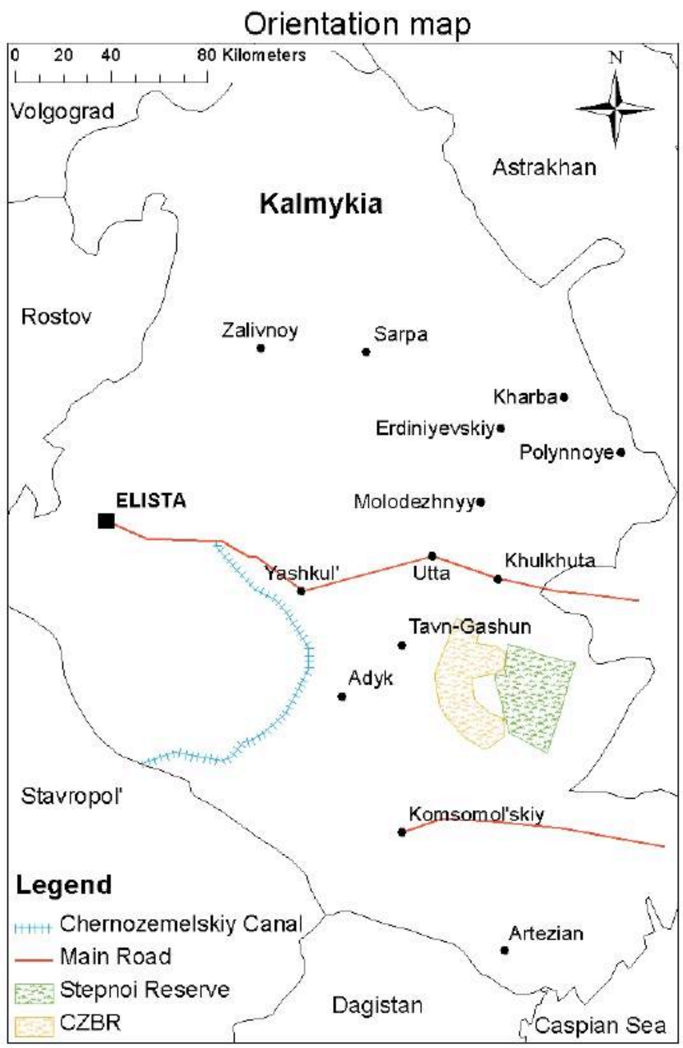


Figure 3.1 Orientation map of Kalmykia, depicting the state boundaries, Elista the capital of Kalmykia, key settlements referred to throughout the thesis, the CZBR and SR, the Chernozemel'skiy canal and north and south main east-west roads.

Table 3.1 List of explanatory variables with corresponding explanation of the a priori reasons of why they were included in the model.

Variable	Reason / Hypothesis for testing
Biological Variables	
Mean annual precipitation	Saiga are less likely to be found in areas with high snow cover, this is represented by mean annual precipitation. It would be expected that saiga distribution would be negatively correlated with high precipitation areas. Annual data was used to be consistent with the occurrence data covered the entire year.
Normalised difference vegetation index (NDVI)	NDVI refers to the 'greenness' and hence the productivity of an area, which also represents the food availability for ungulates. NDVI is thought to drive saiga migrations (Bekenov et al., 1998, Robinson & Milner-Gulland 2003 & Singh et al., in review)
Distance to water	Although, adapted to survive in the arid steppe saigas will have to persist within a certain distance to water and would probably show an overall preference to areas closer to water, where vegetation might also be better.
Observational Variables	
Time lived in house	A persons probability of encountering saigas will increase with the time they have lived in their house. This category will also reflect more complex effects such as a persons ethnicity.
Frequency of time spent on the steppe	The more regularly a person goes out on the steppe the higher their chances are of seeing a siaga in any given year.
Whether they use a motorised vehicle when shepherding	It would be expected that use of a motorised vehicle whilst shepherding would reduce a respondents' probability of seeing a saiga as the noise would deter them.
Attitudinal Variables	
Nearest main village – 5 regions	The 13 political regions in Kalmykia was too coarse to divide the saiga range, a finer scale was required. Attaching farms to their nearest village, over parameterised the model. Instead the range was divide into 5 regions characterised by a single large village; Sarpa (north west), Erdniyevskiy (north east), Yashkul' (mid west of the range), Khulkhutta (mid-east), and Komsomol'skiy (south) (Map 3.2).
Distance from Utta	There was a large amount of variability in the reports around Utta (see figure 3.1 & 4.1). Therefore a raster was created showing the distance of each location from the village of Utta.
North/South of the main road	The data points were divided between those north / south of the northern main road (Map 3.1). This was because of greater variability to the north of the road. As a trade route, proximity to the road potentially acts as a predictor of poaching activity and it may also reflect saigas seasonal distribution.

Univariate tests were used to analyse whether observational variables (see table 3.1), were significantly related to the occurrence data. None of these variables were close to being significant therefore these were omitted from the maximal model (Tables 1 & 2, Appendix II).

The biological and attitudinal explanatory variables were selected using a priori considerations of the species' requirements, steppe habitat and poaching influence (see table 3.1). NDVI is closely correlated to precipitation NDVI and hence NDVI the two were run separately in two maximal models to investigate which gave the better model. It was found that mean precipitation showed greater significance and gave a lower AIC value than NDVI (Appendix II). The maximal models also consisted of the amount of time an interviewee had lived in their house was used in both models in addition to one of three variables representing the geographical location of their farm (see table 3.1). Within the saiga range there are very different attitude to saigas, notably the villages to the north of the reserves around the village of Khulkhutta are known to be big poaching villages (Kühl, 2009). The three options of explanatory variable shown in table 3.1 were tested in maximal models to see which best explained the data (Appendix II).

Table 3.2 The final list of the explanatory variables used in the models, with source information and conversion methods used.

Explanatory Variable	Source	Conversion Methods
NDVI	MODIS https://lpdaac.usgs.gov/lpdaac/get_data	Using the cell statistics tool in spatial analyst the monthly raster of NDVI was added together creating a raster with the mean NDVI for each point.
Mean Annual Precipitation	Average monthly precipitation of the last 50 years was downloaded from: www.worldclim.org/current	Using the raster calculator each monthly raster of precipitation was added together creating a raster with the mean precipitation for each point
Water Availability	A map of water areas was obtained from the 'Biogeomencer project' www.biogeomancer.org/	A raster was created using the euclidean distance spatial analyst tool, showing the distance to water at the 1km scale and values for each location were extracted.
Time lived in house	Social Survey	None
Main Village	Google Maps	Point locations of villages within the saiga range were extracted using itouch maps, and loaded into GIS as co-ordinate data. Boundaries were then drawn around each region and location points were allocated to a 'Main Village'. These boundaries were chosen to provide roughly similar sized data sets whilst also representing a priori knowledge about the different regions and their approaches to saigas.

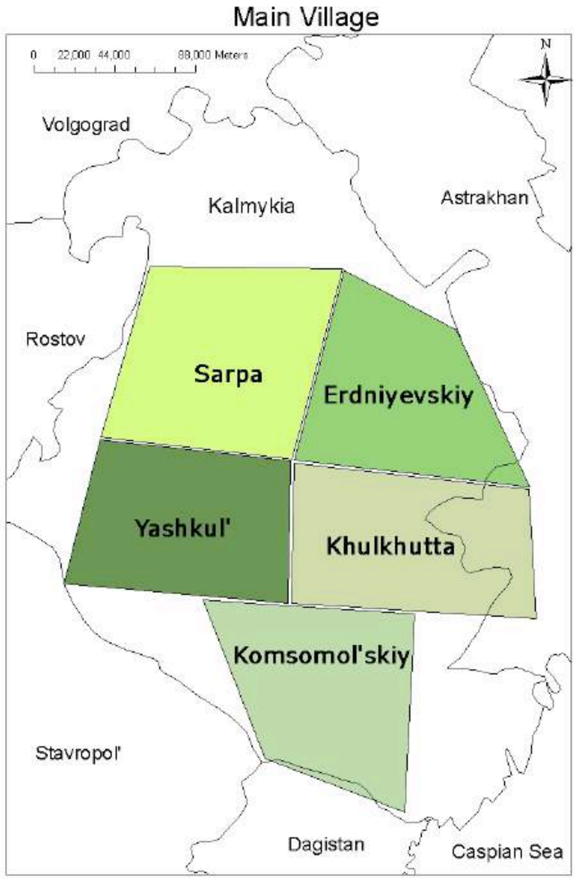


Figure 3.2 Map of Kalmykia presenting the 5 main village regions used as an attitudinal variable in the GLM. The regions include Sarpa, Erdniyevskiy, Yashkul', Khulkhutta and Komsomol'skiy.

Using this information, a maximal model was selected expressing reported presence as a function of mean precipitation, distance from water, main village, and time spent on the steppe. This model proved the most appropriate for each set of presence data and showed no correlation between the explanatory variables. Interactions were not included due to sample size limitations and because there was o a priori reason to expect them. Model simplification was carried out on both maximal models (Crawley, 2007), because the data is non-orthogonal the order of the variable deletion alters the significance of each variable therefore anova tests and ROCR curves (Hirzel, 2006, Manel, 2001) were used between each step to test whether the model had been significantly altered by removing the previous variable. To test the goodness of fit of the model the residual plots were checked, a binned plot of residuals against fitted values and

ROC curves were made and AUC values generated. Model simplification was stopped when the removal of a variable led to a significant change in the model fit.

3.3.3 Further Analyses

Information was collected on herd sizes to see how these had changed over time, and to look for any evidence of shifting baselines (as described in section 2.3). This was achieved by collecting the data using the same question format as Kühl, 2003. The results were then analysed and presented in the same way to allow comparison between the results obtained from the two studies.

All analyses were conducted in R v. 2.5.1 (R Development Core Team, 2007).

4 Results

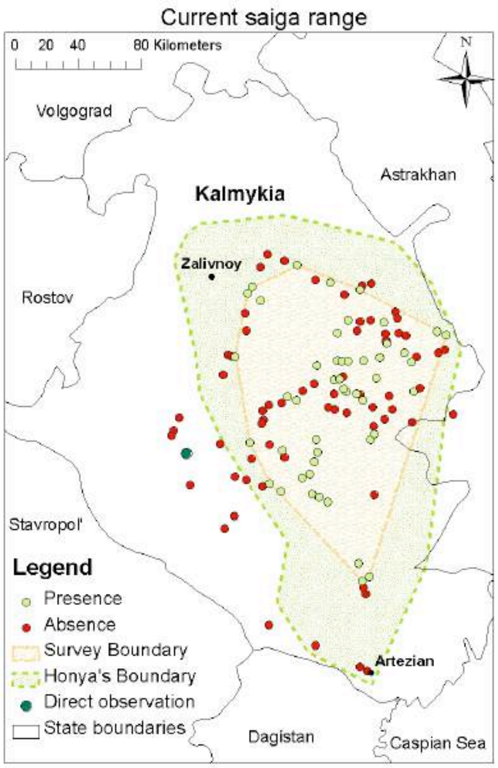
4.1 Expedition Summary

A total of 100 questionnaires were conducted during a period of two weeks in farms and homesteads, covering a total of over 2000km. In addition to the full questionnaires 16 "quick question" questionnaires were conducted, and the GPS locations of the 6 direct saiga observations made during the expedition were recorded.

