Photo by Rich Reading (http://news.nationalgeographic.com/news/2008/03/080327-saiga-picture.html**)**

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Acronyms

ACBK – Association for Conservation of Biodiversity in Kazakhstan
ADCI – Altyn Dala Conservation Initiative
ADMADE - Administrative Design for Game Management Areas
BQCMA – Beverley and Qamanirjuaq Barren Ground Caribou Management Agreement
BQCMB - Beverley and Qamanirjuaq Barren Ground Caribou Management Board
BWMA – Botswana Wildlife Management Association
CBNRM – Community Based Natural Resource Management
CBTHP – Community Based Trophy Hunting Program
CBWM – Community Based Wildlife management
CITES – Convention on International Trade in Endangered Species
CMP – Conservation Management Plan
CMS – Convention on the Conservation of Migratory Species
CoP – Conference of the Parties
FAIRSC – The Fraser of Allander Institute for Research on the Scottish Economy
FZS – Frankfurt Zoological Society
GEF – Global Environment Fund
GoP – Government of Pakistan
IPCC – Intergovernmental Panel for Climate Change
IUCN – International Union for the Conservation of Nature
MACP – Mountain Areas Conservancy Project
MESY – Maximum Expected Sustainable Yield
MTIWP – Medium Term International Work Program
NCCW – National Council for Conservation of Wildlife
NGO – Non-Governmental Organization
SCA – Saiga Conservation Alliance
TCM – Traditional Chinese Medicine
TCP – Toghar Conservation Project
THP – Trophy Hunting Program
VCF – Village Conservation Fund
VWG – Village Wildlife Guide
WWF – World Wildlife Fund

Abstract

Sustainable conservation solutions and discouraging detrimental practices through alternative livelihood options should bring benefit to both species and communities within their ranges. Trophy hunting coupled with community based wildlife management has the potential to encourage valuing of wildlife resources, allow active participation and empowerment of community groups, and generate revenue for conservation purposes. This project focuses on exploring the feasibility of community based trophy hunting of the Betpak-dala population of saiga antelopes (*Saiga tartarica*). Literature on trophy hunting and community based wildlife management was investigated as well as using a population model to assess approaches to sustainable hunting. Hunting levels of 10% of the population, with the majority of the hunt comprising of males in the adult and sub-adult male classes, allowed an annual hunting season. This level of yearly off-take left the population still able to grow and achieve a stable population level at 75% of carrying capacity.

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Exploring a sustainable trophy hunting model for saiga antelope of the Betpak dala population of Kazakhstan.

Section1. Introduction

Saiga antelope formerly ranged from Britain to the Arctic circle in prehistoric times (Bekenov 1998; Kuhl 2008) but have significantly declined from their former ranges and population numbers. Their remnant overall population now exists as two sub-species in five population groups, *Saiga tatarica mongolica* in Mongolia, and *Saiga tatarica tatarica* found in Kalmykia (one population group) and the majority of the total population of *Saiga tatarica tatarica* in Kazakhstan (three population groups) (Milner-Gulland *et al.* 2001; McConville 2006; Singh *et al.* 2010). After suffering severe depletions, driving them down to just a few thousand individuals, the largest of the Kazak population groups, found in the Betpak-dala region, is beginning to recover due to increased protection, through recent anti-poaching efforts and regular patrolling from the Altyn Dala Conservation Initiative (ADCI) and the state hunting organization, "Okhotzooprom". (Klebelsberg 2008; Duisekeev and Sklyarenko 2008).

1.2 Problem to be addressed

The game management authorities and government in Kazakhstan, encouraged by signs of recovery in the population, have shown interest in exploring the possibility of sustainable trophy hunting of saiga antelopes (Milner-Gulland pers.comm), there has also been a call to make an assessment of the feasibility of trophy hunting in the Medium Term International Work Programme (MTIWP) of the Convention on the Conservation of Migratory Species (CMS 2010) in relation to saiga antelopes. Poaching of saigas for meat, hide and horn is thought to be the primary cause of the sharp decline in their population numbers in Kazakhstan (Milner-Gulland *et al.* 2001; Kuhl 2008). The socio-economic drivers of poaching are attributed to high unemployment in rural areas, a lack of options for alternative livelihoods (Milner-Gulland *et al.* 2001), lack of education as regards environmental matters and difficulties in effectively enforcing the

anti-hunting laws for saigas over their vast range area (Kuhl 2009). Social surveys conducted by Kuhl (2008) indicate that there are positive attitudes towards saigas and their conservation, and that poaching is not a favoured activity given alternatives, which implies that there is a potential for success of inclusive community conservation schemes.

1.3 Rationale

Trophy hunting, although intuitively contrary to the concept of conservation (Loveridge *et al.* 2006), has been shown to be a potentially useful tool in respects to raising revenue for local communities and preservation of species and habitats and is practiced with some varying degrees of success with other ungulate species in several areas of the world. Involving communities in the management of a conservation based scheme, rather than using solely government management, allows local people to feel that their interests are included and encourages the placing of value on biodiversity for those locals (Hurst 2004), management approaches along with successful and problematic aspects of community managed trophy hunting programs will be discussed later. Trophy hunting is already in practice in Kazakhstan, those who wish to do so can hunt a variety of species including several ungulates e.g. Maral (*Cervus elaphus maral*), Siberian ibex (*Capra* sibirica), Argali (*Ovis ammon*), Elk (*Alces alces*), and Siberian roe deer (*Capreolus pygargus*). Trophy hunting safari's in Russia, including opportunities to hunt saiga, albeit illegally, are also advertised on the internet (e.g. Easta- The Russia adventure club) demonstrating an interest and a potential market from the hunting community.

1.4 Thesis description

In this thesis, the feasibility of initiating a Community Based Trophy Hunting Program (CBTHP) is investigated for the Betpak-dala population of saiga antelope using current literature on trophy hunting and community based management approaches and a simulated population dynamics model. Density dependent and hunting pressure parameters influencing differing age and sex groups as well as stochastic climate effects are applied within the models to assess the susceptibility of the population to external and internal pressures. Through simulated pressure on the natural cycle of saiga development, both from climate and from anthropogenic sources, an approximation of a sustainable level of harvesting can be ascertained, this level can then be borne in mind

when formulating a management plan for a trophy hunting program. The information can also be incorporated in the targets as agreed by the signatories of the CMS in the conservation of the saiga antelope.

1.5 Project Aims and Objectives

This project will use a population model to assess the feasibility of trophy hunting the Betpak-dala saiga antelope population based in Kazakhstan. Inferences will be drawn from earlier population models (Milner-Gulland 1994, Milner-Gulland 1997) and differing scenarios manipulating vital rates, climate probabilities and hunting levels on different age and sex classes will be explored using a simple Leslie matrix model to assess their effect on the population. Through application of the model and review of relevant literature limitations and recommendations for several aspects of trophy hunting will be suggested. These will include:

1. When would be the best time of year to trophy hunt, considering the maximum benefit to the saiga population and the communities?
2. What numbers of saigas could reasonably be harvested each year at a given population size and structure?
3. What the proportion of each age and sex class could be harvested?
4. What to set the precautionary harvest limits at and how these limits may relate to factors such as the uncertainty surrounding population estimates?
5. Methods for implementing community-based/multi-level management (rather than solely centrally organised) of trophy hunting schemes, and whether this approach is feasible for the Betpak-dala saiga antelope population.
6. What lessons can be taken from other trophy hunting systems already in place on how best to allocate trophy hunting licenses to communities in migratory systems.
7. What the potential revenues could be from trophy hunting in this area, and their relationship to costs and practicalities.

1.6 Overview of thesis structure

The background information in section two discusses previous trophy hunting programmes, community based wildlife management and multi-level management

approaches as well as relevant background information on saiga antelopes and the Betpak-dala ranges. Section three describes the details of the population model and how it is to be used. Section four reports the results of applying that model. Section five discusses the results of the model in a broader context and explores how a trophy hunting programme and a multi-level management system relate to the Betpak-dala saiga population.

Section2. Background information

2.1 Background of trophy hunting

Trophy hunting uses a managed approach to the hunting of wild animals for the pleasure of individuals or groups that enjoy the experience of tracking and killing particular animals (Loveridge *et al.* 2006), often distinct in appearance (Shackleton 2001). Hunters are willing to pay high prices to take part in such activities, and this presents the opportunity to bring money into areas where the desired quarry inhabits. The benefit to conservation is the potential to regulate the harvest (therefore addressing illegal harvesting) and to preserve the selected species and its habitat due to increasing available revenue to government wildlife initiatives and the local communities of the area in which hunting takes place (Harris and Pletscher 2002). It is possible that responsibly managed trophy hunting schemes could bring the maximum amount of conservation benefit to an area or species that would otherwise be lacking in regards to certain conservation fund allocation criteria. Sport hunters may not be motivated by conservation for the intrinsic value of a species but the hunting fraternity are actively involved in maintaining and sustaining the quarry populations for their sport and available hunting habitat in which to practice it (Loveridge *et al.* 2006). The chief benefit of trophy hunting to wider conservation objectives is the hunter's willingness to pay potentially large sums of money for the activity, this then enables conservationists to potentially use this financial input as a resource that can aid the future preservation of species and habitats (Shackleton 2001).

Poorly regulated legal hunting and uncontrolled poaching can be extremely damaging to populations, causing rapid decline and in some cases extirpation of the species from the area (Loveridge *et al.* 2006). Successfully regulated hunting as an inclusion within conservation programmes has been demonstrated to bring benefit to species in many cases (Loveridge *et al.* 2006), such as the wild turkey (Dickenson 1992), white-tailed deer (Woolf and Rosenbury 1998) and beaver (Novak 1987).

2.1.1 Potential revenue

Trophy hunting has the potential to bring in large amounts of revenue at national and regional levels; high prices can be paid for licences, syndicate memberships, travel and on the ground logistics (guides, vehicles, subsistence, etc.) (Loveridge *et al.* 2006). When responsibly managed trophy hunting programs have benefitted the species targeted and also the local community that lives alongside them, recognition of this has led to the establishment of many community based trophy hunting programs (CBTHP) (Shackleton 2001). CBTHPs have been set up with the primary function of preserving and protecting wildlife, with the generation of finance and provision of community benefits being secondary (Shackleton 2001). The measure of an effective CBTHP is when benefits resulting from trophy hunting promote conservation efforts directly from the community, leading to a sustainable system where the size and quality of the quarry population can be maintained or increased therefore making continued trophy hunting feasible, further to this a desirable product of a CBTHP would be wider environmental benefits to the habitat and biodiversity in general (Shackleton 2001). Trophy hunting and other sustainable uses of wildlife have in Africa aided the preservation of habitat available to wildlife. The money generated through hunting acts to discourage political pressure to convert wild areas into agricultural land or be turned over to domestic livestock production, both of which would be extremely damaging to the ecosystem as it stands (Barnes 2001; Loveridge *et al.* 2006).

Sport hunting in many countries is highly lucrative, in 1992 field sport expenditure in the UK was approximately £1.4 billion (Cobham Resource Consultants 1997, in Loveridge *et al.* 2006), the shooting of red grouse in Scotland supports the equivalent of 940 jobs and in 2000 generated £17 million worth of GDP (FAIRSC 2001). In Botswana hunting expenditure totals approximately $19 million (BWMA 2001), South African game farms generated $44 million in 2001 (Van der Merwe and Saayman 2003). Prices for trophy hunting individual animals can be very high, for instance in the U.S. a trophy bighorn sheep can cost up to $160 000 (Marty 2002).

The hope is that revenue generated from trophy hunting would not be dissipated away from the areas and nations in which it takes place to hunting organisations from outside the host country, and also that a significant proportion would be directed towards

conservation activities. Of the $19 million generated through hunting in Botswana, the Botswana Wildlife Management Association estimates that 49.5% of this remains in the hunting areas and a further 25.7% remains in country (Loveridge *et al.* 2006). Lewis and Alpert (1997) reported that of revenue generated in Zambia from hunting activities the majority (67%) was received by the Administrative Design for Game Management Areas (ADMADE) program and of this 53% is spent on management of wildlife and the remaining 47% on community development (Loveridge *et al.* 2006). The CAMPFIRE project in Zimbabwe were involved in the leasing out of hunting concessions between 1989-96, generating 93% of the income of Zimbabwean rural councils participating, amounting to $8.5 million (Bond 2001).

A danger in the distribution of funds generated by sport hunting is that there may be a bias towards areas where there is a high abundance of trophy species and low human population density, communities that may travel to those areas to hunt may not have motivation to change their activities as they do not benefit from the schemes. Distribution may also be hampered due to corruption on all levels, poor representation of rural communities in program management and political marginalisation (Murombedzi 1999). Community based natural resource management (CBNRM) may encounter the problem of local communities not necessarily wanting to invest profits into conservation (potentially preferring agricultural expansion) or willing to partake in the opportunity costs of the project (Murombedzi 1999).

2.1.2 Biological impacts

Trophy hunters seek a spectacular prize for their hunting efforts; frequently the animals selected for these prizes will have large display/defensive features which make them particularly attractive such as horns, tusks or antlers (Shackleton 2001; Loveridge *et al.* 2006). Males in their prime are desirable for hunters and the largest of these is often most sought after (Frisina *et al.* 2000), the taking of these males potentially could have detrimental impacts on herd dynamics, the long term genetic effects of removing superior males being unknown (Shackleton 2001).

