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Table of Contents

Topnaar Livestock Management in the Lower Kuiseb: Strategies, Obstacles, and Outcomes

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Abstract

The Topnaar people living in the Kuiseb River Valley of the Namib-Naukluft National Park (NNP) have farmed livestock for hundreds of years. In the face of changing circumstances in the Topnaar socio-ecological system, we seek to (1) understand current Topnaar livestock management strategies, (2) understand the challenges faced by Topnaar livestock farmers, and (3) the effects of Topnaar management practices on livestock health and abundance. Using systems theory as a framework for our research, we drafted and administered a 22-question survey to twelve Topnaar livestock owners about animal demographics, management practices, perceived threats to livestock, and NPP polices. We also conducted individual interviews with two key informants: the Chief Warden of the NNP and the head of the Topnaar Traditional Authority. To understand the challenges faced by Topnaar livestock farmers and the outcomes of their current practices, we focused on the relationships between perceived causes of livestock deaths and management practices including vaccinations, supplementary fodder, and herding. Our data identified predation as the most significant perceived cause of small stock mortality by number of farmers impacted. In addition, we found that there was no significant relationship between vaccinations or consumption of supplementary fodder and any source of small stock mortalities. There were also no statistically significant relationships between management practices and livestock body condition scores.

Introduction

Systems theory describes a set of interrelated and interdependent parts that, when changed, exert an impact on other parts of the system and overall system function. Open systems also include inputs (or "inflows") from and outputs (or "outflows") to an external environment. These inflows and outflows result in outcomes—including the quantity of a "standing stock" in the system—and may cause positive or negative feedback loops. In socio-ecological systems, resource systems and governance systems set the conditions for "action situations," in which actors transform resource unit inputs into outcomes. These socio-ecological systems are embedded in both related ecosystems and in social, economic, and political settings, all of which may impact any of the system's primary components (see Figure 1; McGinnis and Ostrom 2014). In the Lower Kuiseb River Valley of western Namibia, the interactions between actors in the indigenous Topnaar community with the resource and governance systems of the Namib-Naukluft National Park (NNP) in the context a dynamic ecological setting comprise a complex socio-ecological system.

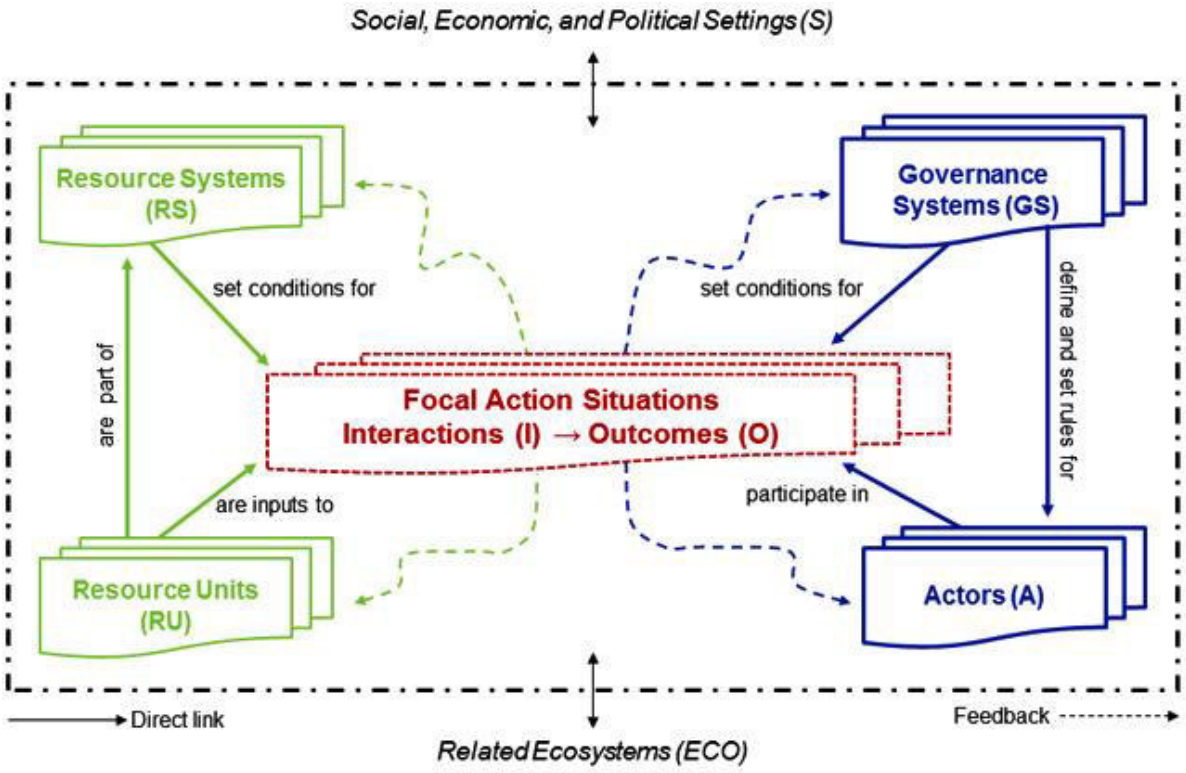


Figure 1 A Socio-Ecological System (McGinnis and Ostrom 2014)

For more than three centuries, the Nama-speaking Topnaar resided in mobile settlements scattered along the ephemeral Lower Kuiseb River. Precipitation and flooding in the upper Kuiseb catchment manifest in occasional, temporary flows of water along this ephemeral river, which recharge a subterranean aquifer. This underground water table feeds a variety of deep-rooted trees and vegetation that provide shade and nutrition to wild and domestic animals, including *Acacia erioloba* and *Faidherbia albida* (Schachtschneider and February 2010). This oasis of riverine vegetation divides barren gravel plains from the hyper-arid dunes of the Namib Sand Sea, thus creating a unique convergence of three diverse central Namib ecosystems (Schachtschneider and February, 2010).