4.2 Saiga Range

The presence absence data obtained for the period June 2008 – July 2009 (see figure 4.1) shows the current range of the pre-Caspian saiga antelope population. In some regions it can be seen that reporting of saiga occurrence is inconsistent, in particular the area just above the centre of the range near the village of Utta (figure 3.1). The boundary that can be extracted from this data encapsulates the area in which the majority of the population is found (see figure 4.1). However, because the habitat is relatively homogenous, saigas are nomadic and the detection rate is not one hundred per cent, a few individuals are still likely to occur outside this boundary. During this survey a direct sighting was made of a small herd consisting of approximately 3 saigas to the west of the Chernozemel'skiy canal, contradicting the results from the questionnaires. When compared to the range obtained from previous distribution studies the survey boundary shows a dramatic decrease in the total range of the saiga.

The boundary based on expert opinion (CZBR scientific officer – Khongir Manzhiev) suggests a larger range size than that obtained through the questionnaire survey (figure 4.1). Both, the survey range and the expert opinion range, show to differing degrees a continued decrease in range size to the south (figure 4.1 and 4.2). However, the boundary based on expert opinion shows an increase in the northern part of the range.



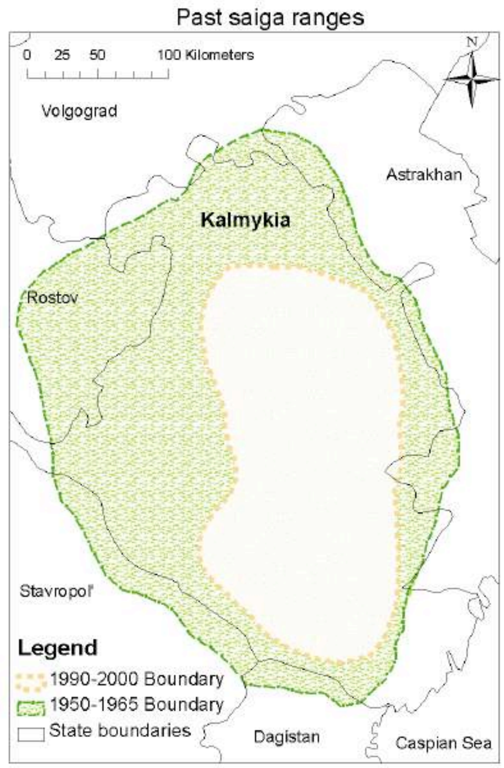


Figure 4.1 Map of Kalmykia indicating occurrence points, range boundary obtained from the questionnaire survey and the boundary drawn from expert opinion (CZBR scientific officer – Kh. Manzhiev)

Figure 4.2 Map depicting past distributions of saigas from 1950-1965 and the most recent boundary prior to this study from 1990-2000 (Lushchekina & Struchkov, 2001)

Seasonal maps of saiga presence in June 2008 – July 2009 were produced in GIS (figure 4.3). These maps show a wide distribution throughout the year, suggesting that there are no longer distinct seasonal ranges. A particular month of interest is May when the saigas should be forming large birthing aggregations and it was thought that they are concentrated in the reserves at that time. However this data suggests that there are still groups outside the reserves in this month.

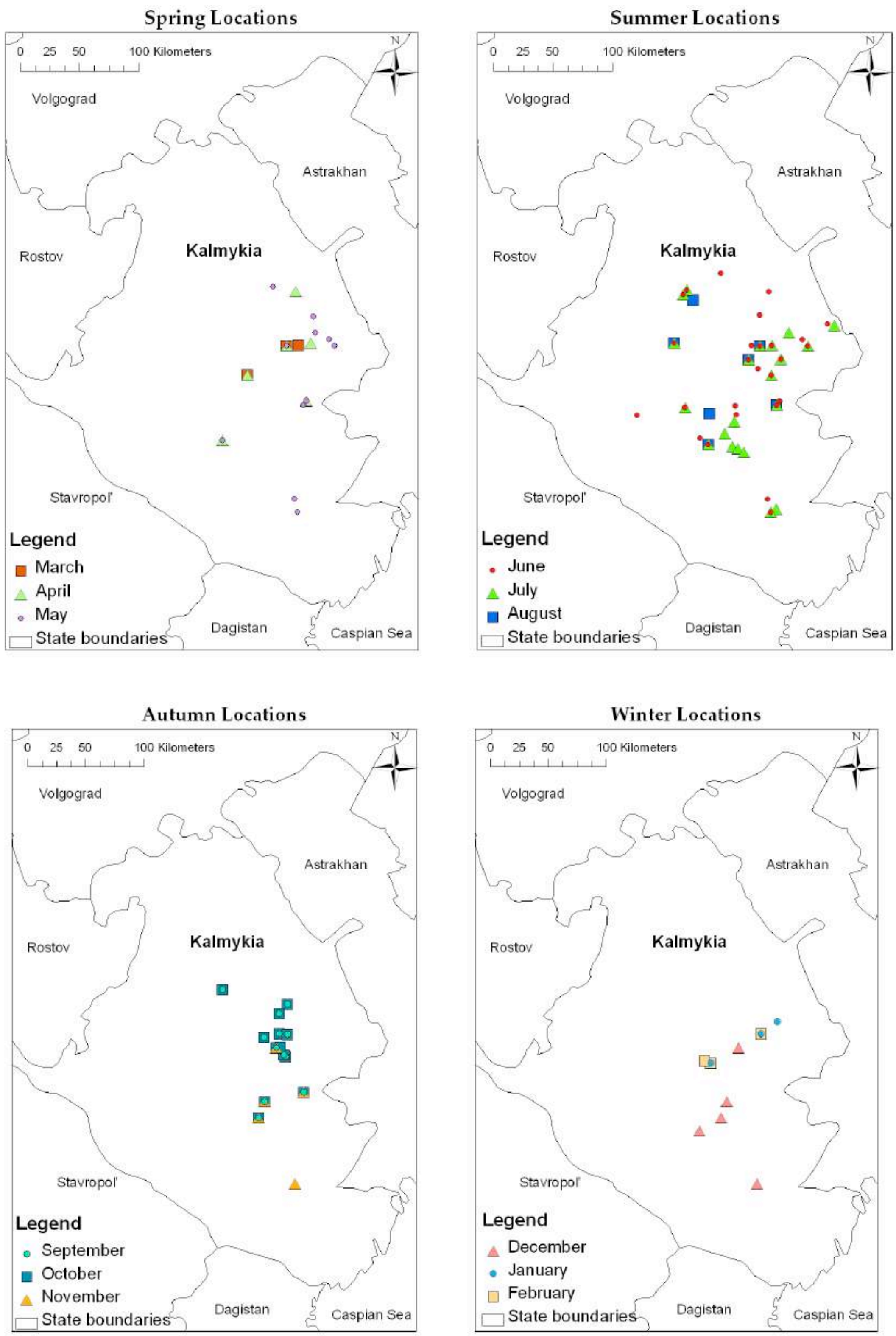


Figure 4.3 Seasonal distribution maps of Kalmykia for the period of June 2008 – July 2009 constructed using the data collected from Question 8 of the questionnaire (see Appendix I).

4.3 Reliability of occurrence reports

The inconsistency of occurrence reporting in the last 12 months instigated further analysis to examine the factors affecting the probability of a positive report of saiga presence. Two models were produced one representing the reporting of saigas ever and the other for the last 12 months (June 2008 – July 2009). The minimum adequate model for reports of saigas 'ever' is the same as the maximal model because if water availability was removed the model was significantly altered. The model produced explains 50% of the variation and fits the data very well, with an AUC value of 0.94 (Table 4.1; ROCR curve in Appendix II). The maximal model for reports of saigas in June 2008 – July 2009 was the same as the 'ever' model however this model could be simplified substantially without causing a significant change in the model. The minimum adequate model for the last 12 months explains 10% of the variation and shows an acceptable fit, with an AUC value of 0.70 (Table 4.2; ROCR curve in Appendix II; Fielding & Bell, 1997). The binned residuals of both models were checked and seen to show no trend.

As would be expected the model explaining the reporting of occurrence data at a site ever is mostly explained by biological (precipitation and water availability) and observational variables (time lived on the steppe) (see Table 3.1 for explanations of variables and Table 4.1 for model results). Sarpa, in the north west of the saiga range (Map 3.2) where you are more likely to see saigas, was the only village that significantly differed from Erdniyevskiy, the baseline village, but even then the difference is only marginally significant.

Table 4.1 GLM output of saiga presence ever with binomial errors. The residual plots were checked and were within acceptable limits.

Variables	Estimate	Standard Error	Z value	P Value
Intercept	49.512	21.424	2.311	0.021*
Mean Annual Precipitation	-2.502	1.074	-2.331	0.020 *
Water Availability	1.315	0.721	1.824	0.068
Time lived in house	0.483	0.177	2.731	0.006 **
Main Village – Khulhutta	14.300	2393.209	0.006	0.995
Main Village – Komsomol'skiy	2.251	2.039	1.104	0.270
Main Village - Sarpa	5.237	2.660	1.968	0.049 *
Main Village – Yashkul'	-0.984	1.146	-0.858	0.391

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Redidual Deviance: 32.326 **D.f**: 64 **AIC**: 48.326 **R^2**: 0.5017648 **AUC:** 0.9368056

Interestingly the model created analysing the recording of occurrence data for the last twelve months, show that biological or observational variables explaining the data but instead the variable of village is the only remaining significant variable. For this time period Sarpa is not significant, however Yashkul' (and to some extent Komsomoloskiy) shows significant negative correlation i.e people in these regions are less likely to see saigas than those in Erdniyevskiy.

Table 4.2 GLM output of saiga presence in the last 12 months. Residual plots were also checked and shown to fit within acceptable limits.