It has been shown previously that intensive trophy hunting interferes with territorial and mating behaviour in sable antelopes (Fergusson 1990), which in turn led to reduced calving period of protracted parturition and a higher rate of calf mortality. Harris *et al.*

(2002) suggest that to minimise long term evolutionary consequences hunting regimes should attempt as far as possible to resemble natural mortality patterns, although it has not been proven that hunting levels in saiga directly affect the gene pool.

In other species phenotypic effects have been evident e.g. the selective hunting of a population of big-horn sheep caused a decrease in body weight and horn size, indicating a potential reduction in fitness in the population (Coltman *et al.* 2003). Milner *et al.* (2007) conducted a study that examined the implications of sexual bias in hunting programs, the consequence of the disproportionate removal of males from the population can be that the mean age of males in the population becomes reduced which can potentially interfere with birth synchrony, offspring sex ratios, delay birth dates and therefore body mass development, with the overall result of depression of recruitment. Potentially the removal of too many of the mature adults can lead to a young age structure of the remaining population, males may suffer more with the exertions of the rut and potentially suffer increased mortality in the winter months. Late born offspring may have lower body weights entering the winter which may hinder their survival through those months, especially if the winter is harsh (Festa-Blanchet 1988).

It may be less damaging to the herd if old adult males are taken from the herd, which has been suggested is the case with some trophy hunting, although old males are more likely to be victim to predators as their condition deteriorates (Shackleton 2001) and age estimation in some species may be difficult (Lundervold *et al.* 2003). The removal of a proportion of the breeding males may not be detrimental to the growth rate of the herd if the species is polygynous (Shackleton 2001). Species that operate harem breeding systems have shown resilience to sexually biased selective hunting, this has been observed in ungulate populations in Tanzania by Caro *et al.* (1998). Even with this resilience any system can only be subject to certain level of pressure, Ginsberg and Milner-Gulland (1994) found that saiga antelopes experienced a threshold effect of male to female ratio as a consequence of sexually biased harvesting of the population. If the ratio of adult males was less than 2.5% of breeding females then the females experienced a drastic drop in fecundity, potentially threatening the stability of the population (Milner-Gulland 2003). To mitigate the effects of sexual bias in hunting the number of males allowed to be removed could be restricted, enabling smaller populations to be subject to trophy hunting without collapsing. A minimum age

threshold could also be imposed on males, given that age differences can be reliably assessed, this could also be further supported by delaying the hunting season until after the rut, giving older males the opportunity to breed (Milner *et al.* 2007; Kokko *et al.* 2001).

2.2 Community run conservation projects

Conversion of natural landscapes via the advance of agriculture presents a real threat to wildlife species and their habitats (Du Toit 2002). Giving value to wildlife areas to local communities involves presenting viable options to subsistence or commercial agriculture that benefit rural communities. Attaining this goal could be achieved with the fullest involvement of local communities using Community Based Wildlife Management (CBWM), given that sustainable use of wildlife resources are carefully assessed and monitored in a scientifically sound manner throughout a CBWM program (Du Toit 2002). CBWM has the potential to bring benefits, proprietary control of natural resources and decision making responsibility to groups that would otherwise be marginalised or neglected by centrally controlled conservation programs (Kellert *et al.* 2000).

CBWM programs to be effective need to have in perspective the economic benefits to be gained from CBWM as opposed to other land use options (Du Toit 2002), in regards to trophy hunting the maximum amount of information on a selected species i.e. their population numbers and movements, existing pressures on the species and their habitat, are essential to the success of a program. Given the maximum available information on a species, the maximum expected sustainable yield (MESY) can be established which will be essential for sustainable management of the target species (Du Toit 2002).

The setting up of a community management committee, with a strong leadership acceptable to the whole community enables the management of relationships between community members, available resources and visitors (Yaman and Mohd 2004). This committee will be involved in matters relating to the community, thereby protecting the interests of the community and any actions conducted on its behalf. The committee needs to be well regulated and accountable to prevent any level of corruption and misuse of benefits gained by the project (Yaman and Mohd 2004).

To counter the possibility of corruption i.e. misappropriation of funds, falsification of census data or illegal/unlicensed hunts, full transparency is essential in the reporting of all aspects of the hunts (Shackleton 2001). Without this a CBTHP may lose credibility with international hunting organisations and conservation agencies, as well as potentially losing support for the program in the communities themselves (Shackleton 2001).

2.2.1 Problems

One concern of CBWM programs is that without outside technical support and central regulatory control, there is a potential for over exploitation of wildlife resources, biased distribution of profits and detrimental practices that may be counterproductive to conservation (Du Toit 2002; Spinage 1998). There is a potential for the misappropriation of revenues by influential members of the management board and a lack of dissemination of benefits into the community as a whole or to all communities signed up to a project/program (Kellert *et al.* 2000). This has been shown to be evident in Kenya and Nepal by an investigation into CBWMs conducted by Kellert *et al.* (2000), where controlling groups misused their increased authority to further their own agendas. Another frequently encountered problem Kellert *et al.* (2000) found was that often the expectations of what a CBWM could achieve by the communities involved in CBWM were beyond the scope of the conservation project/program which lead to frustration, conflict and was potentially damaging to the continuation of the project/program. Biodiversity protection goals were often marginalised in favour of social and economic advancement, local residents viewing CBWM as a means for this purpose (Kellert *et al.* 2000).

2.2.2 Examples – CBTHPs in Pakistan

Several successful examples of Community Managed Trophy Hunting Projects (CBTHP) have been set up in Northern Pakistan; these have been established with community management systems in conjunction with conservation and development NGOs and the Government of Pakistan (GoP). For instance the Mountain Areas Conservancy Project (MACP) was launched in Northern Pakistan with the aid of funding from the Global Environment Facility (GEF), the United Nations Development Program (UNDP), and the government of Pakistan (GoP), to develop the use of trophy hunting and other

sustainable use options in Northern Pakistan (Humme 2003). The MACP has encouraged community interest in conservation activities, benefits being improvements in local socio-economic conditions (80% of the profits from trophy hunting being distributed into local communities), and increases in wild animal populations in the area. The longest running CBTHP, the Torghar Conservation Project (TCP) has used the revenue earned through trophy hunting to hire local people as wildlife guards to protect against poaching, equally distributing these positions across sub-tribes in the region, guards are selected by the sub-tribes and other male members of the sub-tribes are also encouraged to be vigilant against poachers (Shackleton 2001).

2.2.3 Policy and regulation

The responsibility of aiding the government of Pakistan (GoP) to comply with the recommendations put forward in CITES Conference of the Parties (CoP) – CoP 10 Appendix I and CoP 11 Appendix II, falls to the National Council for Conservation of Wildlife (NCCW). The NCCW ensure that provincial governments and NGOs are acting in the interests of the CITES CoP agreements in respects of promotion and supporting activities, as well as allocating quotas for CITES listed species based on information presented in species conservation plans (including population data). Shackleton (2001) recommends that certain criteria are fulfilled before the allocations of trophy hunting quotas are issued, those being:

1) Presence of trophy-sized animals;
2) Good probability of hunt success;
3) Capacity of the community to undertake a hunt;
4) Utilisation plan for fund/income;
5) Conservation plan and membership in a district conservation committee;
6) Notification of controlled hunting area.

Successful hunts (including details of the trophy collected) are reported to the NCCW, they then are responsible for issuing export permits for both CITES listed and non-listed species, these permits are issued on the proviso that the trophy was taken in a community controlled hunting area (Shackleton 2001).

Pakistan as a signatory nation to CITES is obligated to provide the CITES secretariat with a report on the status of listed species and how many of the population are hunted and

exported as trophies. Exported trophy animals are optionally requested to provide details of hunting permit numbers, countries of destination and numbers of import permits. CoP10 requires that community based management plans are monitored by the GoP and that annual surveys are conducted of listed species (Shackleton 2001).

A detailed Conservation Management Plan (CMP) is needed by each CBTHP to address biodiversity conservation in general and particularly the conservation needs of the target species and its habitat, the CMP should be monitored and subject to annual review by the GoP and their effectiveness should also be annually evaluated by NGO biologists in conjunction with a village wildlife guide (VWG) (Shackleton 2001).

A standard technique was adopted in Pakistan to measure each trophy, and the use of self locking big game tags, as used in other big game hunting countries, as a mark of the legality of the hunt has been recommended (Shackleton 2001), this also assists the export process.

2.2.4 Marketing

A necessary component of a CBTHP is a good working relationship with an outside tour operator or middleman to facilitate the marketing of the program to the wider international hunting community/fraternity (Yaman and Mohd 2004), ideally this would be with an organization that have a keen interest in the conservation objectives of the area in which the project is based or with conservation generally.

Government monitoring of marketing by communities to the wider international hunting fraternity is suggested, but direct involvement in the commercial side of the hunting is advised against as this may decrease the confidence of foreign hunters and international conservation agencies (Shackleton 2001). Initially marketing of the hunts should be done in conjunction with sympathetic outside organisations but communities should work towards marketing their own hunts, in Pakistan workshops run by IUCN-Pakistan and WWF-Pakistan, with community representatives and representatives of national and international outfitters present, on appropriate means of marketing trophy hunting internationally were suggested to facilitate education of the community in this area (Shackleton 2001).

2.2.5 Distribution of profits

Profits from trophy hunts can either be paid directly to the community from the hunter/s, from which the community have to pay a proportion to the government for the license, or the entire fee can be paid to a government authority that then pay a proportion to the community (this could be paid in advance and then distributed on successful completion of the hunt). The ideal situation is probably for the hunter to pay the government license fee and the community fee separately, although this can be problematic if a cancellation fee system is in operation (Shackleton 2001).

In Pakistan village conservation funds (VCFs) were set up to pay for conservation actions (in accordance with the CMP) and social benefits that encourage a positive attitude towards conservation, any VWGs would be paid from this fund, decisions on spending the VCF on actions beneficial to the community were discussed in meetings involving the whole community (Shackleton 2001).

2.2.6 Successes

In most CBTHPs in Pakistan poaching was significantly reduced and increases were seen in population numbers of the targeted species, negative impacts of domestic animal grazing were reduced and community members (as well as gaining a more positive attitude towards wildlife and their habitat) recognized the necessity for wildlife and biodiversity conservation (Shackleton 2001).

Successes in the MACP has encouraged other mountain communities in Northern Pakistan to start their own trophy hunting programs along the same lines, ungulate populations have seen significant increases as a consequence and revenues generated in the 2002-3 and 2003-4 hunting seasons generated $78 000 and $82 000 respectively (Humme 2003). Another example of a successful CBTHP is that of the Beverly and Qamanirjuaq Barren Ground Caribou Management Agreement (BQCMA) presented in box 1.

Box 1 - The Beverly and Qamanirjuaq Barren Ground Caribou Management Agreement

Figure 1. Barren ground Caribou http://www.grambophoto.com/gallery/SlideShows/phpslideshow.php?directory=Project2

After population crashes in the Caribou (*Rangifer tarandus groenlandicus*) (figure 1.) herd populations in the Eastern Canadian Arctic (in the area that is since 1999 Nunavut Federal Territory) in the 1960s, 70s and 80s caused concern for their future as a sustainable resource for the indigenous population, a course of co-management was agreed upon (Hurst 2004). The size of the caribou range (approx. 700 000km^2) and the level of indigenous dependence on the species made exclusionary conservation protection of the habitat unfeasible, so therefore an ecosystem approach inclusive of local people needed to be addressed. In 1982 the Beverly and Qamanirjuaq Barren Ground Caribou Management Agreement (BQCMA) was signed by local indigenous peoples and the Canadian government. The success of a co-management program depends on a climate of mutual respect between involved parties; local peoples are far more likely to participate in conservation if they feel that their own interests are also being served (Hurst 2004). Direct local interest and involvement in maintaining a sustainable wildlife population greatly aids conservation effectiveness.

The BQCMA co-management board (BQCMB) were responsible for recommending harvest levels for the Beverly and Qamanirjuaq barren ground caribou herds; controlling the harvest allocations between jurisdictions encouraging traditional hunters to collaborate with management approaches; monitoring the status of the herds and their habitat; and developing research proposals (Hurst 2004).

Sport hunting of barren ground caribou in the Northwest Territories generates £5.3 million annually, £300 000 of that being generated in Nunavut, in 1999 each animal harvested in the Northwest Territories in guided sport hunting brought approximately £1380 into the local economy (Ashley 2000; Hurst 2004).

The impact of sport hunting on the barren ground caribou populations are monitored closely by the BQCMB, quotas are set each year dependent on the state of the population, if herd size declines below 150 000 measures are taken to halt the decline, such as predator control or revised harvest limits (Kendrick 2003; Hurst 2004). In 2004 the two herds combined population was 775 000.