However, the nomadic Topnaar historically ranged far beyond the Lower Kuiseb: from the relatively fertile Namibian interior to the port city of Walvis Bay. This massive land area—extending over 2000 kilometers along the Kuiseb—afforded the Topnaar a wide range of livelihood options. Traditionally, many Topnaar augmented small stock, cattle, and donkey farming in the highlands and the Kuiseb with harvesting the wild !nara (*Acanthosicyos horridus*) melons growing in the Namib Sand Sea dunes, gathering marine resources along the coast, and trading with Europeans in Walvis Bay (Budack 1983; Botelle and Kowalski 1997; Kinahan 2017). However, livestock continue to hold significant cultural and financial import for the Topnaar people. Small stock and cattle are often kept for subsistence meat and milk consumption, while donkeys provide both meat and transportation in the form of donkey carts. All livestock species are also sold to purchase necessities, and their historical significance gives

them a valuable cultural role in the Topnaar tradition (Vigne 2000). Continued traditional management techniques include keeping animals in kraals (log enclosures) and herding them with human herders or dogs. Often, Topnaar livestock is managed communally but owned individually, as multiple households often share a single kraal (Widlok 2010). Historically, however, their nomadic lifestyle provided Topnaar farmers with the greatest advantage to maintaining herds in an arid, marginal landscape. Their livestock enjoyed a wide range along the Kuiseb and into interior grasslands (Kinahan 2017).

Yet, the Topnaar live in only a fraction of this historical area today. In 1884, German colonists coerced the Topnaar chief Piet !Haibib into selling a large section of the Topnaar territory (Kinahan 2017). The German colonial government of South West Africa declared a portion of this area the Namib-Naukluft National Park in 1907, and the park was expanded under the South African apartheid government in 1978. Early colonial conservationists restricted Topnaar movement within the park, subjected the slaughter of their animals to a permit system, prohibited killing problem predators, and occasionally threatened them with expulsion from the Kuiseb (Kinahan 2017). Today, the Namibian Ministry for Environment and Tourism manages the NNP (*NNP Management Plan* 2013). In theory, the policies of the Namibian government, as well as those specific to the NNP, prioritize the sustainable development of the Topnaar communities living within the confines of this park. However, this governance structure continues to limit Topnaar actors' access to livestock-enriching resource systems. First, NNP zoning laws demarcate only a small land area for livestock farming, thus eliminating the mobility that historically enabled Topnaar farmers to maintain their herds in an arid, marginal environment (Werner 2003; Magnusdottir 2013; Kinahan 2017). Moreover, human-wildlife conflict complicates the relationship between biodiversity conservation and local communities. Many Topnaar farmers contend that livestock predation has increased since the creation of the NNP (Botelle and Kowalski 1997). While national legislation establishes a standardized protocol for livestock predation compensation, overlapping NNP policy does not mandate any payment for livestock losses (R. Solomon, *pers. comm.*, 3 November 2017). Previous communications with Topnaar farmers also suggests complications in tangible application of these policies (Botelle and Kowalski 1997). We attempt to understand these current practical applications through interviews with park officials and Topnaar farmers. Moreover, our study will address gaps in the existing literature by examining discrepancies between actual park legislation and Topnaar understanding of these policies.

Changes in the lower Kuiseb ecosystem also impact Topnaar livestock farmers, particularly tenuous access to the water resource system. Many extra-local actors rely on the Kuiseb aquifer; it has supplied water to Walvis Bay since 1923, and to Swakopmund and Rossing Mine since 1974 (Christelis and Struckmeier 2011). The Topnaar traditionally depended on natural springs for their water, but also began to utilize the aquifer in the late 1970s after the South African government installed bore holes to encourage settlement (Dieckmann et al. 2013). Yet, recharge is rare in the Lower Kuiseb. During the period of 1982 to 2010, groundwater is decayed a rate of nearly 14.8mm^3 per year (Benito et al. 2010). This water table degradation threatens the vegetation structure along the river that provides fodder, shade, and habitat for Topnaar

livestock. Extreme climatic events such as floods and droughts are also likely to be more frequent and intense (Dieckmann et al. 2013). Like the rapidly dwindling groundwater resources, extreme floods could lead to loss of livestock, damaged infrastructure, and changing vegetation structures, as the Topnaar experienced in exceptional 2011 flood. Moreover, an analysis of flood data since 1986 indicates a possible shortening of the drought cycle from seven to ten years to three years, as surface flow did o reach the middle or lower reaches of the Kuiseb in 2007, 2010, 2013, or 2016 (Morgan 2017). Some Topnaar households have already responded to recent drought by replacing cattle with goats and sheep, which are less fodder- and water-intensive (Seo and Mendelsohn 2008; Dieckmann et al. 2013). Understanding current livestock management strategies within the context of this ecological system and the potential changes it will undergo through climate change is crucial for maintaining and improving traditional livelihoods in the Topnaar community amidst unpredictable changes in their land.