Variables	Estimate	Standard Error	Z value	P Value
Intercept	0.6931	0.3873	1.790	0.0735 .
Main Village – Khulhutta	-0.6931	0.7416	-0.935	0.3500
Main Village – Komsomol'skiy	-1.3863	0.8062	-1.719	0.0855 .
Main Village - Sarpa	-0.2877	0.9916	-0.290	0.7717
Main Village – Yashkul'	-1.9459	0.6866	-2.834	0.0046 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual Deviance: 89.311 **D.f**: 67 **AIC**: 99.310 **R^2**: 0.105 **AUC**: 0.702

The reason for the inconsistent reporting will vary between the different villages. Although the model cannot distinguish between the reasons, using prior knowledge of the region it is possible to infer that in regions such as Yashkul' the reduction in saiga sightings is probably due to the reduction in saiga range size, as expert opinion also suggests that saigas are rarely found in this region (E.J Milner-Gulland, pers comm). In Komsomolsky, however, there may be a number of factors influencing the results; the reserve is in this region and therefore people here should be seeing saigas (and although some are, others are reporting not seeing saigas for a long time; this might also be due to the influence of the road, discussed later), the headquarters of the reserve is in this region, the suggested reduction in range size and also there are potentially social reasons for the results, such as less truthful reporting by some members of the community.

A priori, we expected that Khulkhutta might be subject to less truthful reporting, as it is a known poaching village. For this reason further analysis was carried out showing the variability in the data in different villages. We would expect that within a particular village, people would be consistent in their reporting, especially given that observational and demographic variables were not significant in the model. Khulkhutta, Erdniyevskiy and Sarpa show 60%, 64% and 63% variability of reporting, whereas Komosomolskiy, and Yashkul' have less variability with 75% and 77% respectively reporting the same answer. A chi-squared test showed reporting rate to be significantly different in the different regions (X-squared = 13.1728, df = 4, p-value = 0.0105). The consistency percentage of each village highlights Erniyevskiy, Khulkhutta and Sarpa as being highly variable. This supports the prior hypothesis that poaching villages would have great variability in their reporting of saiga observations than non-poaching villages. Although, there was not prior confirmed knowledge of any of the villages within the Erdniyevskiy region being poaching areas, during the trip it became clear that Molodeznyy, Harba and Polynyoy were known locally to have poaching. It is surprising however that Sarpa should fit into this category, however by looking at the distribution of survey locations (figure 4.1) it can be seen that unlike the other regions this area was not sampled evenly. Instead all the reports in this region were from along the boundary of the saiga range meaning that you would in fact expect great variability in this region, regardless of attitude. This is not the case in Erdniyevskiy and Khulkhutta, both of which had sampling within the full region.

Table 4.3 Occurrence data from the five regions of the saiga range, showing the variability in the consistency of reporting's.

Village	Yes	No	% Consistency
Erdniyevskiy	14	25	64
Khulkhutta	9	6	60
Komsomol'skiy	9	3	75
Sarpa	3	5	63
Yashkul'	17	5	77

4.4 Local Perceptions of the Saiga Population

Of the people interviewed who had lived in the same house prior to 1991 (36% of the total data collected), the majority reported a decrease in the saiga population (86% of interviewees that answered the question on whether there had been a change in the saiga population). All changes reported in the saiga population size were classified as a decrease; no one reported an increase in the population since 1991, although a couple of respondents mentioned that they thought the population was beginning to recover in the last year or two.

Herdsizes were thought to have decreased with no one reporting the sightings of herds of thousands or tens of thousands today that were observed before 1991 (Figure 4.6). To make sure these results weren't spatially biased we only included the 36 interviewees who had lived in their house prior to 1991 and could therefore report on the same location. The two data sets for presence before 1991 and presence today was tested using chi-squared test and fishers test for significance. Both tests showed a high degree of significance between the data for the two periods.

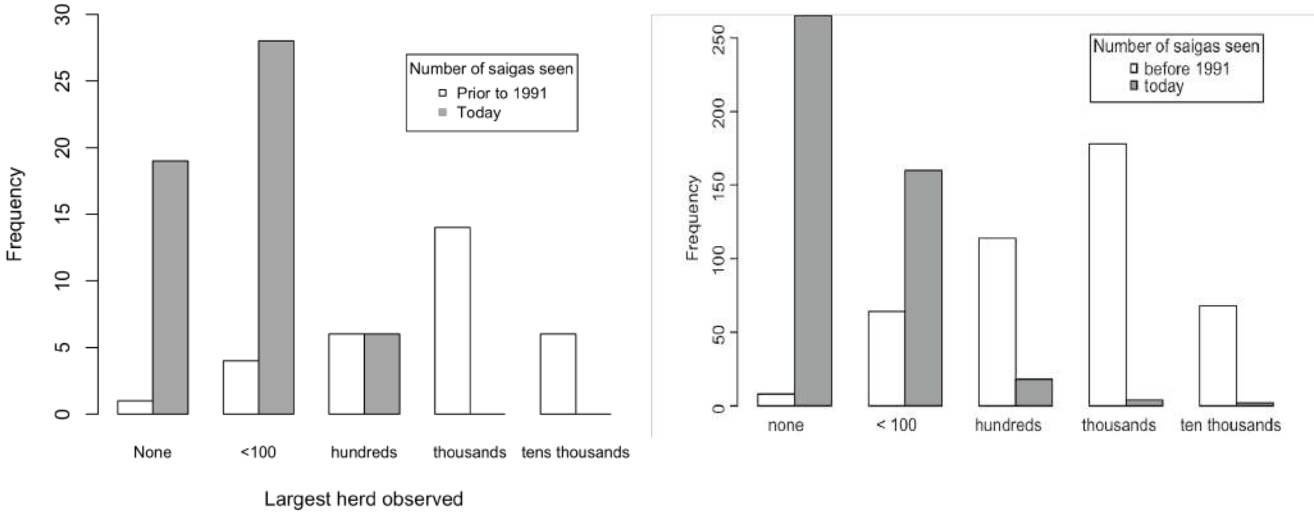


Figure 4.4 Comparison between two complementary datasets showing the changes of saiga hersizes by local people. Both studies compare data from the 12 months prior to the survey and before to 1991. On the left are the responses to the 2008/2009 questionnaire survey (n = 36) and on the right are the results of a 2003-2005 survey (n = 432) (Kühl, 2009). In both case the difference between the two samples is highly significant (x2 = , and 581.37, df = 4, p<0,001 respectively)

58% observed a reduction in the saiga population size, 88% of those people cited the cause of this decline was due to poaching which was at its peak during the 1990s (as reported by 65% of respondents). Other reasons given were climate and wolves. As a result of the overal reduction in population size, interviewees also reported seeing less males and smaller herds. A commom comment was that the saigas "came in smaller and smaller groups less and less often, until they no longer come here anymore". These results closely mirror those reported in Kühl et al. (2009), suggesting that there is no evidence for shifting baseline in people's perceptions of saiga population change.

Unexpectedly the primary factor cited for controlling saigas distribution was a lack of water availibility (40%). Following this was the more expected effect of poaching (32%), it is possible that respondents may not have provided their truthful opinion of the influence of poaching because of the controversial nature of this subject. Other factors currently controlling saiga distribution were accredited to fires (22%), vegeatation (20%), climate (17%), wolves (17%), rangers (15%), saiga population size (10%), human presence (10%), livestock density (7%), physical barrier (1%), and terrain (1%) (see figure 4.5). The "rangers" category refers to the local perception that the CZBR rangers actively control saiga movements, keeping them in the reserves.

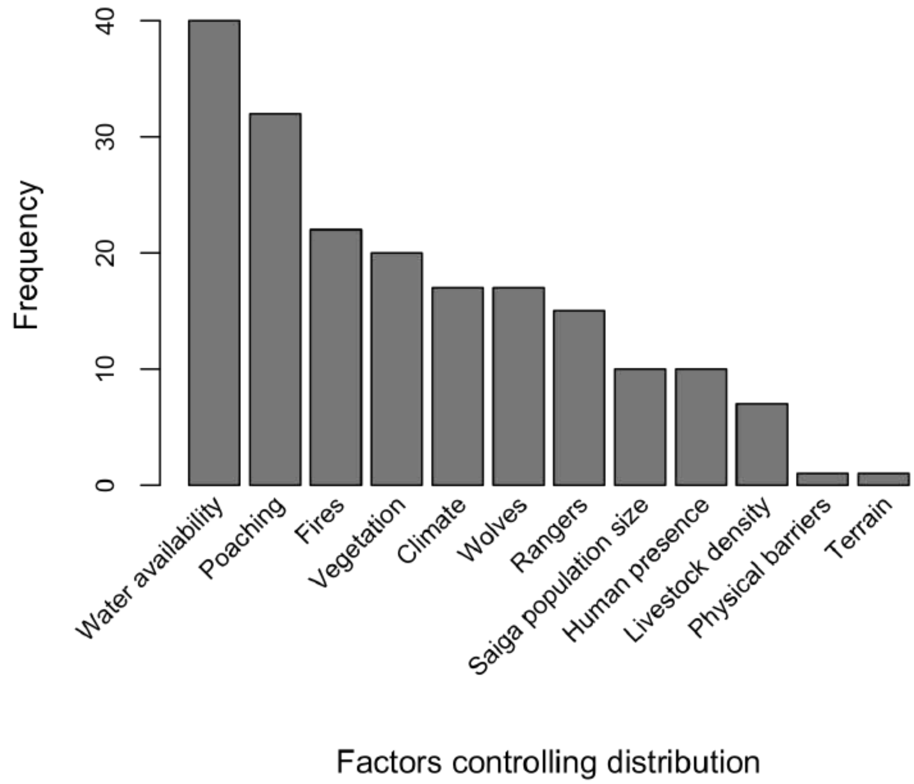


Figure 4.5 Local perception of the factors controlling saiga distribution.

It is interesting to note that water availibility came out as being the biggest factor controlling saiga distribution today (with 40% citing it as a controlling factor). Expert opinion in the region is that natural water availability is in fact increasing, with annual precipitation in the region increasing every year. However, the questionnaire survey highlighted the difference between precipitation and water availabilty. Although there may be more precipitation in recent years, participants reported that the collapse of the Soviet Union resulted in less government controlled maintanence of the countryside including not filling up canals and ponds. This human controlled factor has lead to a reduction of avaible water sources, leaving just the artificial wells used for the livestock. Further still, it is likely that even the availability of artificial wells has reduced since 1991 due to the reduction in the number of farms and lack of maintainance resulting in many wells breaking down, as is the cse in Kazakhstan (E.J Milner-Gulland, pers comm)

When asked about saiga interaction with livestock many reported that in the past saigas had eaten and drunk in the same places as livestock. At this time when there were still such large herds of saiga this probably caused competition for resources between the two. Person No. 70 worked as a livestock expert during the Soviet Union and explained how in the 1970s the government would regulate the saiga population so they didn't starve, the meat would go to the shops and the skins to the factories, so that livestock and saigas both had enough to eat. The hunting would take place from official hunting stations and would begin in the Autumn. Wolves were also controlled, and there is now a local perception that their population has increased since 1991. Since the collapse of the Soviet Union many of the interviwees reported a reduction in livestock, for example 45,000 sheep in 1991 down to 30,000 in 2009 (in fact the livestock population decreased even further in the early 2000s and is now recovering). At the same time poaching was at its height and the saiga population was reducing rapidly.