2.3. Background information on saigas

2.3.1 Life Cycle of the Saiga Antelope

The saiga antelope (*Saiga tatarica*) is a migratory herding species that dwells in a few populations in the semi-arid deserts of Kalmykia, Kazakhstan and Mongolia (Bekenov *et al.* 1998). It has a discrete yearly cycle (see appendix 6.1) with seasonal migrations, male ruts and the formation of harem herds in December, and the formation of large aggregations when calving takes place during a few days in May (Milner-Gulland 1994). The migratory range of the saiga is very large, and they tend to avoid disturbance from humans where at all possible (Kuhl 2008; Singh *et al.* 2010a) this makes them dependent on the suitable undisturbed habitat, in particular the breeding grounds are important for their overall population performance (Kuhl 2008; Singh *et al.* 2010a). Migrations are from the South to the North in the summer and in the opposite direction in the winter (Figure 6.), local migrations in response to exceptional weather conditions and human disturbance can also occur (Zhirnov 1982; Fadeev and Sludsky 1982; in Milner-Gulland 1994). The habitat of the saiga in Kazakhstan is mostly semi-desert and steppe grassland. Temperatures range from 30-55˚C in the summer to -20 to -45˚C in the winter, droughts in the summer are a relatively common occurrence as are severe winter conditions known as dzhuts (Milner-Gulland 1994; Bekenov 1998; Singh *et al.* 2010). The saiga is approximately the size of a domestic goat, they are sandy coloured with a pale belly in summer (Figure 1.) then in winter their coat thickens and takes on a creamy colour (Figure 2.) (Bekenov *et al.* 1998). Adult males carry horns and the protuberant nose that is a distinctive feature of all saigas which swells in the males during the rut (Bekenov *et al.* 1998). In good years free from climatic extremes saiga populations have the potential to increase rapidly due to the early attainment of sexual maturity of the females, the high likelihood of twinning, the ability of females to remain fecund throughout their lives and the ratio bias towards females in the adult population (Milner-Gulland 1994).

Figure 2. Saiga antelope with summer coats. Photo N.Singh

Figure 3. Male saiga with winter coat. Photo Paul Johnson. http://www.arkive.org/saiga-antelope/saiga-tatarica/image-G6002.html

2.3.2 Calving

Fecundity of females is affected by their condition before mating; mean number of offspring will be significantly lower in drought years (Milner-Gulland 1994). Birthing is for the majority of the saiga population temporally and spatially synchronised, groups of up to 200 000 individuals have been known to aggregate together at this time (Kuhl 2008), calving on mass over a period of 5-8 days, this period is timed to coincide with the most advantageous time of the year, the weather is growing warmer, watering places are available nearby and plants are putting forth fresh growth (Bekenov *et al.* 1998). Mass birthing aggregations of saiga are thought to reduce predation from wolves (Sludsky 1962, Baskin 1976, Filimonov 1979, Bekenov *et al.* 1998). Adult male and female saigas segregate at the onset of the birthing season, males herding together and mostly remaining outside of the calving areas and then migrating ahead of the females that have calved (Bannikov 1961).

2.3.3 Calves

Calves exposed to frosts and cold rains which can occur around the birthing period suffer a higher mortality than those not exposed to such conditions (Bekenov *et al.* 1998). The sex ratio between male and female saiga calves is 1:1, although birth weights can vary significantly dependent on the size of the litter, the sex distribution of the litter, the date of birth, the identity and status of the mother and the location at which they are born (Kuhl 2008). Body mass at birth correlates to future fitness especially for males in who even a small weight decrease can amplify into adulthood and affect their chances of reproductive success as only the largest and hence strongest males emerge

triumphant from the rut and acquire harems (Clutton-Brock *et al.* 1982, Kuhl *et al.* 2007). Initially after birth the calves' exhibit hiding behaviour, they bed down on the ground for the first 4-5 days being visited by their mothers twice a day to be fed, and after this they follow their mothers almost constantly. Once the calves are approximately 2-3 weeks old they form nursery herds watched over by adults (Bekenov *et al.* 1998, Kuhl 2008).

2.3.4 Sexual maturity

Females are the first to achieve sexual maturity at 7-8 months old (Milner-Gulland 1994). Kuhl (2008) found that of females in their first year of sexual maturity 77.4% were fecund and of those 11.7% produced twins (Figure 4.), the tendency of first year females is to give birth to singleton calves (Fadeev and Sludsky 1982, Kuhl 2008). Males reach sexual maturity between 1.5 and 2 years old, this coincides with the full formation of their adult horns (Milner-Gulland 1994), they continue to increase in weight until they are about 3.5 years old (Bekenov *et al.* 1998).

2.3.5 Adult females

Saiga females can live up to ten years old, but generally live up to about 7 or 8 years old and weigh approximately 28.1 kg (Milner-Gulland 1994). During the mating season females form harems of between 5 to 30 or more individuals (Bekenov *et al.* 1998; Kuhl 2008) governed by one male. The fecundity of females is dependent on their physical condition at the time of mating, which is in turn dependent on the amount of summer rainfall that particular year (Milner-Gulland 1994). The gestation period is between 135-141 days (Bekenov *et al.* 1998) culminating in mass birth events in May (Milner-Gulland 1994; Kuhl 2008). Kuhl et.al (2008) found that amongst older females 94.9% were fecund and of those 72.8% produced twins, triplets are produced but not in significant numbers (Figure 4.).

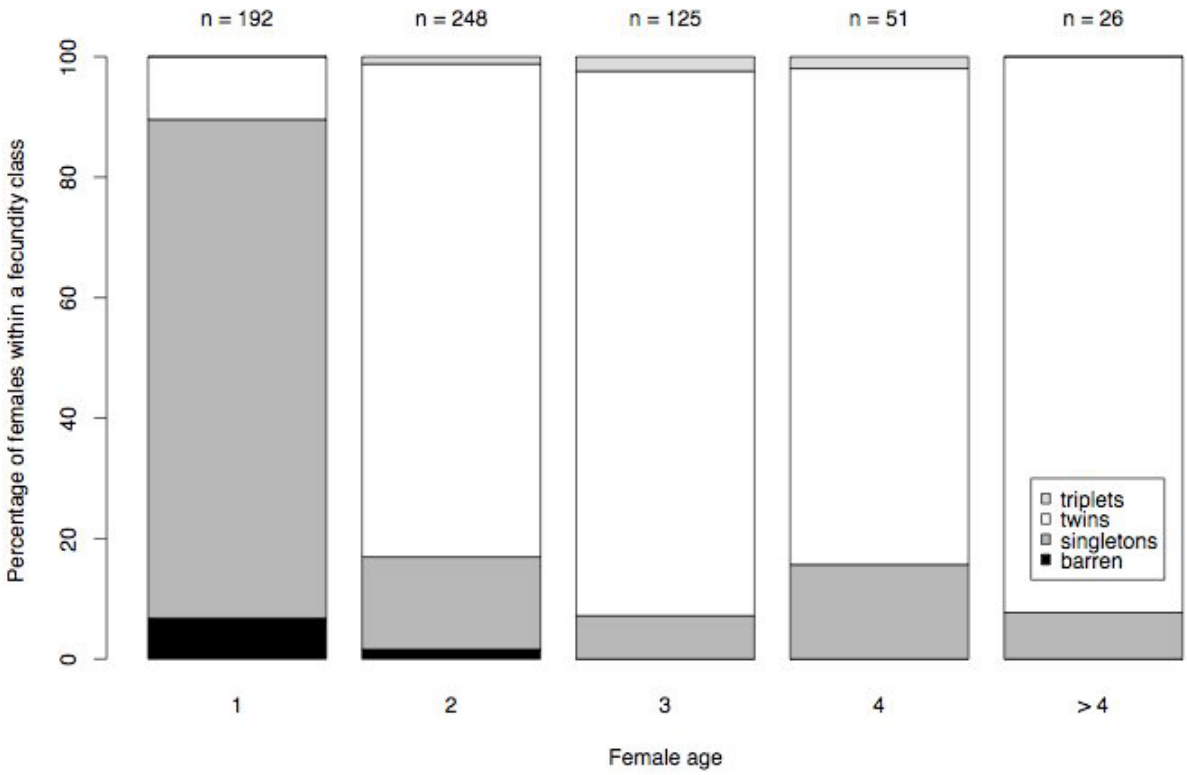

Figure 4. Graph showing fecundity differences between SF and AF (from Kuhl 2008)

2.3.6 Adult males

Figure 5. Adult male saiga. Photo: Rostislav Stach. www.cic-wildlife.org/index.php?id=57

Adult males live shorter than females, they can live up to about eight years old but generally because of the weakening caused by the rut (especially if this is followed by a harsh winter) and selective poaching they live up to about five years old (Milner-Gulland 1994), this also accounts for the female biased sex ratio of saiga adults (Bekenov *et al.* 1998).Adult males weigh up to 40.6 kg, their body size is a determining factor in whether they get to mate or not as only the strongest males will control harems, males defend between 5-50 females (Kuhl 2008), but it is thought that they will only mate with up to 12 females per mating season with the excess females not breeding (Milner-Gulland 1994). As a consequence of this pattern of behaviour reproductive success is more variable in males than in females (Clutton-Brock 1988). Adult males carry translucent amber horns (Figure 5.) that

are up to 12 inches long, these are used in battling other males for dominance over female harems during the mating season, their horns are also much valued in traditional Chinese medicine (TCM) for their curative properties.

2.3.7 Mortality

Saigas are susceptible to extreme weather conditions causing major mortalities in winter and in summer, generally female and calf mortality is higher in the summer and male mortality is higher in the winter (Milner-Gulland 1994). Newly born calves may be particularly susceptible to bad weather, mortalities being as a result of hypothermia or being too weak to suckle and therefore dying from malnutrition (Lundervold 2001). Summer droughts, occurring about 3 years in 10, may adversely affect females and calves, deaths being more from indirect causes such as predation, food shortages or disease (Lundervold 2001), these mortalities can significantly affect population growth rate (Milner-Gulland 1994). In winter saigas can be affected by a weather condition known locally in Kazakhstan as the dzhut, where snow cover is especially deep (>30cm), or dense (i.e. 0.25-0.30g/cm^2), or where there is a layer of ice over the snow, strong winds and low temperatures combine with these conditions and can cause mass mortalities (Bekenov *et al.* 1998). Dzhuts occur approximately 1 year in every 10 and have been known to cause mass starvations (Zhirnov 1972; Lundervold 2001), in 1971-1972 approximately 400 000 died in Betpak-dala alone (Fadeev and Sludskii 1982), in 1975-1976 a further 100 000 died as a result of extreme winter conditions (Lundervold 2001), males are especially susceptible to dying over the winter, making up 70-80% of the fatalities (Bannikov *et al.* 1961) as the exertions of the rut severely weaken them (Milner-Gulland 1994). The winter mortality and indeed the annual mortality being weighted more towards males coupled with the longer survival rate of the females means that the adult ratio of males to females is biased toward females (Milner-Gulland 1994). The saigas migratory movements and their high reproductive rate go some way to limiting mortality caused by extremes of climate.

Bekenov *et al.* (1998) estimated the normal annual mortality rate for adults to be at 16%, with the assumption that summer mortality was 5%. Milner-Gulland (1994) using previous sources differentiated between normal and extreme weather conditions as set out in table 1. Saigas are also susceptible to mass mortalities caused by disease such as

foot and mouth disease (Fry 2004; Morgan 2006), and in this year (2010) 12 000 saigas of the Ural population are believed to have died on mass from *pastuerellosis*, the majority of these being females and their young calves (Grachev 2010).

	Female			Male		
Age	**1**	**2**	**3-10**	**1**	**2**	**3-5**
Summer						
Normal	**22**	**10**	**10**	**22**	**10**	**25**
Drought	**76**	**15**	**15**	**76**	**10**	**25**
Winter						
Normal	**14**	**10**	**10**	**14**	**10**	**10**
Dzhut	**20**	**20**	**20**	**20**	**20**	**50**

Table 1. Mortality table (Sources: Bannikov 1961; Zhirnov 1982; Zaikin and Zhirnov 1989; from Milner-Gulland 1994)

2.3.8 Density dependence

Population growth can be affected by density dependence when resources are scarce and competition is such that female fecundity can be altered and increases in mortality take place (Caughley and Sinclair 1994). Without reliable information on true population numbers and carrying capacity density dependence can be difficult to calculate, although it has been shown to be in effect for a number of ungulate species, including saiga antelope (Coulson *et al.* 2000; Lundervold 2001). A density dependent decrease in fecundity was demonstrated by Coulson *et al.* (2000) in saigas, whereby the production of twins were reduced and singleton births increased, limited opportunities to forage in the autumn may cause poor body condition in females during conception leading to this effect. In the winter range saiga density is higher and competition with domestic animals may be in effect, limiting food availability, causing a density dependent effect (Lundervold 2001).

Lundervold (2001) suggests that even when the Betpak-dala population was at its highest count, this may not have approached carrying capacity seeing as official annual culls, taking between 12-39% of the population, had been carried out on since 1954.

2.3.9 Migratory Patterns

Saiga migrations involve travelling long distances from the winter pastures, in the southern desert zone, several hundred kilometers north to summer pastures in the steppe region; they can be found in large herds inhabiting several semi-desert areas in Central Asia and Russia (Bekenov *et al.* 1998; Kuhl 2008; Singh *et al.* 2010). Saiga

migration is driven by the search for new pastures, weather conditions, access to watering places, levels of disturbance and the difficulty of foraging, i.e. as a consequence of deep snow (Lundervold 2001; Singh *et al.* 2010), as these drivers are unpredictable, their routes, speed of travel and temporal patterns are variable. Winter ranges are south of latitude 48˚, this is a desert zone, distribution is governed by snow depth and density, in spring they move northwards, stopping to form birthing herds in May and then continuing towards latitude 49˚ where they range for the summer in semi-desert regions. In autumn saigas form large migration herds and then beginning their journey back southwards, spreading out over large distances on route to the winter ranges (Lundervold 2001). Saigas do not remain in the same migrating groups from season to season and neither do they stick to the same migration patterns, both temporarily and spatially. Although exact patterns of saiga movements are not known, approximate migration routes for the Kazakhstan populations are shown in figure 6 (Bekenov *et al.* 1998).