In addition, the social, political, and economic setting of rapidly changing rural demographics exerts a significant influence on the capabilities of Topnaar livestock farmers. The Topnaar have experienced a decline in their rural population since the establishment of their semi-permanent, subsistence-based desert lifestyles (Botelle and Kowalski 1997). Many young Topnaar no longer find traditional lifestyles attractive, especially after recent years characterized by drought and hardship (Titus 1998). Instead, many Topnaar seek wage employment in nearby Walvis Bay (Widlok 2000). Rural livelihoods remain dependent on livestock farming and subsistence harvesting of the !nara melon, but the lucrative pull of urbanization is rapidly changing Topnaar community structure.

These ecological, political, and social components interact in a manner that promotes unique adaptations to raising livestock in an arid environment. However, they also present challenges to maintaining large numbers of healthy livestock in the context of rapidly changing ecology and social structures. Our study analyzes the effects of these complex linkages through systems theory, focusing on the inflows and outflows that influence quantities of healthy livestock. Our three objectives are to: (1) understand current Topnaar livestock management strategies, (2) understand the challenges faced by Topnaar livestock farmers, and (3) identify the impact of Topnaar management strategies on the health and abundance of livestock.

Methods

To address our research objectives, we created a survey directed at Topnaar livestock farmers living in 12 rural settlements along the Kuiseb River Valley (see Appendix 1). Each section of the survey addressed a different aspect of livestock ownership and management, including livestock demographics, mortality rates and causes, and livestock movement. Some questions also explored perceptions of National Park regulations, and the effects of those perceptions on livestock-based livelihoods.

With the assistance of two translators, we delivered this questionnaire to a group of 12 Topnaar livestock owners and herders spread across 7 villages. One of these translators was a member of

Topnaar Traditional Authority, who scheduled our interviews and introduced us to the livestock owners.

We organized our analysis into the following sections: respondent demographics, livestock demographics, management practices, threats to livestock, and effects of management practices on livestock health and abundance. Under respondent demographics, we explored the respondents' age distribution and livestock management position (owner, herder, manager). We considered same variables for respondents' household members, and examined the main reasons respondents cited for farming livestock. These questions were geared towards understanding if and how urbanization trends influence the Topnaar socio-ecological system.

For livestock demographics, we analyzed the total number of livestock owned, the gender and age of these animals, and the average size of a herd. We also examined controlled inflows and outflows to the standing stock of Topnaar animals, including the number of livestock bought, eaten, and sold over the past year. Further, we compared the body conditions of different types of livestock we observed on Topnaar farms during our interviews using a standard livestock condition assessment metric (NSW).

Next, we sought to understand the nature and prevalence of different Topnaar livestock management strategies. The management strategies identified were: using a herder, using a dog, using supplementary feed, vaccinating livestock, and sharing a kraal with farmers outside of the immediate family. We also analyzed the length of time that livestock spent outside the kraal browsing and foraging.

To understand threats to Topnaar livestock, we assessed the most prevalent causes of livestock mortality over the past year for different types of livestock. We also identified the locations where Topnaar farmers perceived the most frequent predation incidents through a mapping exercise accompanying each survey. Using an interactive aerial map of the area around each village, we asked the Topnaar farmers to identify where predation events occur.

Finally, we analyzed how different management strategies impact Topnaar livestock loss and health (observed body conditions). We explored the relationship between human and canine herding and loss to predation using ANOVA through the statistical software JMP. Next, we explored the effect of vaccination on livestock mortalities from disease, drought, and predation. Due to a small sample size on the quantity of animal deaths from these factors, we conducted contingency analyses comparing categorical variables. These categorical variables were: whether farmers vaccinate (Y/N) and whether they lost any livestock to disease, drought, and predation (Y/N). We applied the same contingency analyses to the relationship between supplementary feed and loss to disease, drought, and predation. We also analyzed the correlations between average livestock body condition and whether farmers herd, vaccinate, or provide supplementary feed.

We also conducted semi-structured interviews with two key informants: Riaan Solomon, the Chief Warden of the Namib Naukluft National Park, and Chief Seth Kooitjie, the head of the Topnaar Traditional Authority. The goal of these semi-structured interviews was to gain more

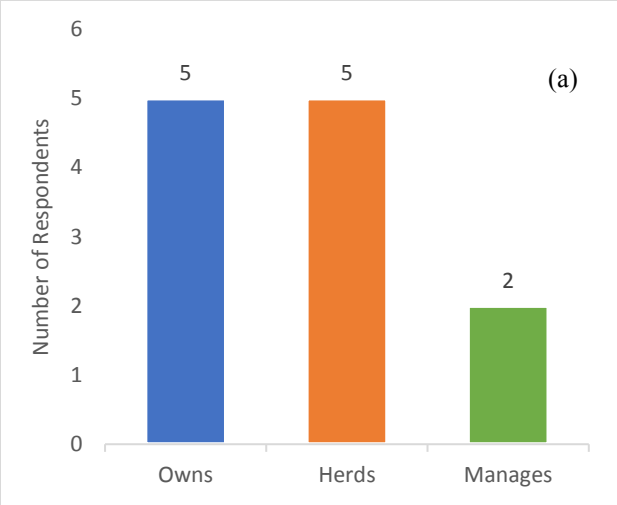
insight into the interactions between different components of the socio-ecological system that influence Topnaar livestock management. Our questions for Mr. Solomon focused on disentangling NNP policies from broader Namibian national park policies, in addition to understanding his discretionary power as a law enforcer in the park (see Appendix 5). Using the information gathered from these interviews and official NNP policy available online, we compared and contrasted how the Mr. Solomon and Topnaar farmers understand and interpret official regulations regarding predation and livestock movements.