Figure 4.6 shows how the distance saigas come to the tochkas has increased since prior to 1991 to today. Interviewees thought that this was due to animals becoming more cautious and scared of humans because of poaching, also an increase in machinary and dogs, and saigas being less brave now they are only really seen in small herds (safety in numbers). This has several implications, primarily and obviously if saigas don't come so close to the houses anymore, residents will see them less, thus skewing monitoring results. 33 respondents reported seeing saigas interacting with livestock, this interaction included drinking and grazing in the same places as livestock, and many reported occasions when the sheep would get caught up with a herd of saigas and would 'get taken off by them'. A quarter of interviewees (reported by 25 respondents) also reported that saigas have stopped drinking and grazing in the same places as livestock. If the saigas no longer come to the artificial wells where the livestock drink this will further reduce their access to water. Moreover, as so many canals and lakes have dried up in some regions, we would expect that saigas would need to rely more on these artificial wells to survive in the region, not less.

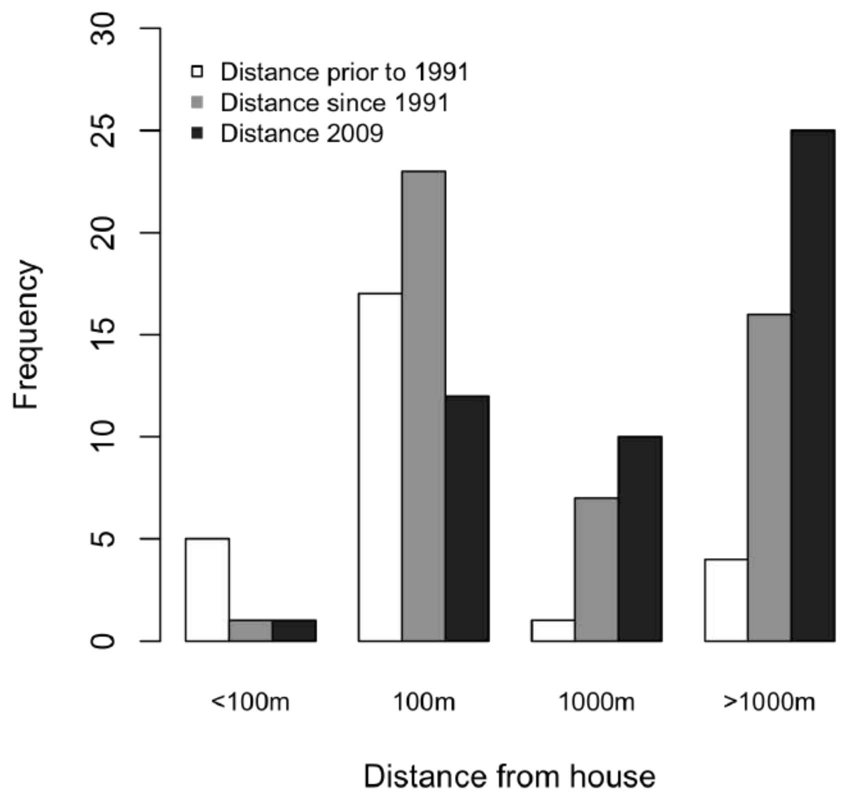


Figure 4.6 Distance of saigas from the house prior to 1991, since 1991 and in the last 12 months

Saiga distribution seemed to be limited by the main road running east-west across the southern border of the reserves. To the north of this road respondents reported saiga observations in the last 12 months whereas to the south those interviewed had not seen saigas. Those that lived close to the main road reported traffic collisions with saigas. This road is a busy lorry route and was thought by the local residents to deter saigas from crossing. Although the road itself doesn't form a block it seems that the traffic frequency is what prevents saigas crossing. With the open steppe a car (especially at night) can be seen from a large distance, therefore if cars are driving through relatively frequently the effect can become continuous effectively preventing the saigas crossing.

However, because the traffic will not be constant and during the day the saigas are likely only be deterred by cars within a smaller distance some saigas will be able to cross. Additionally there is a clear and visible difference in vegetation north and south of the road. To the south the vegetation was characterised by short, sparse plants. The area appeared very dry. The sample size for the south of the road was also smaller as the area was much less inhabited than to the north. This could mean that the saigas had a lower detection rate to the south, where there were fewer farms to see them and more land around each farm for the saigas to pass through without being noticed and potential to actively avoid farms.

4.5 Poaching

The model suggests that poaching may be influencing people's attitudes to reporting saiga presence and this is supported by poaching being cited as a major reason for the current saiga distribution. Through the course of the semi-structured interviews many participants provided further insight to the poaching currently taking place in Kalmykia.

When asked if eating saiga was a status symbol one lady answered that in fact it was completely the opposite. 1 male saiga costs 600-800Rb which is cheaper than a sheep (1 sheep costs 1,500Rb), because of the significant difference in price poorer people will eat saiga meat at celebrations instead of livestock. She continued by explaining that there is still a lot of poaching, and people come to the village to sell the meat or you can order it from a third party. This lady's brother reported that both locals and those from further away poach and even the chairmen come here and poach.

A villager in Tavn-Gashun told us of a van that comes to the village from the direction of Elista and Yashkul'. On the way to the village the people always pick up hitch-hikers and give them a lift back to the village. However on its way back the car will never pick anyone up. The feeling was that these unknown people came to the area to poach saigas and would have dead animals in the back of the vehicle on the way back hence not giving people a lift.

It was difficult to assess people's involvement with poaching. One example being an interview with the farm supervisor where he behaved very warily and claimed to have never seen saigas on this farm (that he had lived on his whole life) and to not know anything about poaching. He then suggested we spoke to one of the shepherds, who had just arrived back from the steppe, who happily told us that he had seen a few of them the week before. Another interviewee said "*there were certain people would not like him to talk about such matters* [poaching]".

Some sayings that were voiced during the survey, and provide an insight into local perceptions about poaching, were:

"*Where there's saigas there's poaching*"

"*Any fool knows its because of poaching*"

"*If there hadn't been any poaching there would still be saigas here, everything else for them is ok*"

"*The gypsy phone works very well*" – when saigas are the area word spreads very quickly around the farms and poaching then takes place.

"*Everyone knows who the poachers are, we live in a village where every knows everyone. But you're not going to report your friend's son*"

"*The poachers are now getting their retribution for killing saigas, recently three poachers have been killed or badly injured, through driving accidents*"

These quotes give an idea as to the prevalence of poaching within Kalmykia and some of the attitudes to those that poach.

Box 4.1 Khongir Manzhiev, a case study.

Khongir is 26 years old graduate of the Kalmyk State University who works as a scientific officer at the CZBR, with a special responsibility for saiga monitoring. Khongir has always lived in the same village and has therefore seen first hand how the saiga population has changed in his area as well as more generally over the whole of Kalmykia.

Picture 4.1 Saigas crossing the Tavn-Gushun canal, picture used with kind permission of H. O,Neil

In contrast to the apparent lack of migrations shown from the seasonal distributions, Khongir suggests that saigas are constantly moving to avoid predation. Although, in 2008 when the temperature did not get so high the saigas did not migrate north but instead stayed near his village, Ardyk, and ate the vegetation with dew on it.

Honya reported seeing saigas crossing the canal near Tavn-Gashun in 2008 (see photo 4.1), suggesting that such human infrastructure does not act as a physical barrier to saiga distribution. However, he also noted that after the construction of this canal in the 1980s 500 saigas got stuck in the mud of the new canal and died there.

5 Discussion

The results of this project provide a case study of the overall importance of using local knowledge in species distribution studies, as well as identifying some limitations that need to be taken into consideration when using these data. A new method of assessing the reliability of monitoring data was developed testing the relative importance of three different explanatory variables in a binomial GLM. The study also demonstrates the potential for incorporating this method, of questionnaire surveys over the entire saiga range, into the current monitoring conducted in Kalmykia, with recommendations for improving the method for the future. In addition, important presence data was collected for use in future SDMs for the pre-Caspian population of saiga. To aid future monitoring and decision making in Kalmykia, current range maps using the presence data for 2008/2009 were produced and presented to the Ministry of Environment and partners in Kalmykia.

There is now a substantial literature evaluating the use of various modelling methods (Elith et al., 2006) and some papers refer to the problems associated with using biased monitoring data (Singh, 2009). Examples could not be found that discussed the benefits and limitations of using local knowledge to provide the occurrence points for use in distribution modelling and as additional information to complement the results of a SDM. Neither was there any study that presented a method for testing the reliability of local knowledge data prior to use in SDMs.

The following sections discuss the implications of the saiga range results, evaluate the potential use of the questionnaire data in light of the reliability of the data and explore local perceptions of the pre-Caspian saiga population putting these in the wider context of wider. The section ends with recommendations for future monitoring and social engagement programmes, and suggestions of further research required to fill gaps in scientific knowledge.

5.1 Boundaries

It is very important for current management of saigas to have an accurate and current knowledge of their distribution in the region. The 2008/2009 range obtained from the results of the questionnaire survey shows the area which contains the majority of the saiga population, a few saigas will persist outside this range. However outside this area, saigas are only likely to be found in small numbers. As such this is the core area in which to focus future monitoring and protection measures.

One area outside the 2008/2009 boundary, where saigas can still be seen, is in the South West of the range near the Chernozemel'skiy canal (see figure 3.1). According to the results of the interview and participatory mapping, respondents in the south west of the range felt that saiga distribution was limited by this canal. Although, we have seen through other witness accounts that saigas can cross canals (see photograph 4.1), and we ourselves saw a group of 3 saigas to the west of the Chernozemel'skiy canal (figure 4.2), this still provides a rough boundary. A few saigas may cross, but the majority of the population stay to the east of the canal. It may not be the canal itself that hinders movement but it provides a clear demarcation to represent the distribution.