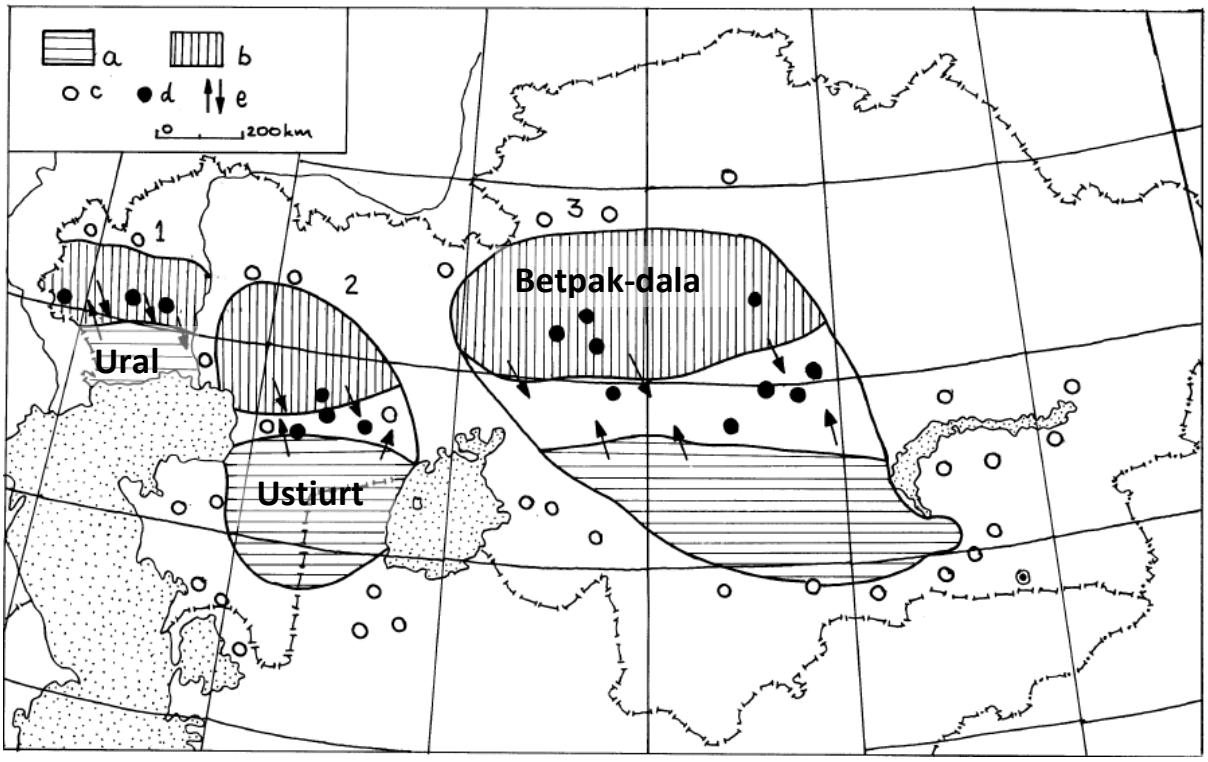

Figure 6. – Approximate migratory ranges of Kazakhstan saiga populations (from Bekenov et.al 1998). (a) winter ranges; (b) summer ranges; (c) occasional sightings; (d) usual birth areas; (e) Migration routes

2.3.10 Historical exploitation of the saigas.

Hunting of saiga antelopes has been in practice for centuries, it wasn't until late in the 19th and early in the 20th century that they were over exploited as a resource for the first time and they experienced severe declines in their population numbers (Bekenov *et al.* 1998; Milner-Gulland 2001). Whilst under the governance of the Soviet regime restrictions imposed on the hunting of saiga allowed them to recover to large numbers, although during this period extensive land use changes were introduced within the saiga ranges, expanding existing agricultural use of the land (Singh *et al.* 2010). With the collapse of the Soviet Union, restrictions on saiga hunting were removed, coupled with the opening of the Chinese-Russian border and an increased trade in saiga horn for the TCM market and heavy pressure from poaching by rural Kazakh peoples due to widespread unemployment and poverty, these and other pressures lead to severe overharvesting of the saiga and a subsequent population decline of over 90% in only 15 years (figure 7.) (Milner-Gulland *et al.* 2003; McConville 2006). As a consequence of this over exploitation it is thought that the saigas have become more wary of humans, which may have affected their detectability (McConville *et al* 2009.; Singh *et al.* 2010).

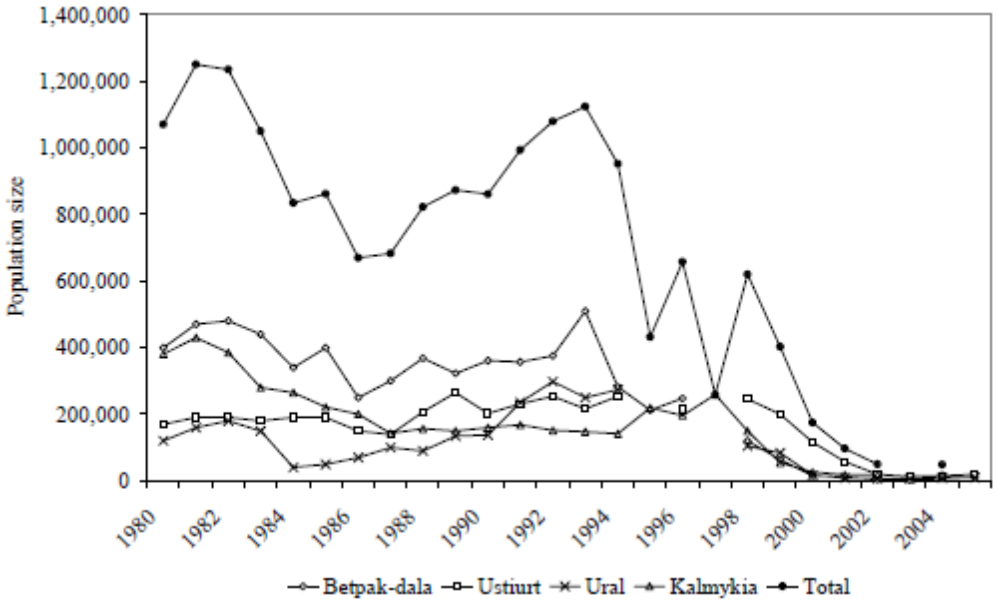

Figure7. Pattern of population decline for the saiga antelope (*Saiga tatarica*) for all population groups. (Taken from McConville 2006, data from the Institute of Zoology, Almaty).

2.3.11 Why are saigas a good prospect for trophy hunting?

The potential for saiga antelopes to rapidly increase their population numbers due to their high rates of fecundity, early sexual maturity for females, lifelong productivity, and high likelihood of adult females producing twins, indicates that they as a species could be suitable to a sustainable trophy hunting programme (THP). Population growth or decline is highly dependent on levels of female mortalities and fecundity rates. Trophy hunting is far more likely to target the adult males in the population and if the level of adult male off-take is carried out sustainably allowing adult male replacement, from the sub-adult male population, through age dependent selection of trophy targets, even with concessionary allowances for accidental kills, the success of a THP is plausible. Potential revenue from trophy hunting of saigas can be estimated from current species hunted in Kazakhstan and Mongolia.

2.3.12 Current conservation measures in Kazakhstan

The decline of saiga overall population numbers of approximately one million individuals in the early 1990s by 95% over just 15 years (Milner-Gulland 2003), is one of the most sudden known in a large mammal (Edge of Existence 2010). They are listed as critically endangered on the IUCN Red List (IUCN 2010); all states, except Mongolia, within the saiga ranges have signed a multilateral environmental memorandum of understanding, under the Convention on the Conservation of Migratory Species (CMS) (Saiga Conservation Alliance 2010), concerning the conservation, restoration and sustainable use of saiga antelope; and they are included on Appendix II of the CITES listings "in which trade must be controlled in order to avoid utilization incompatible with their survival" (CITES 2010). Although there are signs of recovery in some populations due to conservation efforts, they are still particularly vulnerable to poaching due to their relatively large body size and exposure to anthropogenic pressure as a result of their large migratory ranges (Kuhl 2008). Pressure is increased as a result of the demand for saiga horn for Traditional Chinese Medicine (TCM) and high prices are paid for saiga horn (e.g. $300 per kilo in the Kazakhstan capital, Almaty (Kuhl 2008). Its popularity for use in TCM having increased since the 1980s, when saiga population numbers were much higher and it was promoted as a cheaper alternative to Rhino horn (Western and Vigne 1985).

In 2006 the Altyn Dala Conservation Intiative (ADCI) was set up to focus on conservation issues of saiga antelope and other key species of the steppes, they provide support for anti-poaching efforts already in existence and has the eventual goal of establishing a protected area network of approximately 3-4 million hectares within the range of the Betpak-dala population (Klebelsberg 2008). Saiga population groups in Kazakhstan are surveyed annually by the Institute of Zoology of Kazakhstan (in conjunction with the Committee for Forestry and Ranching of the Ministry of Agriculture of the Republic of Kazakhstan, the Industrial Association Okhotzooprom, regional departments of the Forestry Committee, the Association for the Conservation of Biodiversity of Kazakhstan), using aerial surveys and ground vehicle surveys (McConville 2006; Grachev 2008; Singh *et al.* 2010). A problem with population counts is that the saigas are unevenly distributed and their range covers a huge area so there is a possibility of missing entire herds, causing an underestimation of their numbers or alternatively a survey may happen upon saigas in their highest density and cause an overestimation of their numbers (Lundervold 2001; McConville 2006). The ADCI are now also involved in the monitoring of the Betpak-dala population, looking to improve surveying techniques and monitoring methodology, with the aim of producing more reliable figures for the population and further understanding their migratory patterns (Klebelsberg 2008).

2.4 Location and community background (Study area)

The Betpak-dala saiga population range (figure 8.) lies between the Aral Sea to the west and Lake Balkhash to the east, to the North in the summer to a similar latitude as the Kazakhstan capital Astana and South in the winter as the border town of Taraz. Their range may cross into parts of several of Kazakhstan's regional provinces (Kyzlorda, South Kaz and Zhambyl in the South; Karagandy in central Kazakhstan; and Kostana and Akmola in the North). Migratory patterns are thought to be governed by temperature, food availability and level of disturbance from people (Kuhl 2008), but much remains unknown about their movements and grouping behaviour throughout the year (Bekenov 1998). The migration of the Betpak-dala population group covers approximately 600-1200km each way, moving from South to North in the summer and vice versa in the winter (Bekenov 1998; McConville 2006; Singh *et al.* 2010). This central part of Kazakhstan is dominated by vast areas of steppe grassland habitat and semi arid desert,

mostly free of trees, it has a few larger towns and sparsely dotted with rural communities and farming outposts, town density is indicated in figure 9. The Kazakhstan saiga population was formerly counted as one population but between 1960 and 1990 human settlements and land cultivation reduced suitable habitat sufficiently to split the population into three separate groups occupying the range areas of Ural, Ustiurt and Betpak-dala. A survey conducted between 1986 and 1993 (Grachev and Bekenov 1993) of 14 000 marked calves proved that there was no inter-group mixing between this time. Betpak-dala has more human inhabitants than the other range areas in Kazakhstan and more domestic livestock is farmed in the range area, so as a consequence saigas stand a greater chance of transmissions of diseases or parasites from contact with domestic livestock and disturbance from humans (Lundervold 2001).