Finally, we situated the data from our surveys and the information from these semi-structured interviews in the relevant scientific literature. We compared demographic survey responses with historical census data to reveal patterns in Topnaar livestock management practices over time. Finally, we used historical livestock census data to assess the change in total Topnaar small stock population over the past 40 years, as well as the impact of flood events on livestock populations.

Results

Respondent Demographics

Our respondents were mostly livestock owners or herders, with few having both responsibilities (Figure 2a). Respondents were mostly adults and few were senior citizens (Figure 2b)



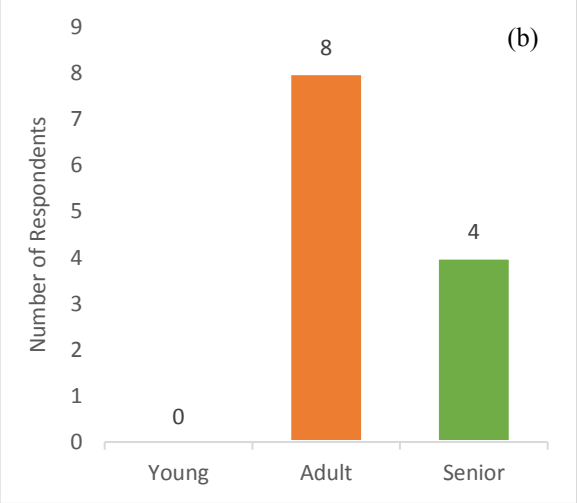


Figure 2 (a) Respondent Livestock Responsibilities (b) Respondent Age Groups. Young: 0-16, Adult: 16-60, Senior: 60+.

All of the other members respondents' household live at home, and the majority of them are adults, with few young people and one senior (Figure 3a). More than half of the respondents' family members manage livestock in some capacity (Figure 3b).

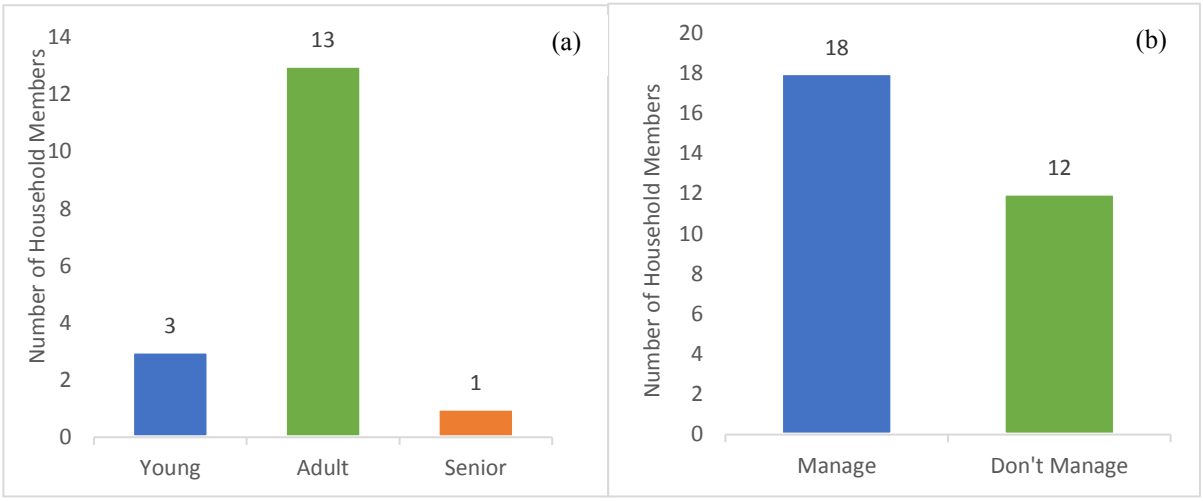


Figure 3 (a) Age Groups of Household Members (b) Number of Livestock Managing Household Members

Interviewees did not overwhelmingly cite one purpose their livestock; rather, most farmers keep livestock for multiple reasons. Most utilize their animals for consumptive purposes (i.e. milk and meat), to sell and for cultural purposes. Few see their livestock as inheritance (Figure 4).