Comparison of the boundary obtained from the questionnaire survey (figure 4.2) with the boundary drawn by a scientist from CZBR (figure 4.3) highlights a possible limitation of the survey approach. In the last 12 months Kh. Manzhiev has received reports of saiga observations in the town of Artisan on the southern border between Kalmykia and Dagestan and Zalivnoy in the north-west of the saiga range (figure 3.1). This suggests that the range produced through the questionnaire survey is likely to be biased by which farms were visited and which people were questioned. However, by conducting a number of interviews in each area a relatively consistent overall picture was created. The fact that none of the participants interviewed in the Komsomolskiy region as part of this survey had seen saigas for about 10 years suggests that although saigas may still come to this area they only are found in very small numbers. The consistent method used for the survey provides an objective range boundary encapsulating a high, but unquantifiable, percentage of the saiga population.

Human infrastructure is known to form a barrier to ungulate movement in ecosystems such as the Eurasian steppe (Ito, 2005). In this study infrastructure did seem to represent the rough line of a boundary in some places, such as the Chernozemel'skiy canal (figure 3.1). Another example of this is the main road running east-west across Kalmykia to the south of the reserves (figure 3.1).

5.1.1 Seasonal distributions

The seasonal models of saiga distribution show a wide distribution throughout the year, which suggests that the species' typical large mass migrations are perhaps no longer occurring to the same extent as was the case in the past in this part of their range. Supporting this theory is the ranger monitoring data which documents saiga presence in the CZBR and SR throughout the year (O'Neil, 2008), meaning that only a proportion of the saigas migrate out to the other areas. It is likely that because of their reduced population size and the protection provided by the reserves that many animals remain in the reserves all year round, with only small numbers still migrating (Berger, 2004; Bolger, 2008). There is a possibility that outside the reserves there are resident animals in certain areas, as has been recorded in Uzbekistan (Saiga News, Issue).

A further point of interest is that during the month of May, the time when birthing takes place, the saigas are still being seen across a large area of Kalmykia. It has already been observed that the saiga birthing aggregations in many countries are reducing and disbanding. This may provide further evidence to corroborate this theory, or it might simply represent male saigas and barren females.

5.2 Reliability of monitoring data

The two models provide a useful comparison between the reporting of occurrence data ever, and the reports made regarding the last 12 months. They show that the reports of whether saigas have ever being seen at the site can be explained by biological factors as well as the more obvious time lived in house component. Reports from the last 12 months are explained by very different factors, and biological data no longer explain the distribution. It makes sense that respondents have less incentive to lie about the occurrence of saigas at their farms ever, whereas there may be many reasons prompting them to give certain answers for the current situation. This was compounded by some respondents saying "*there are certain people that wouldn't like me to be talking about this sort of thing*". This means that it is not just down to the attitude of the individual but also the influence of those around them. Participants may not risk social difficulties for the sake of a short interview.

The variability in answers is highest in the Khulkhutta region which represents the main poaching area. Erdniyevskiy is also highly variable, the region is adjacent to Khulkhutta, and includes some other known poaching villages such as Molodyezhniy. This result suggests that further engagement efforts need to be made in Erdniyevskiy and Khulkhutta (discussed further below).

The evidence provided by these models shows that although certain data within the questionnaire results are still valid, presence data obtained for the last 12 months are unreliable in certain regions. This means that any inferences made with these data must be extremely cautious and supported by further investigations.

The current literature recommends two methods for accounting for biased data, both solutions revolve around the monitoring procedure. Either the existing data can be re-sampled using a fixed-size subset of observations within each environmental stratum or if there are not sufficient data to do this, which is often the case, then the model produced can be used to inform a second round of monitoring, (Singh, 2009) which will provide additional data in unrepresented areas that will complement the original data set. In both cases the resulting datasets will be more reliable for statistical and analytical purposes.

There are no methods to correct unreliable data however, therefore these data cannot be used in a SDM, instead they can be used to improve further methods reducing unreliability in future monitoring.

5.3 Local Perceptions

Local perceptions provide a useful insight into other potential factors that might be controlling saiga distributions. Water availability is a very difficult factor to model as the water bodies within the saiga range are temporary and therefore are not there every year. The use of this as a biological variable works for the presence of saiga 'ever' because over time each of these water bodies will have been available at different points. However, this may prove to be the reason that current distribution is not explained by this variable. Not only will some of the water bodies not be available in this time period (due to rainfall that year), but furthermore, reports now suggest that many of these water bodies are drying up since the collapse of the Soviet Union and the subsequent reduction in countryside maintenance, and therefore the data layer available is even less representative of the present water availability.

The results of the social survey provide an interesting insight into saiga distribution but also local perception of saigas. These perceptions although often inaccurate are interesting to understand in themselves for conservation efforts. The fact that many people reported the rangers actively keeping saigas inside the reserves has many implications. Local people obviously feel saigas are well protected now, which may deter some from poaching. Many described rangers rounding up saigas on motorbike and helicopters, from personal communication with rangers and government officials we know that this does not actually happen. Interestingly these are also the same methods people described poachers as using, this could potentially mean that poachers are deceiving people, or respondents are trying to say that ranger are poaching, or most likely is that they are inferring what happens and this is the only way they can think to round up saigas (see section 2.3.2 – rules of inferences).

Figure 4.7 shows how saigas do not come as close to human dwellings now as they did in the past. Anecdotal evidence stated that this was due to a number of reasons; primarily because saigas have become more nervous now as a result of poaching, this has been exacerbated by reduced group sizes causing them to be more wary, but also because of the increase in machinery, dogs and cars which deter saigas.

5.4 Using LEK in species distribution studies

As the following two sections show the use of local knowledge in SDMs is complicated, with a number of associated benefits and limitations. However, with a priori thought and planning, and understanding of the factors that might be influencing peoples reasons for answering questions a certain way, this information can still be valuable.

5.4.1 Benefits of using LEK

Participatory monitoring based on local knowledge is a cost effective and quick method of collecting data over a large spatial area and time period (respondents can effectively act as long term monitors). As this study has shown, local knowledge can provide information on a wide variety of subjects from saiga observations to changes in the local environment that control their distribution. Although in this type of participatory monitoring the participants are only involved in the interview process, this method reaches a large number of people, directly involves the local population in saiga conservation work and indirectly results in a large amount of publicity.

Steppe habitat is characteristically homogenous especially when focusing on one relatively small area such as the saiga range in Kalmykia. Grassland is the dominant plant type, there is little rainfall, and a continental climate with a hot summer and very cold winters. From direct observation in the field however it is clear that within this habitat there are very different areas. The scale of this variability is difficult to recreate in a model given the available data. Local knowledge can be used to investigate these factors further without having to exclude them from the study completely. Additionally, models only explain the influence of variables a researcher has selected, LEK can provide additional information that a western researcher may not have considered to be a controlling factor. Thus, by incorporating LEK into species distribution studies, the limitations, gaps and errors in SDM can be accounted for. This point was demonstrated in this case study by the information gained on water availability. Local knowledge can provide a context to SDM, and can even validate the predictions. Finally, local knowledge can highlight further factors that require further research.

5.4.2 Limitations of using LEK in species distribution studies

The results of this study have also highlighted the potential limitations of using local knowledge. Relying on people's perceptions can result in biased reporting (due to poaching in this case study) and inaccuracies due to recall problems or observational issues for example the length of time a respondent has lived in their house. The difference between the boundaries obtained from the questionnaire survey and that of expert opinion demonstrates the influence of people's perspectives and the subjectivity of this method.

The problem of shifting baselines syndrome has been demonstrated in a number of different projects (see section 2.3.2) but was not apparent in this study. This could be due to the fact that the time period between surveys was not long enough to show a change (the first study was in 2003) or that the comparison data set interviewed a wider range of respondents from other saiga range states. Future studies using local knowledge in this region should remain aware of the potential errors that this phenomenon can cause.

Limitations of the questionnaire survey that are harder to account for include prejudiced reports, this is similar to the problem of biased data however, it cannot be accounted for so easily. Wolves were cited as one of the main controlling factors for saiga distribution. In most wolf range states, there are problems associated with human / wolf conflict (Treves, 2003). Kalmykia is no exception as wolves attack people's valuable livestock and cause fear. As a result there is a lot of false or exaggerated perceptions of wolf impacts. Without conclusive research to disprove or validate these claims it is difficult to asses the reliability of these reports.

Additionally, the risk of false negative results is an important factor to consider. In a vast area such as the Steppe, this problem is likely to be particularly pronounced, as it is very likely that saigas can be present in an area but not seen by the residents. This has implications for which demographic groups you chose to interview. In this study, the trade off was between villagers and farmers; villagers have often lived in the area longer so remember a longer period and can therefore provide useful information about changes over time, whereas the people on farms move around and therefore are not able to provide such long term data, however they are on the steppe everyday and have a much better knowledge of the current situation. In such situations thought has to be given to which groups will provide the most useful information to meet the aims of the research. In the case of assessing saiga distribution in Kalmykia the best people to provide the most accurate occurrence data were the farmers and shepherds living on the farms. Although it may be worth noting that as none of the observational variables were significant, people may still be seeing saigas. However this would have to be tested further, by including villagers in a questionnaire and incorporating both groups in the analysis.

5.5 Potential for further use of this method

This method provided a relatively fast and inexpensive way to collect a large range of data covering a wide geographic area. As current monitoring is limited to specific spatial regions this method would provide a useful approach to complement the current research. This method also has the potential to be a useful way of reaching a wider audience for public engagement. The Saiga Conservation Alliance merchandise that was given as gifts to the participants facilitated further discussion of saiga conservation. As a result of the expedition two articles were written in the local newspaper, capturing a wider audience and informing them of the aims of this research as well as why its necessary to conserve saigas. As part of our trip we also visited a children's school camp, 'Saiga Babies' to talk to them about saigas and our work. It was then organised for the next group of children to come and visit us at the Breeding Centre so that they could see saigas and we could try to engage them with saiga conservation. Engagement with the younger generation in Kalmykia is proving successful, however further work needs to target the generation of men in their 18-30s who are currently poaching (Kühl, 2009).

This monitoring would not be required for scientific purposes every year, instead it could be incorporated on a 3 yearly cycle to detect any changes in the population, or when specific information is required in other research. However, as a public engagement intervention asking people to carry out ongoing ecological monitoring through yearly surveys could engage people as "saiga friends". Maintaining a consistency and regularly going back to visit people would also make people feel that their knowledge and views are valued by saiga conservationists which is important for gaining trust and engaging people. Through the experience of this study the variability in peoples interest and engagement in this survey was evident. Although people showed an overall support for the method, there were some that seemed uninterested or even mocking of the approach and questions. These are likely to be the very people that public engagement interventions are trying to reach. There is also the possibility that by conducting the surveys too regularly people will get reporter fatigue (Milner-Gulland & Rowcliffe, 2007). Before long term decisions are made about the future use of this method a survey should be conducted to assess people's opinions of the method and how regularly they would be happy to participate in it.