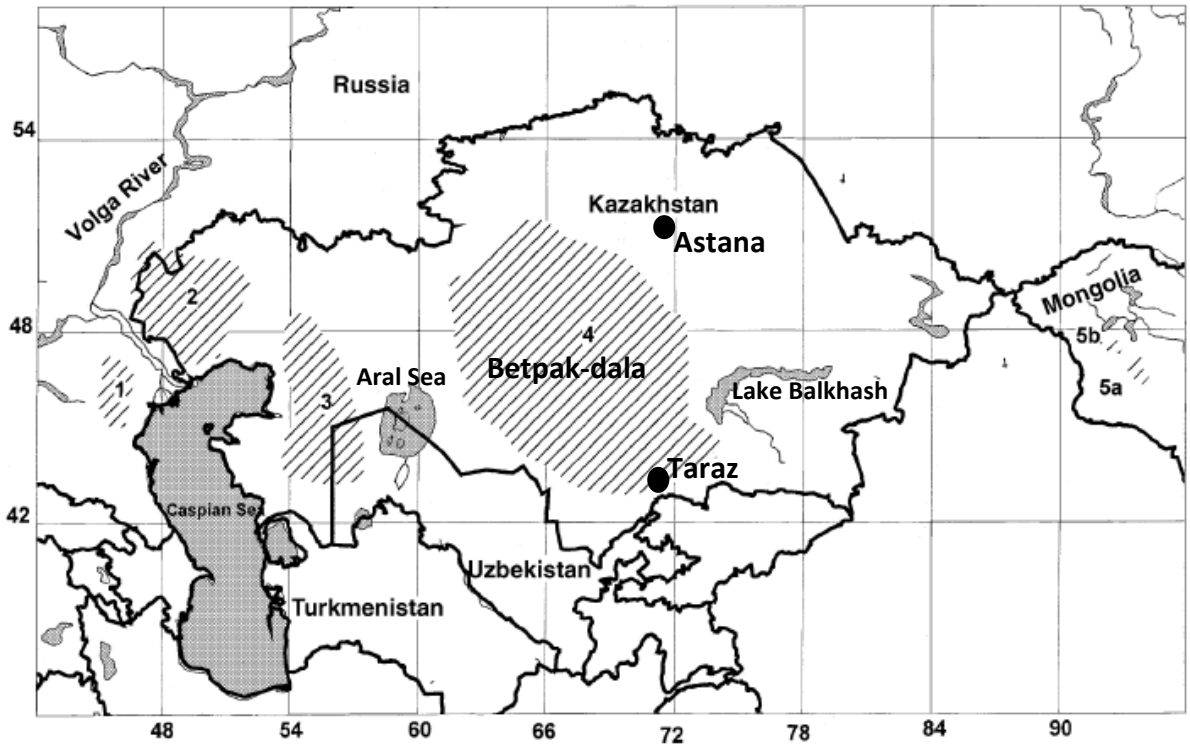

Figure 8. Location of the Betpak-dala population (from Milner-Gulland *et al.* 2001)

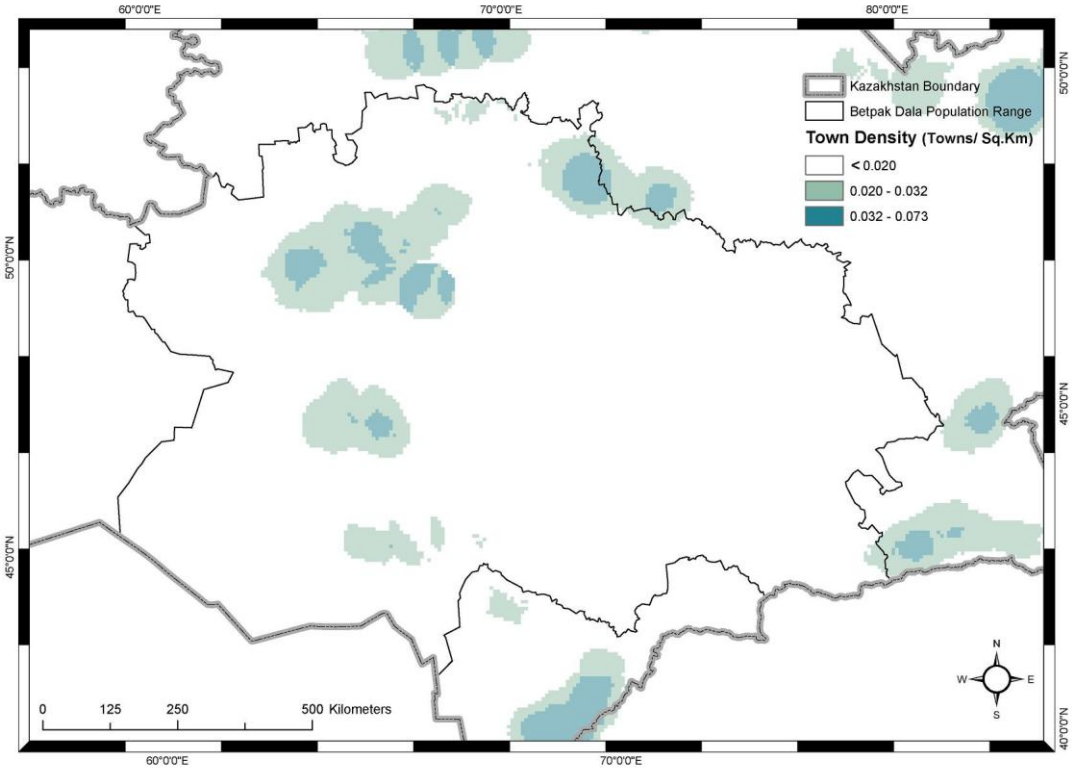

Figure 9. Town density in the Betpak-dala region (used with kind permission of N.Singh 2010)

Section 3. Methods

3.1 Population dynamics model

The basic population dynamics model is a Leslie matrix model and works as represented in the figure 10. The Leslie matrix is time discrete and age-structured model of population growth, with emphasis on female fecundity. This demonstrates the generational succession of the different age classes used in the model. N_1 represents calves (juveniles) born in the last year, N_2 represents the sub-adult class, females in this class are sexually mature whereas males are not, and N_A represents mature adults from two years upwards. Survival from one year to the next is represented by S_1 for juveniles moving into sub-adult class, S_2 for sub-adults moving into the adult class and S_A for last year's adults surviving into the next year. P_1 represents sub-adult female fecundity contributing to next year's calves and P_2 represents adult female fecundity producing next year's calves. H represents the hunting off-take for adults and sub-adults.

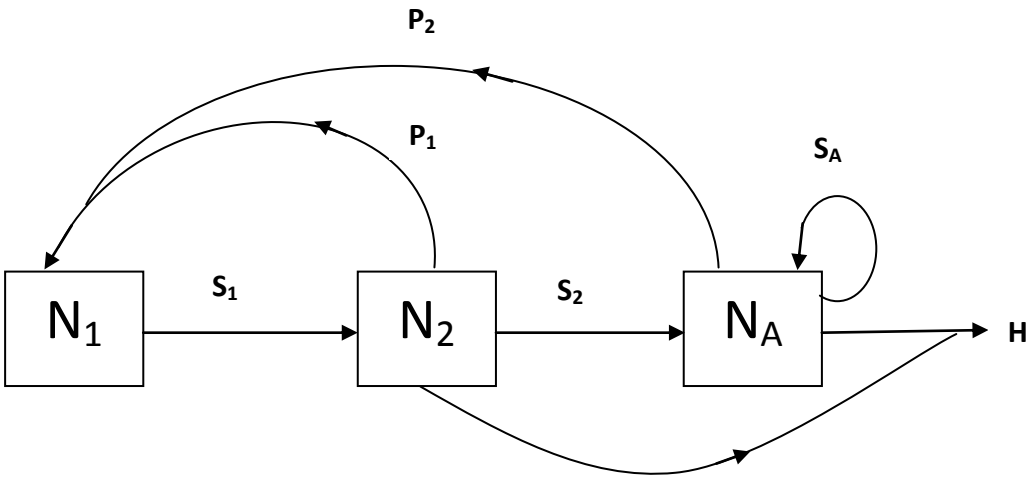

Figure 10. Graphical representation of generational succession of different age classes, with additional hunting pressure (H).

The basic population dynamics model is heavily dependent on female fecundity rates, both for sub-adults and adult females, for the perpetuation of the total population growth. Male influence within this model set up is minimal and population growth or decline is governed by the manipulation of sub-adult and adult female vital rates. Climatic effect was highlighted as an important factor to include within a modelling set

up to give a closer reflection of a natural system as regards saiga antelopes (Milner-Gulland 1994). For this reason the basic model used in this thesis had a stochastic climate effect imposed on it, as used in Milner-Gulland (1994), all variations of the model were applied to that basic stochastic model set up.

The basic stochastic model was written to take into account the unpredictability of the climate, four year types being a possibility: 1) Good summer and a good winter. “Good”, meaning in this case not subject to adverse weather conditions; 2) Good summer and bad winter. “Bad winter”, meaning a year in which dzhut conditions occur; 3) Bad summer and good winter. “Bad summer”, meaning a year in which drought conditions occur; 4) Bad summer and bad winter. In addition to the basic stochastic model, three further condition scenarios were placed upon the model.

Scenario 1) – Density dependent conditions causing a decline in female fecundity when the overall population is at carrying capacity (as suggested to be the case by Coulson et.al 2001), and an additional mortality rate imposed on adult females for the summer, when they are reported to be particularly susceptible to mortalities.

Scenario 2) In addition to the density dependent conditions imposed on the first scenario, hunting pressure is also applied to any of the age or sex classes.

Scenario 3) In addition to the conditions on scenarios 1 and 2, a condition causing a drop in fecundity of adult females to 20% of the expected rate when the ratio of males to total fecund females is less than 2.5% (as described by Milner-Gulland *et al.* (2003) is imposed. This is to cater for the hunting preference for adult males, which potentially could skew the sexual bias of the population,

The details of the basic stochastic model are reported below. Models were run 1000 times to establish a mean effect over 50 years.

3.2 Randomly generated climate year type

The four different climate states as described above had differing probabilities as shown in table 2.

State	Summer	Winter	Probability	Cumulative probability
1	Good	Good	0.63	0.63
2	Good	Bad	0.07	0.7
3	Bad	Good	0.27	0.97
4	Bad	Bad	0.03	1

Table 2. Possible climatic states for a given year (Source Milner-Gulland 1994)

A random number was generated (using the excel random number generating formula) between 0 and 1 to represent each year based on the cumulative probability shown in table 1, e.g. 0-0.63 =state 1(63% chance of occurring in any given year), 0.63-0.7 = state 2 (7% chance of occurring), 0.7-0.97 = state 3 (27% chance of occurring), and 0.97-1 = state 4 (3% chance of occurring).

3.3 Overall survival rates

Rates for all age and sex classes (Table 3.) are calculated from the mortality rates stated in Milner-Gulland (1994), these had previously been sourced from Bannikov (1961), Zhirnov (1982) and Zaikin and Zhirnov (1989).

State	Juvenile males	Juvenile females	Sub-adult males	Sub-adult females	Adult males	Adult females
1	0.64	0.64	0.8	0.8	0.65	0.8
2	0.58	0.58	0.8	0.7	0.4	0.7
3	0.1	1	0.8	0.75	0.5	0.75
4	0.04	0.04	0.7	0.65	0.25	0.65

Table 3. Overall survival for all sex and age classes in a given year (source: Milner-Gulland 1994)

3.4 Density dependent rates

Density dependent rates imposed on the model had differing effects depending on the population status and behaviour. Adult female fecundity was affected by either the total population exceeding the carrying capacity (K), or the male ratio to total fecund females declining to less than 2.5%, in both cases female fecundity was dropped to 20% of the expected rate for that year. Adult female survival was subject to an additional summer mortality rate (0.16) to account for disease transmission and being in a weakened

condition after calving. Density dependence was also imposed on calf survival (0.43), as harsh weather during the calving period may cause limits to available food resource. Carrying capacity of the Betpak-dala population is unknown, the highest population size estimated from aerial counts was 995 000 in 1974 (Lundervold 2001), for the purpose of constructing the model used in this thesis it was set arbitrarily at 200 000.

3.5 Hunting pressure

It is assumed that the preferred quarry of trophy hunter will be in the majority adult males, as their possession of horns fulfils the basic tenant of a trophy prize (Shackleton 2001). Hunting pressure parameters were set to a base state which allowed the total population to achieve 75% of carrying capacity, from this base state parameter setting adjustments were made to investigate varying degrees of hunting pressure on the different age and sex groups. The base state settings are shown in table 4. Juveniles are presumed to be of no interest to trophy hunters, the concessionary rates awarded to both sub-adult groups and adult females are to allow for those that may be shot by mistake during a hunt, variations in the concessionary rates were tested to assess the impact of alternative selection or careless hunting.

Age and sex class	Hunting base state	Deviations from base state
Juvenile male	0%	
Juvenile female	0%	
Sub-adult male	10%	15%, 20%
Sub-adult female	5%	10%
Adult male	50%	75%, 80%, 85%, 90%
Adult female	10%	20% , 30%

Table 4. Base state hunting pressure. Percentages are of the particular age or sex class, not of the entire population

3.6 Fecundity rates

Fecundity rates were calculated by multiplying the mean number of calves produced in the summer dependent on the climatic state and the age of the female (source: Bannikov 1961) by the proportion of females pregnant in the winter dependent on the climatic state and the age of the female (source: Zaikin and Zhirnov 1989), this was as used by Milner-Gulland (1994). Fecundity rates are shown in Table 5.

State	Last year		Adult females	Sub-adult females
1	Good summer	Good winter	1.68	0.89
2	Good summer	Bad winter	1.49	0.53
3	Bad summer	Good winter	0.96	0.85
4	Bad summer	Bad winter	0.85	0.5

Table 5. Fecundity rates for the four possible year types.

Manipulation of the fecundity rates were achieved by keeping hunting levels at the base state, year type probabilities as stated in the literature (Milner-Gulland 1994). Fecundity rates were then manipulated by reducing the conception rates for sub-adult females and adult females (good year or bad year depending on the previous summer) and mean number of offspring rates for sub-adult females and adult females (good year or bad year depending on the previous winter) by 10% (see appendix. tables 7.2.1. and 7.2.2), the resulting fecundity rates (table 6) were applied to the model.

Year type	Normal fecundity		Reduced fecundity	
	Adult female	Sub-adult female	Adult female	Sub-adult female
Good summer/good winter	1.68	0.89	1.36	0.72
Good summer/Bad winter	1.49	0.53	1.2	0.43
Bad summer/good winter	0.96	0.85	0.78	0.6885
Bad summer/bad winter	0.85	0.5	0.69	0.405

Table 6. Resulting fecundity rates from mean offspring x conception rate. Both mean offspring and conception rate have been reduced by 10% to achieve the variation in fecundity rates.