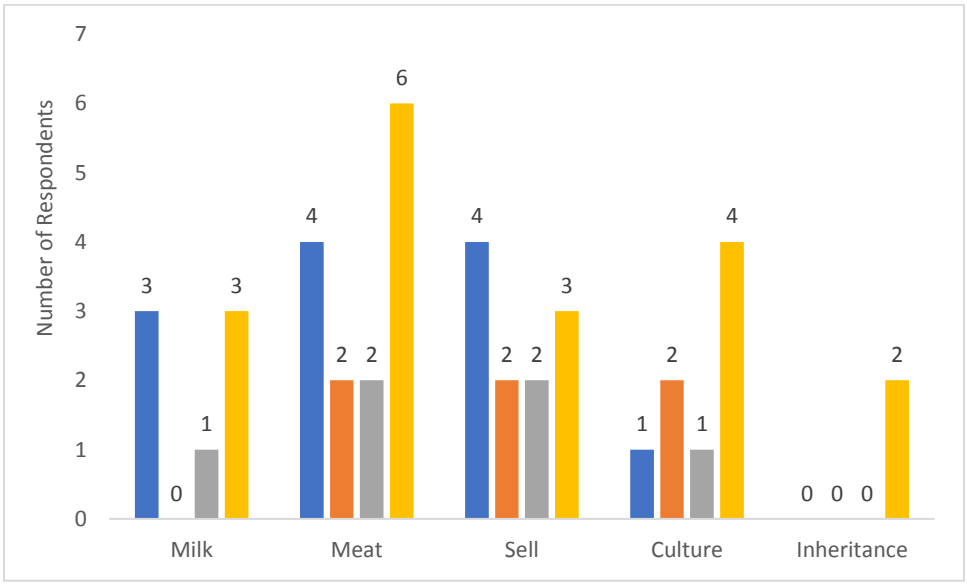


Figure 4 Reasons Cited for Keeping Livestock. Blue for Goats, Orange for Sheep, Gray for Cattle, and Yellow for Donkey

Topnaar Livestock Demographics

Table 1 summarizes our respondents' livestock demographics. All 12 respondents owned small stock, while only five owned donkey and cattle. One cattle owner had 50 cows, which skewed the total and average number of cattle owned upwards.

Table 1 Livestock Demographics Over the Past Year

	Small Stock	Cattle	Donkey
Current Stock			
Total Number	355	100	46
Average Per Owner	29.58	20	9.20
Average Per Capita	29.58	8.33	3.83
Total Female	264	100	34
Total Male	24	0	12
Inflows			
Bought	54	0	0
Total Young	67	1	10
Outflows			
Slaughtered	21	0	0
Sold	23	1	1
Predation Loss	183	1	1
Disease Loss	33	3	3
Poisonous Plants	1	0	0
Drought	33	3	0

Inflows to the standing stock of domestic animals include the 121 small stock, 1 cow, and 10 donkeys purchased or born within the last year (Table 1). 294 small stock, 8 cattle, and 5 donkeys were sold, slaughtered, or otherwise perished in the last year, and comprise outflows from the standing stock (Table 1). In total, 132 heads of livestock entered the system and 307 left the system in the past year; thus leading to a net negative flow of 175 animals (Figure 5).

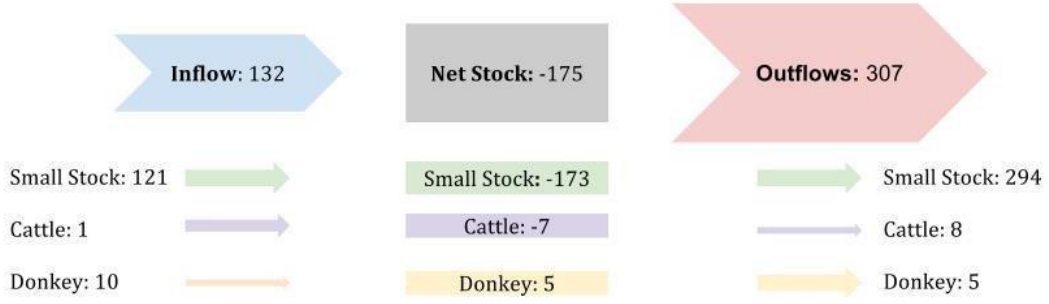


Figure 5 Total Inflow, Outflow, and Net Change of Livestock

Of 49 small stock observed in respondents' kraals, the average body condition was 2.52 on a four-point scale. Out of 11 cattle observed, average cattle condition was 2.24 on a five-point scale. Out of 2 donkeys observed, the average body condition was 2.00 on a four-point scale.

Table 2 Body Conditions of Livestock

	Small Stock (1-4 Scale)	Cattle (1-5 Scale)	Donkey (1-4 Scale)
Average Body Condition	2.52	2.24	2.00

Current Topnaar Management Practices

Our survey results showed that the majority of small stock owners use either a herder (66.67%) or a dog (50%) to control the movements of their livestock. Nearly half of cattle owners use dogs to herd their cows (42.86%), but few personally herd or employ a human herder (20%). Similarly, most small stock owners use supplementary feed for their small stock (75%) while most farmers with cattle and donkey do not use supplements for those animals (33% and 40%, respectively). 83.33% of cattle farmers vaccinate their cattle—a higher percentage than that of small stock owners who vaccinate (66.67%). Only 33% of donkey owners vaccinate their donkeys. Less than one third of interviewed farmers share their kraal with non-family members (Table 3).

Table 3 Percentage of Respondents Using Various Management Strategies

	Small Stock	Cattle	Donkey
Herd (%)	66.67	20	0
Dog (%)	50	42.86	0
Supplementary Feed (%)	75	33.33	40
Vaccination (%)	66.67	83.33	33.33
Kraal Share (%)	30		

Survey responses revealed that the time that livestock spend browsing and foraging outside the kraal differ between species of livestock. Small stock mostly return home every night, and spend an average of 6.3 hours outside their kraals every day. The results were more varied for cattle; 50% of cattle owners said that their cattle return home a few times a week, while 17% answered every night and 33% answered hardly ever. Some cattle owners clarified that sick and old cattle return home every night or a few times a week, while healthy individuals hardly ever return (Figure 6).