If the closed questions remained the same the open questions could be substituted to suit the current research question. The closed questions are a quick and easy way to introduce any interview regarding the saiga population in Kalmykia. By keeping these questions consistent in future research they can act a long term monitoring programme whilst not requiring a specific trip just for the monitoring.

5.5.1 Suggested improvements to the methods

This method proved very successful for the aims of this study however lessons can be drawn from this study and used to improve future research.

It would be good to use local researchers to conduct future surveys, which will not only provide invaluable experience for local students but also will negate the need for a translator which invariably will have an impact on the quality of the survey and meet Article 12 & 18 of the CBD. This is of course reliant on the capacity and interest of potential candidates. In previous attempts in Kalmykia this was not the case, however the Ministry of Natural Resources showed considerable interest in this survey to the extent that they organised their own survey whilst this research was being conducted. This could provide the potential for the continuation of this survey, however the effect of official ministry staff conducting the interviews on participant responses would have to be tested.

If future surveys target farms, many of the questions such as frequency of time spent on the steppe, should be altered to be more suitable; in this survey we found that some respondents, namely housewives, would answer the 'hardly ever' category even though their farms were out in the middle of the steppe. A better approach would be to ask how often people went certain distances away from farm buildings, as this is likely to have an impact as to how likely they are to see saigas. To further the findings of this research future questionnaires could collect more information of demographic groups such as their ethnic backgrounds, which has proved to be important in past research (Howe, 2009), so future monitoring can actively target their efforts so as get the most accurate and reliable data.

The questionnaire survey provides a good opportunity to implement public engagement interventions, that have been shown in this study to be required still. Arguably the most significant improvement to these methods would be for future surveys to incorporate some form of direct engagement, in accordance with Article 13 of the CBD (see below for specific suggestions).

5.6 Implications for future conservation in Kalmykia

The boundary data provide important information for monitoring and conservation prioritisation. The local perceptions data highlight new factors for consideration in future research and conservation actions. Most significantly for future conservation actions is the results of the GLMs. The models highlight the need for further public engagement in the regions around Khulkhutta and Erdniyevskiy, where the data were the most variable and unreliable. This area has received the majority of social engagement work implemented in Kalmykia, but shows that although it has had positive effects on some groups, it is either not enough or effective enough, or not reaching the right groups to substantially address the poaching problem.

Future social engagement could include producing booklets discussing the issues, the reason why poaching is bad (even if people only take 1 or 2 saigas a year this can lead to a big overall impact on the saiga population if every farmer does it), what public engagement programmes there are and how they can get involved with them such as participatory monitoring or the rotating cows programme. Anonymous feedback forms with pre-addressed envelopes could be included to ask people what interventions they think would make a difference, which areas / people they think should be targeted. These could be distributed in future questionnaire surveys as well as through other outlets.

The question of how to effectively engage young men is very difficult to answer especially as a foreign female researcher. This might be best addressed by running focus groups with relevant groups in Kalmykia. The sessions could discuss the problems of poaching, and obtain participants opinions of what actions would best deter these men from poaching, and which would most likely remove the need for them to poach. Participants could include other men from the same age group that would be able to provide insight into the most appropriate ways to engage with poachers; which radio station they listen too, what newspapers they read, and where they are most likely to socialise. In addition, other groups representative of Kalmyk society could be involved to gain their perspectives, in many areas poachers are well known within the local community and as such other people may have useful suggestions. In the British justice system a new programme has been established whereby convicted criminals have to meet with their victims to discuss issues such as why they committed the crime. A similar approach could be taken in Kalmykia with convicted poachers, to investigate their motivation for poaching and opinions of the legal penalties as well as conservation interventions to stop them poaching.

Absence data collection is important for SDMs, but in case of saigas in Kalmykia it is unlikely that even the best techniques would accurately record true absence data. The area is so vast and the saiga's nomadic existence would allow too much room for error. With current presence-only modelling proving so successful at predicting species distributions it is arguable that this would also present a waste of survey effort (Pearce, 2006).

5.7 Further Research

This study has highlighted several knowledge gaps that require further research to provide a better understanding of the saiga population in Kalmykia. Many of these recommendations are examples of research that could be included in future questionnaire surveys.

The results of the range data point to the need for further research into saiga migrations in the pre-Caspian population. It is essential for conservation management decisions to understand the current distribution and movement patterns of saigas. In accordance with this, it would be interesting for future research to investigate further the reasons why saigas are no longer found in some areas, in particular to the south of the range which has shown the biggest reduction. Additionally, further information on the sex and age of saigas found outside the reserve during the month of May, and further information about any possible birthing aggregations that occur outside the reserves, is required. This would be useful to ensure protection of vulnerable females and calves.

The only definitive method of assessing the extent of movement outside the 2008/2009 range boundary and seasonal movements within the range is to use satellite collars. Many researchers in the region are keen to test this method (Iu. Arylov, pers comm.), however there are many difficulties with using this approach that first need to be addressed. Satellite collars are an expensive investment with no guarantee of producing useful results. The movement patterns of the collared saigas may not represent those of the greater population and it is unclear what sample size would be required to produce conclusive evidence. Further practical issues such as how saigas would be chosen and caught also need to be considered. A strong case for the necessity of using satellite collars could be argued with the evidence from this study showing the urgent risk of a collapse in the migratory behaviour of the pre-Caspian population of saiga and in reference to the Convention of Migratory Species (CMS, 2006).

The results of the survey suggest that factors such as water availability and wolves may be significantly influencing saiga distribution. However very little is known about either of these factors. New maps of water areas in Kalmykia are required to assess its availability to saigas. If particular areas appear to have a serious lack of water, enough to be preventing saigas from inhabiting those regions, then recommendations could be made suggesting areas that should be actively managed. This would have dual benefits for saiga conservation and the livelihoods of the local people, who in many regions reported the difficulty in managing livestock with so little water.

Further research is also required investigating the wolf population and distribution in Kalmykia, and the impacts that wolves are having on the saiga population. This could potentially be combined with future monitoring of saigas. Many respondents felt when the saigas were abundant the steppe and farmers were better for it. When there were plenty of saigas on the steppe the wolves did not come to the farms to take livestock as much, as they could feed on vulnerable individuals such as young, old or injured saigas.

A final and extremely positive note is that on 25th June 2009 Russia signed the relevant agreement in the framework of the Convention of Migratory Species, to enhance its support of the conservation of the saiga antelope (CMS, 2006). This is a significant step for Saiga conservation in Kalmykia and will bind the government to providing support to conservation efforts in the region. This could potentially facilitate the implementation of measures outlined in this study.

6 References

Abbitt, R.J.F., Scott, J.M. & Wilcove, D.S., (2000) The geography of vulnerability: incorporating species geography and human development patterns into conservation planning. Biological Conservation **96**, 169–175.

Austin, M.P. (1980) Searching for a model for use in vegetation analysis. Vegetatio **42**, 11-21.

Austin, M.P. (1985) Continuum concept, ordination methods and niche theory. Annual Review of Ecology and Systematics, **16**, 39-61.

Austin, M.P, Cunningham, R. B. & Fleming, P.M. (1984) New approaches to direct gradient analysis using environmental scalars and statistical curve-fitting procedures. Vegetatio, **55**, 11-27.

Austin, M.P. & Smith, T.M., (1989) A new model for the continuum concept. Vegetatio, **83**, 35-47.

Ban, N.C., Picard, C.R. & Vincent, A.C.J. (2009) Comparing and integrating community-based and science-based approaches to prioritizing marine areas for protection. Conservation Biology, **23** (4), 899-910.

Bekenov, A.B., Grachev, Iu. A. & Milner-Gulland, E.J. (1998) The ecology and management of the saiga antelope in Kazakhstan. Mammal Review, **28**, 1-52.

Berger, J. (2004) The last mile: how to sustain long-distance migration in mammals. Conservation Biology, **18**, 320–331.

Bernard, H.R. (2006) Research methods in anthropology – qualitative and quantitative approaches. Fourth Edition. AltaMira Press.

Bolger, D.T., Newmark, W.D., Morrison, T.A. & Doak, D.F. (2008) The need for integrative approaches to understand and conserve migratory ungulates. Ecology Letters, **11**, 63–77.

Boyce, M. (2006) Scale for resource selection functions. Diversity and Distributions, **12**, 269-276.

Brook, R. K. & McLachlan, S. M. (2005) On using expert-based science to "test" local ecological knowledge. Ecology and Society, **10** (2), r3. [online] URL: http://www.ecologyandsociety.org/vol10/iss2/resp3. [Accessed: 15th May 2009].

C.B.D. (1992). Convention on Biological Diversity. [online] URL: www.cbd.int [Accessed: 20th April 2009].

C.M.S. (2006) Revised overview report of the first meeting of the signatories to the Memorandum of Understanding concerning conservation, restoration and sustainable use of the Saiga Antelope (*Saiga tatarica tatarica*) (CMS/SA- 1/Report Annex 5), Convention of Migratory Species.

Chambers, R. (2006) Participatory Mapping and Geographic Information Systems: Whose map? Who is empowered and who disempowered? Who gains and who loses? Electronic Journal of Information Systems in Developing Countries, **25** (2), 1-11.

Crawley, M. (2007). The R Book. Wiley & Sons.

DeMaio, T.J. (1984) Social desirability and survey measurement: A review. In Turner, C.F. & Martin E. eds. Surveying subjective phenomena. Vol. 2, 257–82. Russell Sage Foundation.

Elith, J. (2000) Quantitative methods for modeling species habitat: comparative performance and an application to Australian plants. In Ferson, S. & Burgman, M. eds. Quantitative methods in conservation biology. 39–58. Springer-Verlag.

Elith, J., Graham, C. H., Anderson, R. P., Dudı´k, M., Ferrier, S., Guisan, A., Hijmans, R. J., Huettmann, F., Leathwick, J. R., Lehmann, A., Li, J., Lohmann, L. G., Loiselle, B. A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., Overton, J. M., Peterson, A. T., Phillips, S. J., Richardson, K. S., Scachetti-Pereira, R., Schapire, R. E., Sobero´n, J., Williams, S., Wisz, M. S. & Zimmermann, N. E.

(2006) Novel methods improve prediction of species' distributions from occurrence data. Ecography, **29**, 129-151.

Fielding, A.H. & Bell, J.F. (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation, **24**, 38-49.