3.7 Basic stochastic model

The saiga population was divided into three separate age classes and three separate sex classes, these being: Juvenile males and females, sub-adult males and females, adult males and females. Juvenile males and females represent the calves born in a given year, they are non-reproductive and their number is subject to the fecundity rates of last year's adult female and sub-adult females' populations, their ratio at birth is 1:1 (Milner-Gulland 1994; Kuhl 2008), therefore their number will be equal. Sub-adult males and

females represent first year sexually mature females and pre-sexually mature males; they are both subject to their overall survival rate for the year applied to last year's number of juveniles. The overall survival rate for all age and sex classes is dependent on a random generated selection of one of the four climate year types. The ratio of sub-adult females to males is also 1:1 (Kuhl 2008), which again means that their numbers will be equal. Adult males represent fully mature males, their number is dependent on last year's sub-adult males' randomly generated overall survival rate applied to last year's sub-adult males number, added to last year's adult males randomly generated overall survival rate applied to last year's adult number. Adult females represent females of two years and above i.e. fully fecund, their number is dependent on last year's sub-adult females randomly generated overall survival rate applied to last year's sub-adult females number added to last year's adult females randomly generated overall survival rate applied to last year's adult female number. In addition to this the density dependent summer survival rate is imposed upon the resulting adult female number.

3.8 Sensitivity analysis

Vital rates and year type probabilities within the models were manipulated to test the potential variations that may occur as a consequence of changes in climate or new biological information that may come to light regarding saiga antelopes The base rate of hunting pressure was kept constant and vital rates were adjusted as well as year type probabilities from those established in previous literature (Milner-Gulland 1994).

Section 4. Results

4.1 Establishment of a base state

Hunting pressure was set at a conservative level of 50% of adult males. The carrying capacity (K) condition imposed means that the population in the no hunting scenario (scenario 1) rises to 10% above K and stabilises at that level (figure 11). With hunting of adult males (scenario 2) set at 50% the population is able to stabilize at approximately 95% of K (figure 11). The scenario including the fecundity effect (scenario 3) when male numbers drop to a very low level causes the population to stabilise at approximately 70% of K but does not cause a population collapse. This set up under all three scenarios allows growth to, and stabilisation at healthy population numbers (figure 11); this set up was used as the base state when vital rates and year type probabilities were manipulated to test sensitivity. The starting population used in the model was 22 800 from the previous year (2007 population count, Duisekeev and Sklyarenko 2008) with 19 438 new born calves added to that number (calculated using fecundity and twinning rates), of this population 3990 were adult males, from these population levels, for all scenarios, the total population will experience growth for 22 years before achieving carrying capacity and stabilising at that level (figure 11).

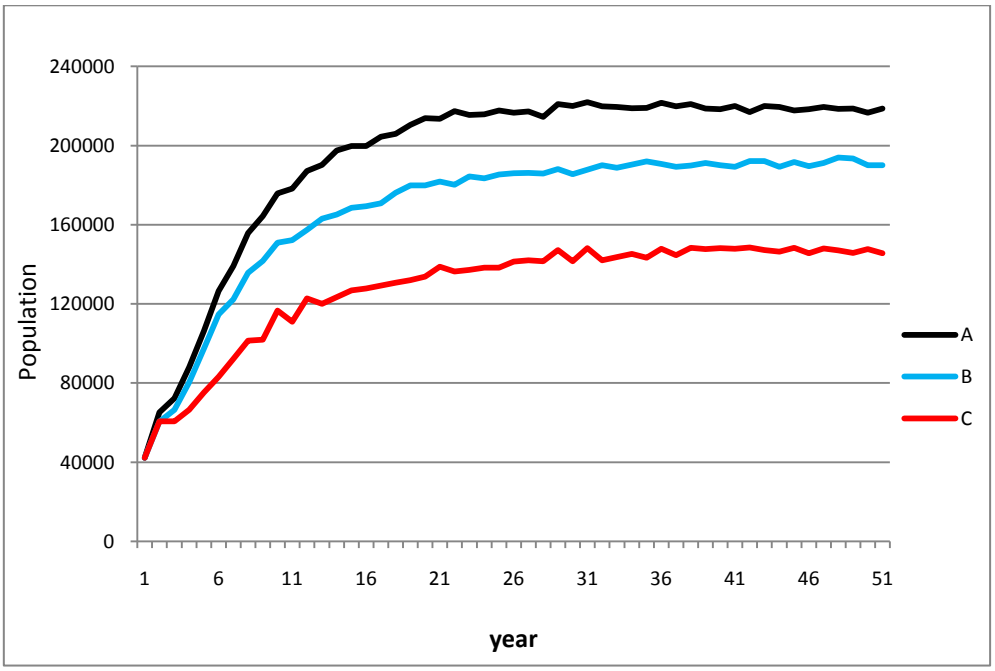

Figure 11. Base state set up for the stochastic model. A = density dependent conditions imposed with no hunting; B = Density dependent conditions imposed with hunting; C = density dependent conditions imposed with hunting and male to female ratio fecundity effect imposed.

4.2 Manipulation of hunting pressures

Due to the preference of trophy hunters for adult male trophies hunting pressure on all other sex and age groups were kept at constant rates and only manipulated from the base state for adult males. The base state hunting pressure on adult males was set at 50%, this had no effect on female fecundity and allowed growth and population stability at 70% of carrying capacity with all conditions of the model applied. Male hunting pressure levels were tested at 75%, 80%, 85%, and 90% of the adult male population.

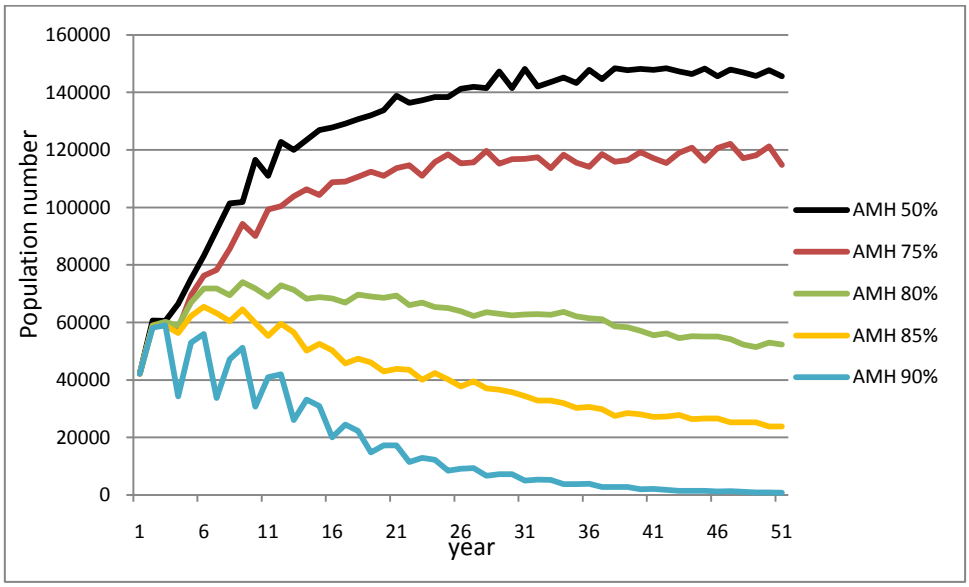

Figure 12. Differing results of hunting pressures applied to model with all density dependent and female fecundity reducing conditions imposed. AMH = hunting pressure applied to adult males.

Increasing the hunting pressure on adult males above the base state of 50% was only sustainable up to hunting 75% of the male population, this allowed the total population to rise to 60% of carrying capacity. From 80% of the male population harvested and above the total population showed a declining trend, hunted at 90% of their number male numbers dropped often below the threshold causing the effect on female fecundity and the total population collapsed, results are represented graphically in figure 12. Hunting pressure was increased on sub-adult females and adult females to assess the impact on the total population, having the greater influence on population numbers, increases to 20% for both classes, caused reductions in population stabilisation levels and greater hunting pressure caused total population declines. For the achievement of total population stability at 75% of carrying capacity limits of hunting pressures needed to be imposed upon each sex and age class would be: no

hunting of juveniles; sub-adult males hunted at between 10-20% of their number within the total population; sub-adult females hunted at between 5-10% of their number within the population; adult males hunted at between 50-65% of their number within the total population; and adult females hunted at between 5-10% of their number within the total population. This range of hunting options accounts for approximately 10% of the total population with males making up 75-80% of those in the harvest.

4.3 Sensitivity analysis

4.3.1 Reduction in year type probabilities

Milner-Gulland (1994) states that the data for the frequency of adverse weather conditions is based on anecdotal evidence, there is also the potential that the probabilities of adverse weather conditions may change due to global or regional climate change, this would affect the occurrence of years in which there are both good summers and good winters, for these reasons changes in year type probabilities were manipulated.

Climate change models from the Intergovernmental Panel on Climate Change (IPCC) predict that in the desert areas of Kazakhstan there will be a decrease in summer precipitation and an increase in the amount in winter (IPCC 2007), this would lessen the probability of a year with no adverse weather occurring, for this reason year type probabilities were manipulated in the model to explore the effect of a decrease in wholly good weather years. Hunting pressure levels were kept at the base state. Year type probabilities were manipulated by reducing the probability of a good summer and good winter year by 15% and then equally distributing the deficit amongst the other categories. This resulted in increases of probabilities of differing percentages for the other categories, these being: Good summer/bad winter year probability increased by 31%, bad summer/good winter year probability increased by 11.5%, bad summer/bad winter year probability increased by 51% (table 6). The result of these changes (table 7.) was to slow the rate of population increase for both the no hunting and hunting only scenarios, although both were able to approach a level of stability at 90% and 80% respectively, of carrying capacity. The scenario including the fecundity effect was only able to increase from the starting population by a limited amount until it stabilised at approximately 55% of carrying capacity. This test was then repeated with adult male

hunting pressure at 75%, as a stable population had been achieved at this level of hunting previously using the model, this had little effect on the no hunting and hunting only scenarios but caused a downward trend after an initial rise in population in the scenario with all conditions in place. Year type probabilities were then manipulated as above but with a 20% reduction in good summer/good winter year probability, the resulting increases for the other categories were: Good summer/bad winter year probability increased by 37.5%; bad summer/good winter year probability increased by 13.5%; and bad summer/bad winter year probability increased by 58.3% (table 6). At 50% hunting pressure on adult males the results (table 7.) were similar to the 15% change in year probabilities as reported above, with a slowing of the rate of population increase and a reduction in the total population level at which the models for no hunting and hunting stabilised to approximately 85% and 75% respectively, of carrying capacity. In the scenario including the fecundity effect the total population experienced a smaller rise and stabilised at 45% of carrying capacity. When hunting pressure on males was increased to 75%, with all other hunting pressures remaining the same, scenarios 1 and 2 experienced little or no change, scenario 3 decreased after an initial small rise and showed a stronger downward trend than observed in the 15% year probability change.

Year type	Probability of occurrence	Probability change 1 (PC1)	Probability change 2 (PC2)
Good summer/good winter	0.63	0.5355 (-15%)	0.504 (-20%)
Good summer/Bad winter	0.07	0.1015 (+31%)	0.112 (+37.5%)
Bad summer/good winter	0.27	0.3015 (+11.5%)	0.312 (+13.5%)
Bad summer/bad winter	0.03	0.0615 (+51%)	0.072 (+58.3%)

Table 7. Manipulation of year type probabilities. Probability of good summer/good winter was reduced in both PC1 and PC2, the difference was then evenly distributed amongst the other categories, increasing the probability of years with adverse weather.

Scenario	% carrying capacity (K)			
	PC1- AMH = 50%	PC1- AMH = 75%	PC2- AMH = 50%	PC2- AMH = 75%
1	90	90	85 - 90	85 – 90
2	80	80	75 - 80	75 – 80
3	55	40 declining to 30	45	30 declining to 20

Table 8. Effects of year type probability manipulations on total population. AMH – adult male hunting pressure

4.3.2 Reduction in fecundity rates

The result of changes in fecundity was to slow the rate of population increase and reduce the total population level at which the models for no hunting and hunting stabilised to approximately 90% and 80% respectively, of carrying capacity. In the scenario including the fecundity effect the total population rose to approximately 48% of carrying capacity and then stabilised at that level. The test was repeated with hunting pressure on adult males set to 75% and the result was practically the same for the no hunting scenario, a similar growth rate for the hunting scenario but stabilisation occurring at approximately 70% of carrying capacity and the scenario with including the fecundity effect due to low male numbers showed a downward trend after an initial rise in total population. The impacts on the total population of both levels of hunting pressure on adult male are shown in table 9.