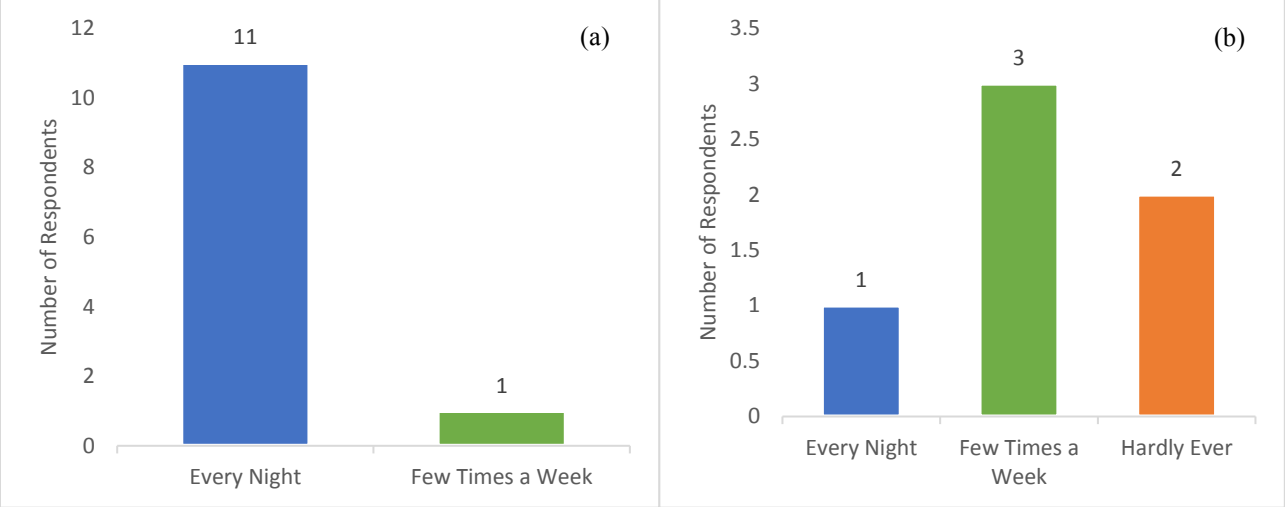


Figure 6 (a) Frequency that Small Stock Return Home (b) Frequency that Cattle Return Home

Threats to Topnaar Livestock

Survey results demonstrated that Topnaar livestock farmers lose their livestock to the following threats: predation, disease, poisonous plants, theft, and drought.

Table 4 Percentages of Farmers Citing Various Reasons for Livestock Loss

	Goat	Sheep	Cattle	Donkey
% yes to predation	83.33	66.67	16.67	16.67
% yes to disease	54.55	50	50	20
% yes to poisonous plants	8.33	33.33	20	0
% yes to theft	8.33	16.67	0	0
% yes to drought	58.33	16.67	33.33	0
% yes to other reason	18.18	16.67	16.67	0

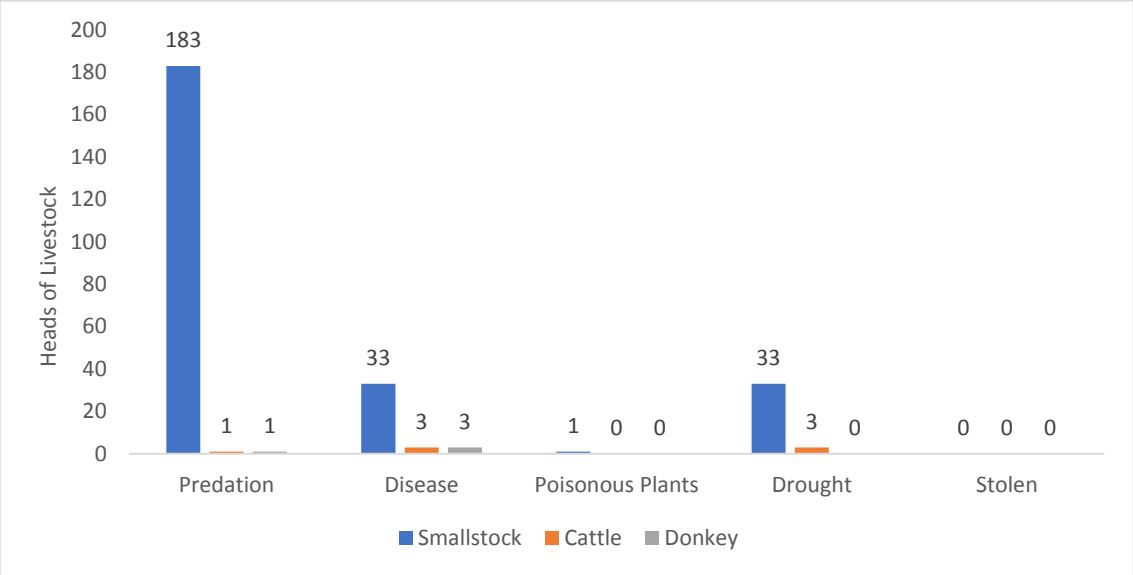


Figure 7 Number Livestock Losses due to Various Factors, By Species

Disease and predation were overwhelmingly the most frequently cited causes of small stock death. Relatively few cattle and donkey were lost to predation or disease. In general, livestock owners did not perceive poisonous plants, theft, or other causes to be serious threats to their livestock (Table 4). This was substantiated by one-way ANOVA tests on the numbers of livestock lost. Loss to predation, disease, and drought were significant while loss to poisonous plants was not (Table 5). When asked if there were any other causes for livestock losses, some farmers explained that a few of their animals occasionally mix with other herds and do not return home.