Ferrier, S., Drielsma, M., Manion, G. & Watson, G. (2002) Extended statistical approaches to modelling spatial pattern in biodiversity in north-east New South Wales. II. Community-level modelling. Biodiversity and Conservation, **11**, 2309–2338.

Franklin, J. (1995) Predictive vegetation mapping: geographic modelling of biospatial patterns in relation to environmental gradients. Progress in Physical Geography, **19**, 474–499.

Gilchrist, G. & Mallory, M.L. (2005) Comparing expert-based science with local ecological knowledge: What are we afraid of? Ecology and Society **12**(1): r1. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/resp1/ [Accessed: 18th August 2009].

Grin, F. (2000) Kalmykia: From oblivion to reassertion? European Centre for Minority Issues (ECMI), working paper 10.

Guisan, G. & Zimmerman, N.E. (2000) Predictive habitat distribution models in ecology. Ecological Modelling, **135**, 147-186.

Guisan, A. & Thuiller, W. (2005). Predicting species distribution: offering more than simple habitat models. Ecology Letters, **8**, 993–1009.

Gusian, A., Brooenniman, O., Engler, R., Vust, M., Yoccoz, N.G., Lehmann, A. and Zimmermann N.E. (2006) Using niche-based models to improve the sampling of rare species. Conservation Biology, **20** (2), 501-511.

Hirzel, A., Le Lay, G., Helfer, V., Randin, C. & Guisan, A. (2006) Evaluating the ability of habitat suitability models to predict species presences. Ecological Modelling, **199**, 142-152.

Howe, C. (2009) The role of education as a tool for environmental conservation and sustainable development. PhD Thesis, Imperial College London. [online] URL: http://www.iccs.org.uk

Huntingdon, H.P. (2000) Using traditional ecological knowledge in science: methods and applications. Ecological applications, **10**(5), 1270-1274.

Hutchinson, G.E. (1957) Concluding remarks, Cold Spring Harbour Symposium. Quantitative Biology, **22**, 415-427.

Ito, T.Y., Miura, N., Lhagvasuren, B., Enkhbileg, D., Takatsuki, S., Tsunekawa, A. & Jiang, Z.W. (2005) Preliminary evidence of a barrier effect of a railroad on the migration of Mongolian gazelles. Conservation Biology, **19**, 945–948.

Jackson, J. B. C. (1997) Reefs since Columbus. Coral Reefs, **16**, Suppl.: S23-S32

Jiménez-Valverde, A., Lobo, J.M. & Hortal, J. (2008) Not as good as they seem: the importance of concepts in species distribution modelling. Diversity and Distributions, doi: 10.1111/j.1472-4642.2008.00496.x

Johnson, C. J., Parker, K. L., Heard, D. C. and Gillingham, M. P. (2002) Movement Parameters of Ungulates and Scale-Specific Responses to the Environment. The Journal of Animal Ecology, **71** (2), 225-235.

Jones, J.P.G., Andriamarovolona, M.M., Hockley, N., Gibbons, J.M. & Milner-Gulland, E.J. (2008) Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. Journal of Applied Ecology, **45**, 1205-1212.

Kühl, A. (2003) Saiga antelope community-based conservation - why and for whom? In Department of Environmental Science and Technology, pp. 95. Imperial College, University of London.

Kühl, A. (2008) "The Conservation Ecology of the Saiga Antelope" PhD Thesis Imperial College London. [online] URL: http://www.iccs.org.uk

Kühl, A., Balinova, N., Bykova, E., Arylov, Y.N., Esipov, A., Lushchekina, A.A. & Milner-Gulland, E.J. (2009) The role of saigas poaching in rural communities: Linkages between attitudes, socio-economic circumstances and behaviour. Biological Conervation, **142**, 1442-1449.

Krebs, C. J. (1991) The experimental paradigm and long-term population studies. Ibis, **133**, 2-8.

Legg, C. J. & Nagy, L. (2006) Why most conservation monitoring is, but need not be, a waste of time. Journal of Environmental Management, **78**, 194-199.

Lushchekina, A. & Struchkov, A. (2001) The saiga antelope in Europe: Once again on the brink? The Open Country No 3.

Manel, S., Williams, H.C. & Ormerod, S.J. (2001). Evaluating presence-absence models in ecology: the need to account for prevalence. Journal of Applied Ecology, **38**, 921–931.

Mallon, D.P. (2008) In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1.[online] URL: www.iucnredlist.org [Accessed 07 September 2009].

Milner-Gulland, E.J. (1994) Sustainable utilisation of the saiga antelope. Oryx, **28**, 257-262.

Milner-Gulland, E.J., Kholodova, M.V., Bekenov, A.B., Bukreeva, O.M., Grachev, Iu.A., Amgalan, L. & Lushchekina, A.A. (2001) Dramatic declines in saiga antelope populations. Oryx, **35**, 340-345.

Milner-Gulland, E.J., Bukreeva, O.M., Coulson, T.N., Lushchekina, A.A., Kholodova, M.V., Bekenov, A.B. & Grachev, Iu.A. (2003) Reproductive collapse in saiga antelope harems. Nature, **422**, 135.

Milner-Gulland, E.J. & Rowcliffe, M. (2007) Conservation and sustainable use – A handbook of techniques. Oxford University Press.

Nichols, J.D. & Williams, B.K. (2006) Monitoring for Conservation. TRENDS in Ecology and Evolution, **21** (12), 668-673.

Noss. R. 1999. Is there a special conservation biology? Ecography, **22**, 113-122.

O'Neil, H. (2008) Designing robust ranger based monitoring strategies for the Saiga Antelope *Saiga tatarica tatarica.* MSc Thesis Imperial College London. [online] URL: http://www.iccs.org.uk [Accessed: 15th April 2009].

Olsson, P. and Folke, C. 2001. Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken watershed, Sweden. Ecosystems, **4**, 85–104

Papworth, S., Coad, L., Rist, J. & Miller-Gulland, E.J. (2009) Shifting baseline syndrome as a concept in conservation. Conservation Letters, **2**, 93–100 doi: 10.1111/j.1755-263X.2009.00449.

Pattengill-Semmens, C. V., & Semmens, B. X. (2003) Conservation and management applications of the reef volunteer fish monitoring program. Environmental Monitoring and Assessment, **81**, 43-50.

Pauly, D. (1995) Anecdotes and the shifting baseline syndrome. Trends in Ecology & Evolution **10**, 430.

Pearce, J. L and Boyce, M. S. (2006) Modelling distribution and abundance with presence-only data. Journal of Applied Ecology, **43**, 405-412.

Peterson A.T., Shaw J.J. (2003) Lutzomyia vectors for cutaneous leishmaniasis in southern Brazil: ecological niche models, predicted geographic distributions, and climate change effects. International Journal for Parasitology, **33**, 919–31.

R. Development Core Team (2007) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Rist, L. (2009) "Assessing a threat to sustainable NTFP harvest using Ecological Data and Traditional Knowledge" PhD Thesis Imperial College London. [online] URL: http://www.iccs.org.uk

Robinson, S., Milner-Gulland, E.J. & Alimaev, I. (2003) Rangeland degradation in Kazakhstan during the Soviet era: re-examining the evidence. Journal of Arid Environments, **53**, 419-439.

Sáenz-Arroyo, A., Roberts, C. M., Torre, J., Cariño-Olvera, M. & Enríquez-Andrade, R. R. (2005) Rapidly shifting environmental baselines among fishers of the Gulf of California. Proceedings of the Royal Society of London B Series, **272**, pp 1957-1962.

Saiga News. [online] URL: www.saiga-conservation.com/saiga_news [Accessed: 25th August 2009].

Scott, J.M., Heglund, P.J., Haufler, J.B., Morrison, M., Raphael, M.G., Wall, W.B. & Samson, F. (2002) Predicting species occurrences: Issues of accuracy and scale. Island Press, Covelo, CA.

Senft, R. L., Coughenour, M. B., Bailey, D. W., Rittenhouse, L. R., Sala, O. E. & Swift, D.M. (1987) Large herbivore foraging and ecological hierarchies. Bioscience, **37**, 789–799.

Sharp, A. & Conrad, C. (2006) Community based ecological monitoring in Nova Scotia: Challenges and opportunities. Environmental Monitoring and Assessment**, 113**, 395-409.

Sheppard, C. (1995) The shifting baseline syndrome. Marine Pollution Bulletin, **30**, 766-767

Singh, N., Yoccoz, N. G., Bhatnagar Y. V. & Fox, J. L. (2009) Using habitat suitability models to sample rare species in high-altitude ecosystems: a case study with Tibetan argali. Biodiversity and Conservation, DOI 10.1007/s10531-009-9615-5. 82.

Singh, N.J., Grachev., I.A., Bekenov, A.B., Milner-Gulland, E.J. (in review) Tracking greenery in central Asia – the migration of the saiga antelope.

Spellerberg, I. (2005) Monitoring Ecological Change. 2nd ed., pp 412. Cambridge University Press, New York.

Stokes, P., Havas, M. & Brydges, T. (1990) Public Participation and Volunteer Help in Monitoring Programs: An Assessment. Environmental Monitoring & Assessment**, 15**, 225-229.

Sutherland, W. J., Pullin, A. S., Dolman, P. M. & Knight, T. M. (2004) The need for evidence-based conservation. Trends in Ecology and Evolution Vol 19, No 6 305-308

Swift, D.M. (1987) Large herbivore foraging and ecological hierarchies. BioScience, **37**, 789-99

Treves, A & Karanth, K.U. (2003) Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology, **17**(6), 1491–9.

Treves, A., Naughton-Treves, L., Harper, E.K., Mladenoff, D.J., Rose, R.A., Sickley., T.A. & Wydeven, A.P. (2004) Predicting Human-Carnivore Conflict: a Spatial Model Dervied from 25 years of data on Wolf Predation on Livestock. Conservation Biology, **18** (1), 114-125

Whitebread, E. (2008) Evaluating the potential for participatory monitoring of saiga antelope by local villagers in Kalmykia, Russia. MSc Thesis Imperial College London. [online] URL: http://www.iccs.org.uk [Accessed: 12th April 2009].

Whitelaw, G., Vaughan, H., Craig, B. & Atkinson, D. (2003) Establishing the Canadian Community Monitoring Network. Environmental Monitoring and Assessment, **88** (1-3), 409-418.

Wintle, B. A., Elith, J. & Potts, J. M. (2005) Fauna habitat modelling and mapping: A review and case study in the Lower Hunter Central Coast region of NSW. Australian Ecology, **30**, 719-738.