Scenario	% carrying capacity (K)			
	Normal fecundity (AMH = 50%	Normal fecundity (AMH = 75%)	Reduced fecundity (AMH = 50%)	Reduced fecundity (AMH = 75%)
1	K + 10	K + 10	85 - 90	85 - 90
2	95	90	75-80	70
3	70	60	48	40 declining to 30

Table 9. Effects of reduced fecundity on total population. AMH = adult male hunting pressure

4.3.3 Reduction in overall survival rates

Hunting levels were kept at the base state, year type probabilities and fecundity rates were as stated in the literature (Milner-Gulland 1994). Overall annual survival rates (OASR) (see appendix table 7.3.1) (based on mortality rates as stated in Milner-Gulland 1994) were reduced by 10% (see appendix table 7.3.2). The result of these changes

(Table 10) was to slow the rate of population increase, the scenario without hunting pressure continued to rise but began to stabilise between 70 and 80% of carrying capacity, the scenario with hunting rose to a level of approximately 70% of carrying capacity and then stabilised at that level. In the scenario including the fecundity effect the total population showed a downward trend after an initial rise in total population (Table 10). The test was re-run with adult male hunting pressure set at 75%, the no hunting scenario performed similarly, beginning to stabilise at 80% of carrying capacity, the hunting scenario rose and then began to stabilise at between 60 and 70% of carrying capacity. The scenario including the fecundity effect as a result of very low male numbers in the population showed a decline in total population to approximately 60% of the starting population.

Scenario	% carrying capacity (K)			
	Standard OASR (AMH = 50%	**Standard OASR (AMH = 75%)**	**Reduced OASR (AMH = 50%)**	**Reduced OASR (AMH = 75%)**
1	K + 10	K + 10	70 - 80	70 - 80
2	95	90	70	60 - 70
3	70	60	40 declining to 30	30 declining to 15

Table 10. Effects of reduced overall annual survival rates (OASR). AMH = adult male hunting pressure

Section 5. Discussion

The model set up placed particular emphasis on the majority of animals to be hunted being adult males as literature reviewed indicated that trophy hunters seek a prize with impressive physiological features such as horns, which only male saigas possess. Certain concessionary hunting levels were allowed for other sex and age classes to cater to those hunters that may be unable to find a suitable adult male or shoot one of the other classes by mistake. Manipulation of hunting pressures, with all other conditions imposed, revealed off-take levels that would allow the population to continue to grow and achieve a stable population level at 70% and above of carrying capacity. Sensitivity analysis revealed that when the probability of years with a good summer and a good winter was reduced (with an adult male hunting pressure of 50%) there would be a slowing of population growth rates and a lower level of population stabilisation in relation to carrying capacity, results were similar when fecundity rates and OASR were reduced. Increasing hunting pressure on adult males to 75% of their number caused population declines in all of the sensitivity analysis tests. Results from running the model imply that focussing a trophy hunting programme on adult males in the majority is feasible and sustainable but population declines and reduced growth rates could occur if the frequency of adverse climatic conditions increases or if vital rates are negatively affected.

5.1 Levels of hunting

The base state with adult male hunting pressure at 50%, no hunting of juveniles and very limited allowances for both sub-adult sexes and adult females allows the population to be supported by the high rate of female fecundity, the attainment of sexual maturity of females in their first year, the high possibility of twinning in adult females and the continued possibility of females to reproduce throughout their lives. Adult males are known to be able to fertilise harems of up to 12 females, male numbers therefore can drop to relatively low numbers before there is an effect on female fecundity, as shown by Milner-Gulland *et al.* (2003). Hunting males at higher rates with the same base state set up as before for the other sex and age classes can allow growth and a levelling out of the population at a proportion of carrying capacity when a hunting pressure of 75% on

adult males is applied, above 75% the total population shows declines, with continuing downward trends apparent. Future pressures on the saiga populations are not likely to be only from controlled and regulated trophy hunting programmes if that course of action was adopted. The saigas susceptibility to mass mortalities from disease as a result of severe weather conditions and a level of continued poaching, would place additional unpredictable stresses on the population. At the base level hunting pressure of 50% of adult males would allow a buffer up to 75% mortalities affecting adult males to cater for this unpredictability. Even with a buffer hunting quotas would need to be assessed annually based on the health of the population. Manipulation of the hunting pressures on all but the juveniles in the model showed that the population could experience 22 years of growth before levelling out at a 75% of carrying capacity at a yearly hunting rate of 10% of the total population, with males making up 75-80% of that 10%.

5.2 Age estimation methods

Setting age and sex classed limits on the permitted quota requires that the target quarry of a trophy hunt can be identified to be in a certain age or sex class as reliably as possible. Age estimation methods to be as accurate as possible require tooth evaluation tests to be carried out on dead saigas (Lundervold 2003), even if this was possible on live saigas, for the purposes of hunting they are not practical. Visual estimation of age relies on assessing body size, physical condition and male horn characteristics, these aspects are more useful when applied to males, visual aging of females being more difficult (Lundervold 2003). Adult males achieve their full body size by 3.5 years and their horns are fully developed by two years old, younger males have shorter, straighter horns with black tips. The reliability of estimating male age decreases after 1.5 years. Post kill, during a trophy hunt tour, all saigas could be age assessed using a combination of physical appearance and a tooth eruption method, based on presence of the last appearing permanent teeth (which appear at 19-26 months), this way an establishment between sub-adults and adults taken can be taken into account for monitoring purposes.

5.3 Hunting season

The former hunting season for saiga antelopes was from 1st October to 30th November ending just before the males gather together for the rut, taking males out of the

population at this time, especially with the preference for taking the largest of the males as trophies, risks allowing weaker males to add a greater contribution to the next generation. In other ungulate species such as big horn sheep and sable antelope removal of prime males has interfered with mating behaviour, leading to delays in calving and phenotypic effects resulting in reduced fitness in the next generation (Fergusson 1990; Coltman 2003). Also removal of too many older males before the mating season may involve more younger males in the rut which may suffer increased mortality over the winter. Moving a hunting season after the rut into January, would give prime adult males the opportunity to mate and would reflect the natural pattern of male mortalities over the winter. To allow hunting to cover a larger geographic area and therefore include more communities, the hunting season could potentially continue until the beginning of April when the birthing aggregations begin to form. The population count for the saigas in the Betpak-dala population is conducted at this time, this would enable an assessment of the impact of the hunting season, as well as estimating the population status before mass calving begins. Efforts are being made to improve the count to gain a more accurate estimation of the total population. With the benefit of annual population data, an assessment of what proportion of the population would be tenable to allow for trophy hunting could be made for the next hunting season. Proportional off-take is preferable to a constant set number as stochastic climate effects and the possibility of mass mortality caused by disease, as seen in May 2010 (when 12 000 saigas from the Ural population group were found dead believed to be due to *pastuerellosis*), could cause detriments to the population. Milner-Gulland (1994) showed that to achieve sustainable yields from a saiga population harvest, a heavy bias on males was necessary but not so heavy as to over deplete the breeding stock. Hunting every year would be feasible as long as the off-take from the total population is around 10%.

5.4 Harvesting strategy

A trophy hunting programme including saigas would likely show a higher selection for males, as they are the only ones who bear horns. It is for that reason that hunting levels in this study were focussed on adult males and hunting rates affecting the other age and sex classes were concessionary to cater for accidental shootings. With hunting of male adults at 50% annually, in the base state set up, from the starting population of 42238,

mean growth of the population can still continue for 22 years and then achieve a stable level at 70% of carrying capacity. That stable level can continue with the same rate of hunting. Even with a substantial increase of hunting pressure on adult males to 75% the total population experiences a similar growth period and stabilises at 60% of carrying capacity. The base state set up equates to 1995 adult males, 462 sub-adult males, 231 sub-adult females, and 958 adult females, giving a total of 3646 individuals able to be hunted in the first year, but caution needs to be exercised as the population growth observed in the model is a result of stochastically generated year type possibilities. If there was an instance of adverse climatic conditions for two, three or more years, then male numbers may drop so much as to cause a population collapse due to the male to female ratio in the total population. It may be prudent to allow the population to reach a precautionary threshold limit before the commencement of a trophy hunting program.

5.5 Precautionary harvest limits

Precautionary off-take limits should be assessed annually after the population count has been conducted. Within this assessment several factors should be taken into consideration i.e. numbers of trophy hunts conducted the previous year, the harshness of the previous winter, status of poaching levels, and population numbers (including proportions of each age and sex class). Precautionary off-take limits should stand to cover any sudden mass mortality, any unreported off-takes (i.e. from poaching) and any particularly errors that may have occurred in respects to population counts due to potential inaccuracy from the population census techniques. Efforts are being made to improve the method of the annual census of saigas that takes place in April. Several problems remain with the count technique, such as impaired visibility directly below the plane excluding a strip of approximately 200m on the ground. The width of the counting strip is 2km and herds can be missed by tired or distracted observers, the design of the aircraft used may sometimes impair visibility of the herds; and over or underestimation of herd sizes by observers may occur (Zuther 2009). These problems mean that the count could easily inflate or deflate the true number of the saiga population, which influences the setting of quotas and precautionary limits. Milner-Gulland (1994) suggests that in the case of population numbers becoming very low or years when the population has been affected by particularly bad climatic conditions or have suffered mass

mortalities due to disease, hunting should not occur at all in those years to allow population recovery. The potential for saiga populations to suffer severe declines as they did in the 1990s and in the first years of the 21st century would make it prudent to place a minimum population threshold under which hunting should not take place. If the saiga population does fall under the threshold their particular ability to recover in number rapidly could mean that they will be able to recover to the threshold population in one or very few years. A suggestion based on growth seen in the models used in this thesis would put the minimum population threshold at 50 000 individuals for the Betpak-dala population group.

5.6 Health of the Betpak-dala population

The aerial and ground census surveys conducted by "Okhotzooprom" and the Kazakhstan Institute of Zoology on the Betpak-dala population have reflected a road to recovery after numbers reached drastically low levels. In 2003 the annual population count reported only 1800 saigas in Betpak-dala, since then the population has shown recovery year on year, counts showing: 6900 for 2004, 9900 for 2005, 18600 for 2006 and 22800 for 2007 (no data for 2008). The most recent available population count was from 2009 which reported 45196 individuals, although depending on the extrapolation approach used and potential errors due to the census technique, this figure could be approximately 10% higher (Zuther 2009). The accuracy and reliability of the population counts are being addressed by those involved in carrying them out (now including the ADCI) and improved population numbers could be a reflection of those improvements. Total population estimates are just that, estimates, as previously mentioned the possibility for over or under estimation exists and the methods of extrapolation allow the possibility for a potential 10% error on the final figure. Judging by the increases seen in the population since 2003 and the increased efforts into protecting the population through regular anti-poaching patrols, the precautionary limit of 50 000 individuals in the population before trophy hunting could be feasible and will be achieved in the next two years even with potential population estimate errors. Delaying the start of a trophy hunting program until 2012 could allow time to establish management committees and multi-level management roles, an agreed conservation management plan (CMP), marketing of the hunts and forming associations with responsible tour operators,

financial collection and distribution arrangements and allow further increases in the Betpak-dala population.

5.7 Management

Community based trophy hunting programmes have been successfully implemented in Pakistan and Northern Canada, in both cases multi-level management approaches have aided the success of the projects. Involvement of communities and regional groups encourages valuing of natural resources by rural peoples. Both systems have encouraged rural communities to understand the need for sustainable approaches to wildlife management, through co-operation with governments, tour operators and conservation organisations. Benefits have been apparent for the communities, preservation of the habitat and the target species itself. The range of the Betpak-dala population is vast, migrations from the winter to the summer pastures and vice versa covers several hundred kilometres in each direction; involvement of rural communities within the saiga ranges in a community based trophy hunting programme (CBTHP) would depend on a number of factors including their annual level of contact with the saigas. Communities that have had recorded incidences of poaching may especially need alternative options to generate income, poachers from these locations could potentially gain employment as part of a CBTHP, with their knowledge of finding and hunting saigas, they are also potentially employable in the prevention of poaching itself, as they know the ins and outs of the business better than most other people.

Communities wishing to be involved in a CBTHP would need to organise a community management committee similar to that reported by Yaman and Mohd (2004), members and the leadership of this committee should be acceptable to the whole community and they would act in the interests of the community, manage the hunts, take measures to counter corruption and liaise with NGOs, tour operators and government representatives. The Altyn Dala Conservation Initiative (ADCI) is the major conservation project in central Kazakhstan, including the range of the Betpak-dala saiga population, their remit includes conserving habitat and endangered species such as saiga antelope. The ADCI is implemented by several parties including the Kazakhstan government, the Association for Conservation of Biodiversity of Kazakhstan (ACBK), the Frankfurt Zoological Society (FZS) and WWF International. It is already involved in anti-poaching

activities such as patrols and education, they would be the obvious immediate choice for liaising with and aiding community management committees involved in a CBTHP and bridging the gap to higher government authorities via the ACBK. WWF International could be approached to provide technical advice in the setting up of community management in respects to a CBTHP and potential financial support in the initial set up period of the project, as they have done previously in Pakistan with CBTHPs, until such time that the project could generate enough funds to be self sustaining. Further technical support could be provided by organisations such as the Saiga Conservation Alliance (SCA) and as in Pakistan the Global Environment Facility and the United Nations Development Program could be approached for further financial support. If a CBTHP was instigated then within the CMP there would need to be clear guidelines as to the monitoring of the programme, at each level it would be important to assess the successes and failures of the management associations, adherence to international conventions, impacts on the saiga population and benefits to all involved parties, it would seem prudent to involve an independent assessor, to report on the progress of the programme, as was done for the Mountain Areas Conservancy Project by IUCN (Shackleton 2001). A basic multi-level management set up for a community based trophy hunting program is shown in figure 13.