Table 5 Statistical Significance of Livestock Loss

	Predation	Disease	Poisonous Plants	Drought
Livestock Loss	185	39	1	36
Prob>|t|	0.0408	0.0475	0.0728	0.0153

We also assessed the effects of specific predators on livestock numbers. Because cattle and donkey did not experience significant losses to predation, focused our analysis on goats and sheep.

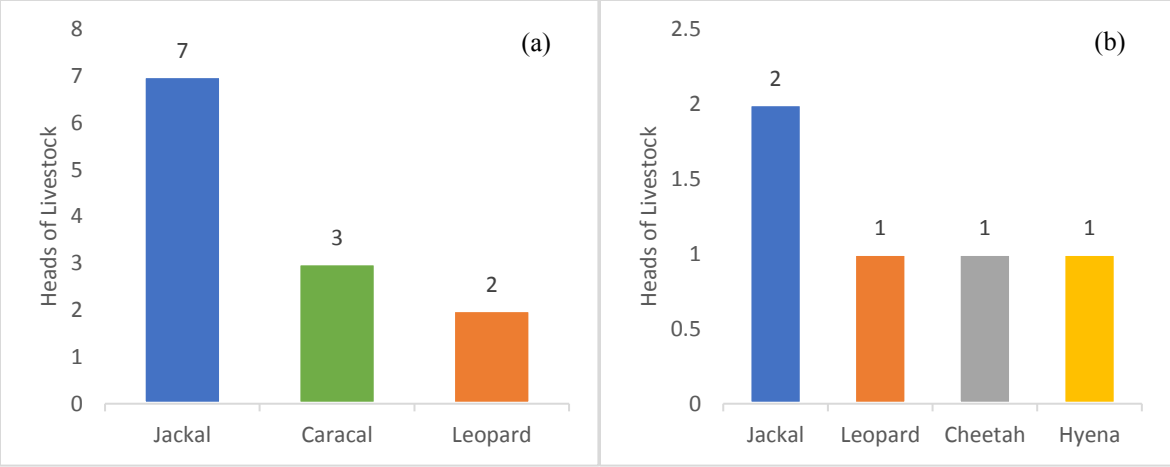


Figure 8 (a) Goat Losses to Specific Predators (b) Sheep Losses to Specific Predators

Our results show that livestock owners perceive the jackal as the main threat to goats and sheep (Figure 8). NPP Chief Warden Riaan Solomon, substantiated these findings in an interview, also naming the black-backed jackal as the main problem predator for Topnaar livestock farmers.

Figure 9 is heat map of predation sites identified by nine respondents. Topnaar farmers perceive predation mostly in the riverbed, with a few exceptions in some upstream settlements. Respondents living in Natab, Oswater, and Homeb identified predation both in the riverbed and on the gravel plains. Respondents interviewed at the same settlements often identified the same predation sites, indicated by the darker hue on several marked locations.