Yli-Pelkonen, V. & Kohl, J. (2005) The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. Sustainability: Science, Practice, & Policy, 1(1), 3-14. [online] URL:

http://ejournal.nbii.org/archives/vol1iss1/0407-007.yli-pelkonen.html
[Accessed: 30th August 2009].

Yoccoz, N. G., Nichols, J. D. and Boulinier, T. (2001) Monitoring of biological diversity in space and time. Trends in Ecology and Evolution, 16 (8), 446-453.

Zaniewski, A.E., Lehmann, A. & Overton, J.M. (2002) Predicting species spatial distributions using presence-only data: a case study of native New Zealand ferns. Ecologial Modelling, **157**, 261–280.

7 Appendices

Appendix I

Questionnaire on saiga presence

Hello, I am currently studying for my MSc in the UK and my project is researching saiga antelope. I am trying to find out the saigas range – how far they travel and where they go at different times of year. I would really appreciate it if you could answer a couple of questions to help with my project. This work is following up on similar research carried out last year jointly by students from Kalmykia State University and Imperial College London, the results of which have been very useful. There are no right and wrong answers – it is just as useful to know if you haven't seen saigas as it is if you have seen them. All the answers will remain anonymous.

Village: Date: Person Number:

Household number: GPS location of house:

Gender: M / F Age:

Main Occupation:

How long have you lived in this house:

[if you have lived in this house for less than 20 years then please only to answer questions relating to the period in which you have lived here]

1) How often, on average, do you go onto the steppe (i.e outside the built up area of the village or away from the buildings of your farm)?

Everyday / Several times a week / Once a week / Once a month / A few times a year / Hardly ever

2) What are you doing when you are on the steppe?

Activity	How Often?				
	Usually	Often	Sometimes	Rarely	Never
Travelling					
- Car/Van					
- Horse					
- Motorbike					
- Other					
Shepherding					
- on horse					
- on motorbike					
Leisure					
Other (Please state below)					

Other:

3) What time of day are you usually out on the steppe?

What time of day?	How Often?				
	Usually	Often	Sometimes	Rarely	Never
Around Dawn					
Mid Morning					
Around noon					
Mid Afternoon					
Dusk					
At night					

4) Have you ever seen saigas in the vicinity of your home (i.e. within a 5 km radius)? (If NO, skip to Question 14)

YES NO Don't know

5) Have you seen saigas in the vicinity of your home since 1991?

YES NO Don't know

6) Since 1991 how recently have you seen saigas in the vicinity of your home?

In the last 2 years	Between 2 - 5 years ago	Between 5 – 10 years ago	More than 10 years ago

7) Have you seen saigas in the vicinity of your home during the last twelve months?

YES NO Don't know

8) In which months did you see the saiga?

	J	F	M	A	M	J	J	A	S	O	N	D	Throughout the year	Don't know
Prior to 1991														
Since 1991														
Last 12 months														

9) How far away from your home did you usually see saigas?

	Prior to 1991	Since 1991	Last 12 months
Right next to it			
100m away			
1000m away			
More than 1000m away			

10) If you see saigas in the spring, do you also see calves?

YES NO Don't know

11) Have you observed saigas crossing main roads, canals and / or railways? Please give details and if possible mark location on map.

12) Have you ever seen saigas grazing in close proximity to livestock, or drinking from water sources at the same time? Please give details.

13) When did you personally last see a saiga? Can you describe what you observed?

14) What was the largest herd you could see at any one time from one location within 5 km of your home prior to 1991? What about today (last twelve months)?

	Prior to 1991	Today	Comments
a) 100,000s			
b) 10,000s			
c) 1,000s			
d) 100s			
e) < 100			
f) None			
g) Don't know			

15) Overall, do you think there have been any changes with regards to the saiga population in this raion since 1991?

YES NO Don't know

16) If YES, what has changed? What has caused these changes?

<table>
<tr><th>Change</th><th>What was the nature of the change?</th><th>When did it start to occur?</th><th>Why did it occur?</th><th>Answer categories: only posed if respondent suggests that saiga population declined or increased</th></tr>
<tr><td>Change in population size</td><td></td><td></td><td></td><td rowspan="3">1. Poaching
2. Predators
3. Climatic factors
4. Anthropogenic factors
5. Other biological factors (e.g pasture)
6. Other (state)</td></tr>
<tr><td>Change in location</td><td></td><td></td><td></td></tr>
<tr><td>Migratory Route change</td><td></td><td></td><td></td></tr>
<tr><td>Change in population structure</td><td></td><td></td><td></td><td>1. Group size decline
2. Number of males decline
3. Other</td></tr>
</table>

17) What do you think prevents the saigas coming into this area now and / or in the past? If applicable mark on location on map.

Reason	Now	Since 1991	Prior to 1991	Comments
Physical Barrier, please state				
Human Presence				
Climate				
Water Availability				
Fires				
Poaching				
Livestock density				
Saiga population size				
Other, please state				

18) What do you think encourages saigas into the area now and / or in the past?

Reason	Now	Since 1991	Prior to 1991	Comments
Good vegetation				
Human Presence				
Climate				
Water Availability				
Protection/Rangers				
Livestock density				
Poaching				
Saiga population size				
Other, please state				

Thank you very much for your help with my research. If you would like to know more about my work, the results of the survey, or other Saiga Conservation Alliance activities you can ask the Director of my studies here, Professor Yuri Arylov, who is based at the Yashkul Saiga Breeding Centre.

Appendix II

Examples of initial maximal model selection for the data covering the last 12 months. Exactly the same process was carried out for the data covering saiga presence ever.

GLM output for observational significance values – In the last 12 months

Variables	Estimate	Standard Error	Z value	P Value
Shepherding using motorised vehichle	0.5698	0.6016	0.947	0.344
Frequency of time spent on steppe	17.119	2174.213	0.008	0.994
Dawn	0.0984	0.581	0.169	0.866
Noon	-0.533	0.502	-1.062	0.288
Afternoon	-1.112e-01	4.718e-01	-0.236	0.814
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

GLM output for observational significance values – Ever

Variables	Estimate	Standard Error	Z value	P Value
Shepherding using motorised vehicle	0.4578	0.864	0.530	0.596192
Frequency of time spent on steppe	17.119	2174.213	0.008	0.994
Dawn	-1.208	1.088	-1.11	0.2668
Noon	-0.769	0.641	-1.201	0.23
Afternoon	-0.827	0.665	-1.244	0.214
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

GLM output for Presence ~ NDVI + Water Availability + Time lived in house + Distance from Utta + North/South of the main road.

Variables	**Estimate**	**Standard Error**	**Z value**	**P Value**
Intercept	3.666e-01	9.388e-01	0.391	0.696
NDVI	-4.696e-01	3.617e-01	1.001	0.317
Water	2.758e-01	2.755e-01	-1.11	0.2668
Time	-0.769	0.641	-1.201	0.23
Distance	6.833e-06	8.346e-06	0.819	0.413
Road - South	-8.344e-01	5.440e-01	-1.534	0.125
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

GLM output for Presence ~ Mean Annual Precipitation + Water Availability + Time lived in house + Distance from Utta + North/South of the main road.

Variables	**Estimate**	**Standard Error**	**Z value**	**P Value**
Intercept	-5.346e-02	1.966+00	-0.027	0.978
Mean Annual Precipitation	-1.905e-03	9.611e-02	-0.020	0.984
Water	1.899e-01	2.660e-01	0.714	0.475
Time	-2.758e-02	2.336e-02	-1.181	0.238
Distance	4.141e06	8.449e-06	0.490	0.6240
Road - South	-8.861e-01	5.374e-01	-1.649	0.0992
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

GLM output for Presence ~ Mean Annual Precipitation + Water Availability + Time lived in house + Main Village.

Variables	**Estimate**	**Standard Error**	**Z value**	**P Value**
Intercept	-0.109	2.323	-0.047	0.962
Mean Annual Precipitation	0.032	0.113	0.282	0.778
Water	0.198	0.291	0.679	0.497
Time	-0.031	0.026	-1.227	0.220
Main Village – Khulkhutta	-0.409	0.852	-0.480	0.631
Main Village – Komsomol'skiy	-1.084	0.858	-1.262	0.207
Main Village - Sarpa	-0.337	1.049	-0.322	0.748
Main Village – Yashkul'	-2.015	0.706	-2.853	0.004 **
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

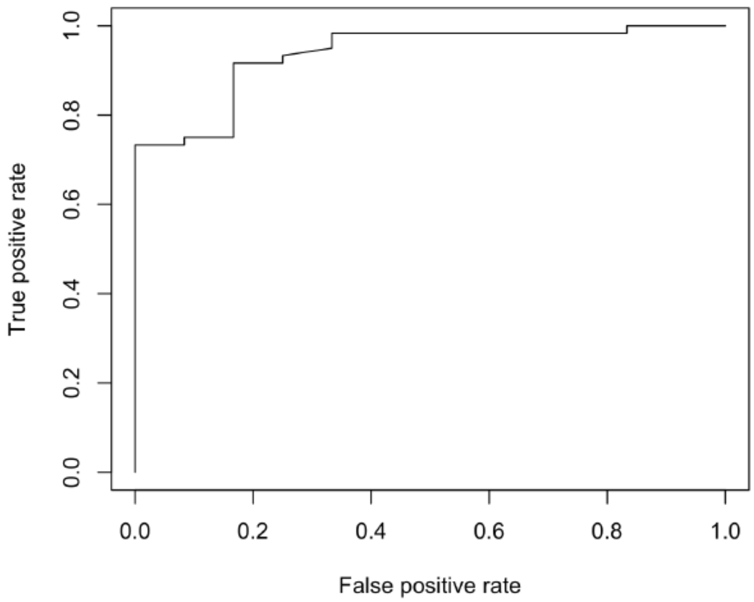
GLM output for Presence ~ Mean Annual Precipitation + Water Availability + Time lived in house + Town Density

Variables	**Estimate**	**Standard Error**	**Z value**	**P Value**
Intercept	0.101	1.977	0.051	0.959
Mean Annual Precipitation	0.012	0.093	0.129	0.898
Water	0.141	0.258	0.548	0.584
Time	-0.037	0.023	-1.629	0.103
Town Density	-52.301	44.759	-1.168	0.243
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

GLM output for Presence ~ NDVI + Water Availability + Time lived in house + Town Density

Variables	Estimate	Standard Error	Z value	P Value
Intercept	0.774	0.833	0.929	0.353
Mean Annual Precipitation	-0.370	0.363	-1.017	0.309
Water	0.204	0.265	0.770	0.442
Time	-0.037	0.023	-1.624	0.104
Town Density	-36.847	45.976	-0.801	0.423
Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

ROC curve for 'ever' data



ROC curve for the last 12 months