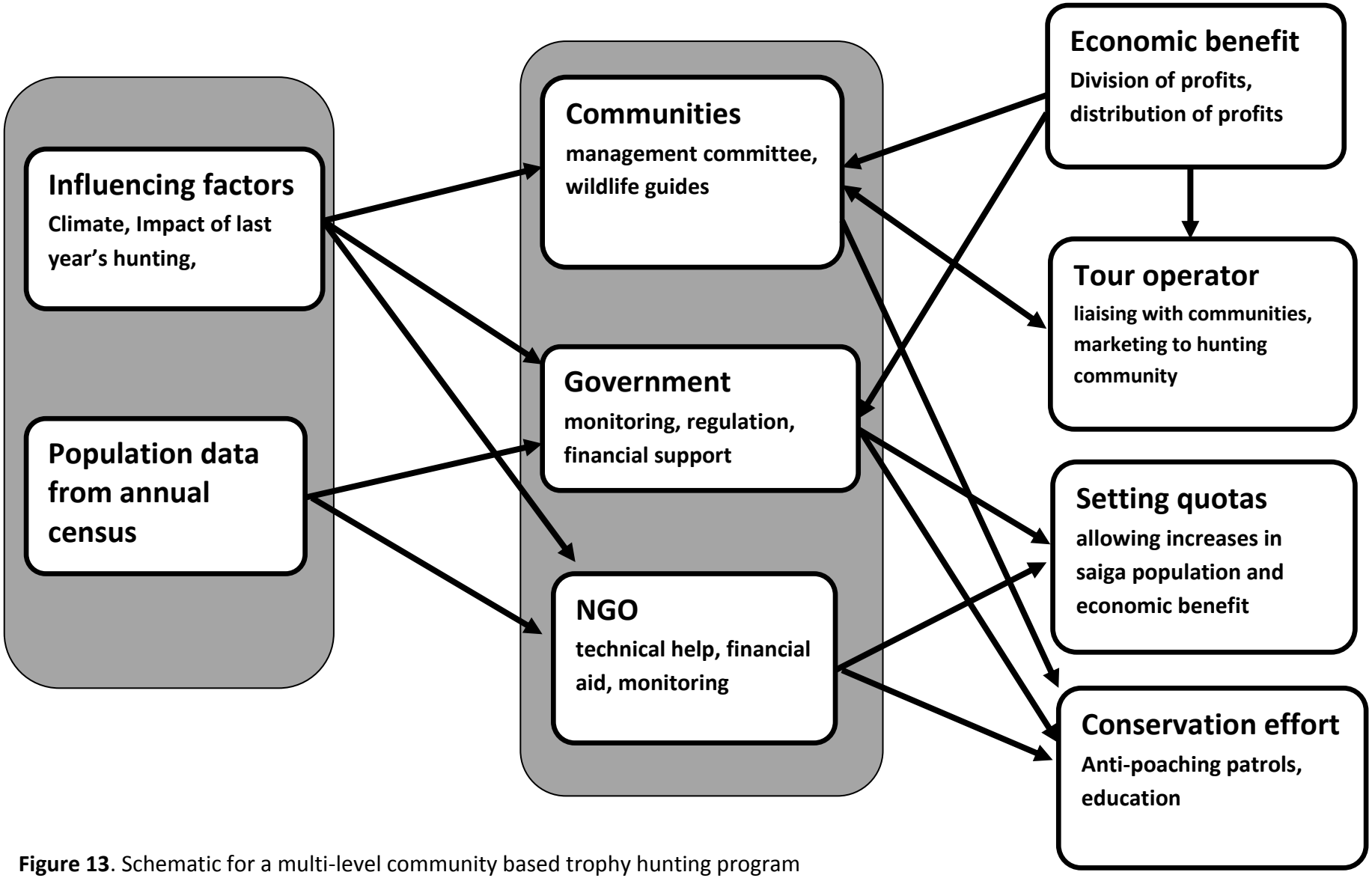

Figure 13. Schematic for a multi-level community based trophy hunting program

5.8 Potential revenue

One of the main hindering factors to a trophy hunting programme (THP) is the continuation of the level of poaching that has been in practice, not only does the legal deterrent need to be strictly enforced but local rural peoples need to be involved in the active prevention of poaching. To encourage this sort of involvement there needs to be a financial incentive to the rural peoples to change their activities if they are involved in poaching, or feel motivated to join the conservation of saigas as an action to protect a value giving resource. If, as the model shows, hunting adult males in the majority as part of a trophy hunting programme can allow the population to grow and sustain a healthy proportion of carrying capacity, it is in the interests of communities wishing to be involved in the THP to prevent additional pressures such as poaching and diseases potentially transferable from domestic livestock.

Poaching activities if carried out with the trade in horns for the traditional Chinese medicine (TCM) market and the sale of meat as the focus could cause a bias towards hunting adult males, fully developed horns being up to 12 inches (>30cm). Kuhl (2008) interviewed a group of regular saiga hunters and found that the majority of the money that they make from poaching comes from the sale of saigas for meat, even though horn has been reported to be sold in Almaty for $300 per kilo (Kuhl 2008), it appears that the hunters take advantage of all the harvestable saigas that they encounter and the majority of their harvest is made up of females (60-70%), females making up approximately 42% of the total population (Milner-Gulland 1997), so more likely to be encountered by hunters. Kuhl (2008) also found that poaching is a low priority choice by rural peoples as a way of earning a living, but small groups of hunters can supplement their income through occasional poaching of saigas. The group of poachers interviewed by Kuhl (2008) aimed to earn $1107 in each hunt lasting 2-3 days (2005 prices), to gain this they would need to harvest 50-60 saigas, of these 15-24 would be adult males.

Kazakhstan is a popular destination for trophy hunting in central Asia, receiving over 2000 hunting tourists per year (Blua 2005), many species are able to be hunted and many tour operators offer hunting packages for foreigners and nationals. Several species of ungulates are on offer to hunt in both Kazakhstan and Mongolia, including ibex (*Capra*

sibirica), maral (*Cervus elaphus sibiricus*), urial (*Ovis orientalis vignei*), Siberian roe deer (*Capreolus pygargus*), chamois (*Rupicapra rupicapra*), white tailed gazelle (*Procapra* gutturosa), black tailed gazelle (*Gazella subgutturosa*), and others (The Hunting Report 2010; Easta 2010; Ok Safari 2010; Trophy Hunt Kazakhstan tour 2010) . Prices for these ungulates vary on their size and abundance, white tailed gazelle are advertised cheaply at $250 per kill (Ok Safari 2010), whereas at the other end of the scale urial are offered at $3400, for hunting services, for a five day tour, with each kill costing a further $7000 (Easta 2010). Species comparable in size to the saiga antelope are the white tailed gazelle ($250 per trophy), black tailed gazelle ($850 per trophy), chamois ($700 per trophy), and the Siberian roe deer ($700 per trophy). Saiga antelope are an unusual species and have been off limits to the trophy hunting community, a moratorium on commercial hunting in Betpak-dala being imposed since 1998 (Milner-Gulland *et al.* 2001), currently saigas hold protected status and a hunting ban that applies to all range states. An opportunity to hunt saigas as a trophy species may present an attractive prospect to those involved in international trophy hunting and it could be likely that a saiga trophy may be as valuable as the highest priced of these comparably sized ungulate species. The 15-24 male saigas that were taken in the harvest of the hunters interviewed by Kuhl (2008) are potentially worth $10500-$16800 at the higher end and even speculating that saigas could only fetch the price of the cheapest species to hunt, the white tailed gazelle, revenue earned from them could be $3750-$6000, which easily out-strips earnings from meat and horn sales from 50-60 mixed sex poached saigas, albeit earned over a longer timescale with a different emphasis on hunting effort.

5.9 Limitations of this study

In conducting this study there were a few details that were unavailable such as detailed migratory patterns of the saiga population in Betpak-dala, knowledge of the true levels of poaching and a gauge of what community interest there is in CBTHP, and also what level of involvement communities would want in a CBTHP. The reliability of population counts are somewhat in question due to factors highlighted earlier in the report, improvements to the census technique are being addressed, the accuracy of the census having an important bearing on the setting of quotas that do not cause a detrimental effect to the population as a whole. On the model itself, the carrying capacity condition

was imposed when the population level reached carrying capacity and not a linear reduction on fecundity as it approaches carrying capacity, this may have had an effect in respects to where the population would stabilize. Biological research into saiga antelopes may discover further information in regards to vital rates, periodic disease and climate affected mass mortality events, which would all have a bearing on the findings reported in this study.

5.10 Further considerations

An assessment needs to be made of how many communities are feasible to include in a CBTHP and how many communities are feasible to include in a CBTHP, this could be achieved through conducting social surveys in various communities in the Betpak-dala saiga population range. It would be advantageous for the saiga population to have a designated hunting season in which trophy hunting would take place. However, the vast area covered by saiga migrations would mean that only certain communities would be in range of the saiga population during that particular time. This brings up the question of whether all communities that may want to be involved in a CBTHP could benefit from it. Research would need to be carried out as to how to address this problem and how to discourage poaching in areas that would be too far away from the saiga population during a hunting season to conduct their own trophy hunts as an alternative financial resource. This again brings up the need for a further research into saiga migratory patterns. Trophy hunting on the face of it seems to far outstrip the financial reward of poaching for meat and horn sales, but to gain a clearer picture of the beneficial differences an assessment of unit per hunter effort for poaching as opposed to trophy hunting could be conducted.

5.11 Concluding remarks

The Betpak-dala saiga population was driven down to a critical level due to uncontrolled poaching after the system of management and enforcement of a ban on hunting ceased due to the collapse of Soviet control. Levels of poverty are high in the rural communities of this region, and hunting of saigas, although illegal, can supplement state benefits and low incomes. Conservation efforts through government initiatives and the state hunting association patrols aim to clamp down on poaching but the vast migratory range of the saigas makes enforcement of the hunting ban difficult. People within the saiga ranges have a positive attitude towards saigas and believe that efforts to conserve them are worthwhile (Kuhl 2008). A community based trophy hunting program offers the opportunity for rural communities to gain revenue from an alternative livelihood and take part in the management of a wildlife resource. Through a multi-level management approach a sustainable trophy hunting program can allow growth and sustained health of the saiga population; address Kazakhstan's commitments to international conventions (e.g. CMS); and encourage the rural poor to actively take part in the conservation of saiga antelopes.

Section 6. Appendices

Month	Location	Behaviour	Other information
January	Desert zone	Harem herds break up ; late mating (first ten days of the month)	Females begin to lose weight
February	Desert zone		
March	Desert zone		
April	Semi-desert zone	Begin to concentrate in calving areas ; first calves born (late in the month)	Males begin to build up fat ; aerial counts carried out
May	Calving areas	Formation of birthing aggregations , Synchronised Birthing ; arrival of saiga in summer ranges in drought years (herds of males arriving first, up to 3-4 weeks before)	
June	Reach their summer range in 1st half of month	formation of nursery herds ; female lactation period (also july) ; last calves born (early)	
July		Females begin to build up fat after lactation period ; herds grow larger	
August	Migration back to winter range begins	Increase in herd numbers	
September			Drop in temperatures ; Kazakh hunting season (Sept-Nov)
October		Formation of larger herds in preparation for mass migration to winter pastures	Optimal hunting season (1 Oct-30 Nov) when the saiga are at their most productive
November	Desert zone	Breaking up of large herds into smaller groups; begin to form harem herds	
December	Desert zone	The rut; formation of harems; mating occurs (last ten days of the month or first ten days of January)	Males lose weight during the rut

7.1 Calendar of annual saiga movements and behaviour. Source Bekenov 1998

7.2 Manipulation of overall annual survival rates

Year type	Juvenile male	Juvenile female	Sub-adult male	Sub-adult female	Adult male	Adult female
Good summer/good winter	0.64	0.64	0.8	0.8	0.65	0.8
Good summer/bad winter	0.58	0.58	0.8	0.7	0.4	0.7
Bad summer/good winter	0.1	0.1	0.8	0.75	0.5	0.75
Bad summer/bad winter	0.04	0.04	0.7	0.65	0.25	0.65

Table 7.2.1. Standard overall annual survival rates based (OASR) on Milner-Gulland (1994)

Year type	Juvenile male	Juvenile female	Sub-adult male	Sub-adult female	Adult male	Adult female
Good summer/good winter	0.576	0.576	0.72	0.72	0.585	0.72
Good summer/bad winter	0.522	0.522	0.72	0.63	0.36	0.63
Bad summer/good winter	0.09	0.09	0.72	0.675	0.45	0.675
Bad summer/bad winter	0.036	0.036	0.63	0.585	0.225	0.585

Table 7.2.2. 10 % reduction in overall annual survival rates (OASR)

7.3 Manipulation of fecundity rates

Sex and age class	Mean offspring (dep. on prev. summer)		10% reduction	
	Good year	Bad year	Good year	Bad year
Sub-adult female	1.05	1	0.945	0.9
Adult female	1.75	1	1,575	0.9

Table 7.3.1. Manipulation of mean offspring rate

Sex and age class	Conception rate (dep. on prev. winter		10% reduction	
	Good year	Bad year	Good year	Bad year
Sub-adult female	0.85	0.5	0.765	0.45
Adult female	0.96	0.85	0.864	0.765

Table 7.3.2. Manipulation of conception rate

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