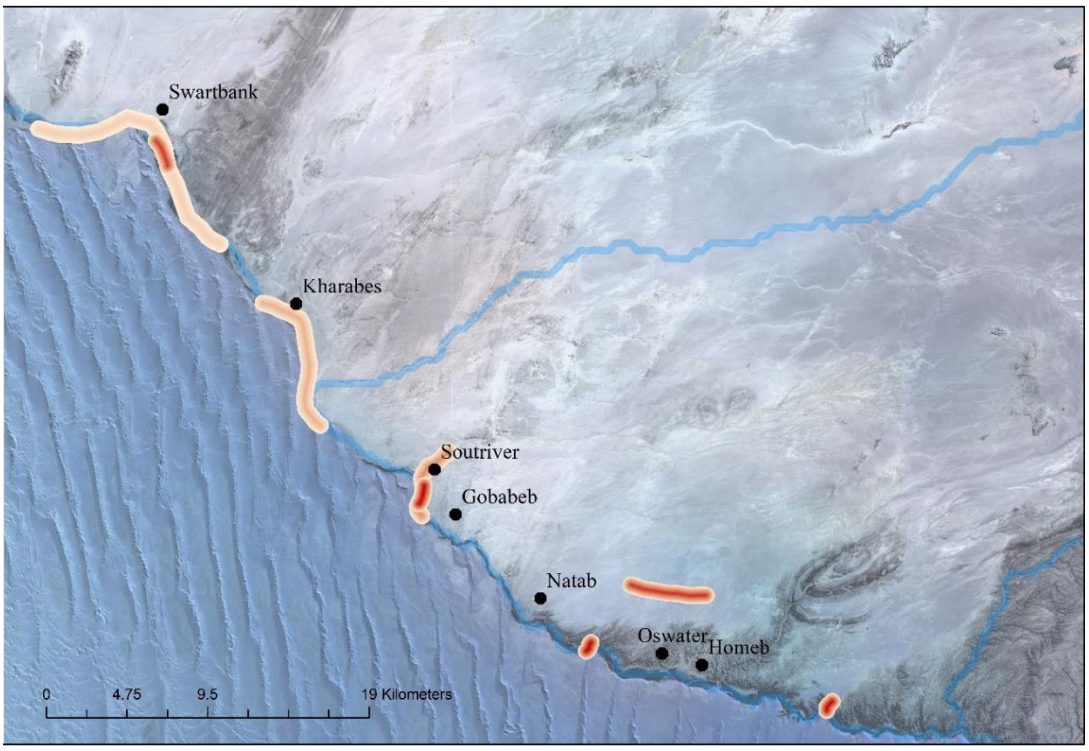


Figure 9 Predator Heat Map

Figure 10 depicts losses to disease, separated according to livestock species. We included only goats, cattle, and donkey due to a lack of data on disease in sheep. Few donkeys and sheep died from disease, but we further explored specific diseases that respondents perceived as serious threats to goats and cattle. Lung sickness is the main disease affecting both goats and cattle (Figure 11). Interviewees also demonstrated general lack of knowledge of what type of disease or illness was killing their cattle and goats.

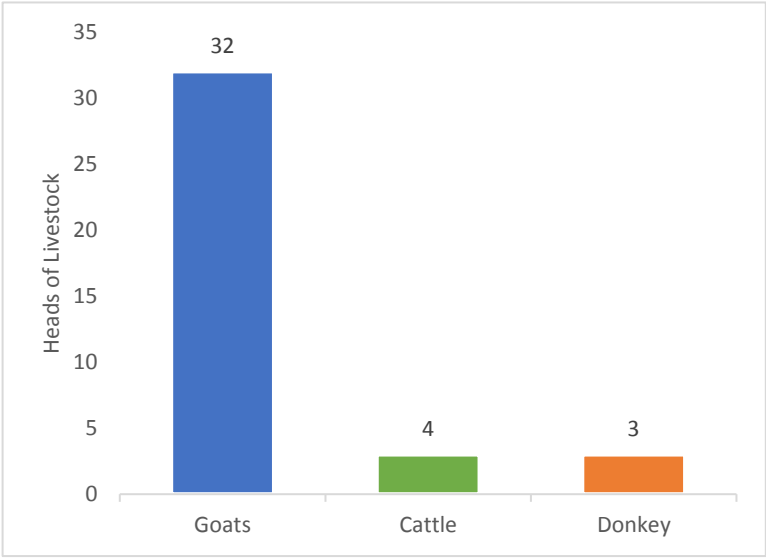


Figure 10 Livestock Deaths from Disease, By Species

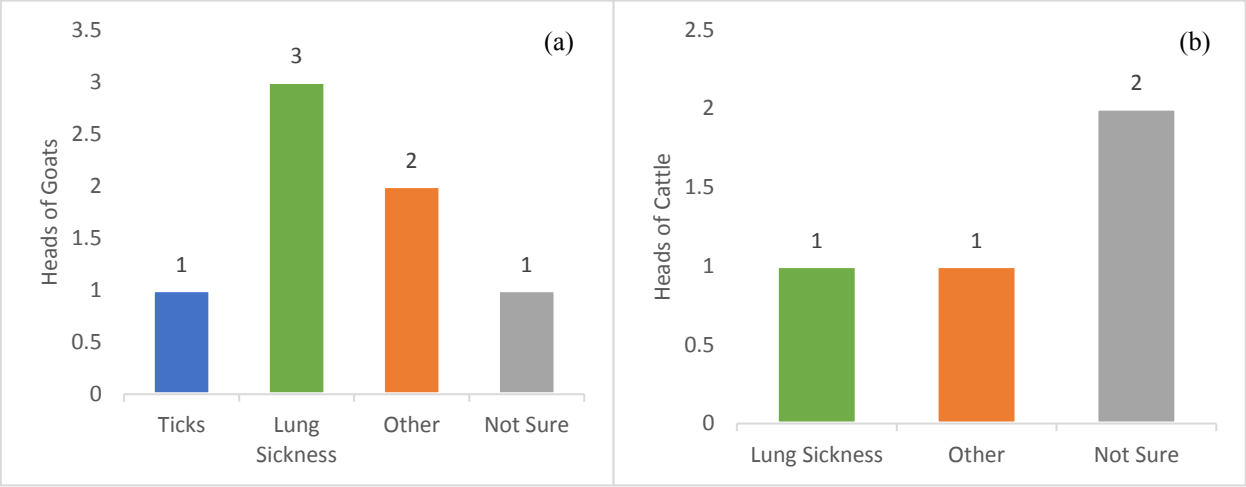


Figure 11 (a) Number of Goats Lost to Specific Diseases (b) Number of Cattle Lost to Specific Diseases

Effects of Topnaar Management Strategies on Livestock Loss and Health

Results indicate a connection between herding and livestock loss to predators. Those who herded using dogs, people, or both experienced far less predation loss than those who didn't (Figure 12). Although the sample size was too small for an ANOVA test on the different types of herding, we were able to compare more generally the difference in predation loss for those who didn't herd versus those who did (person or dog). Farmers who didn't herd lost an average of 40 heads of small stock to predators, while farmers who herded (person or dog) lost an average of only 9.4. This difference is significant at the 5% level (Figure 13). We could not perform similar statistical significance tests for cattle or donkeys due to a small sample size. We also found no significant difference between using both human and canine herders and using just one herding option.

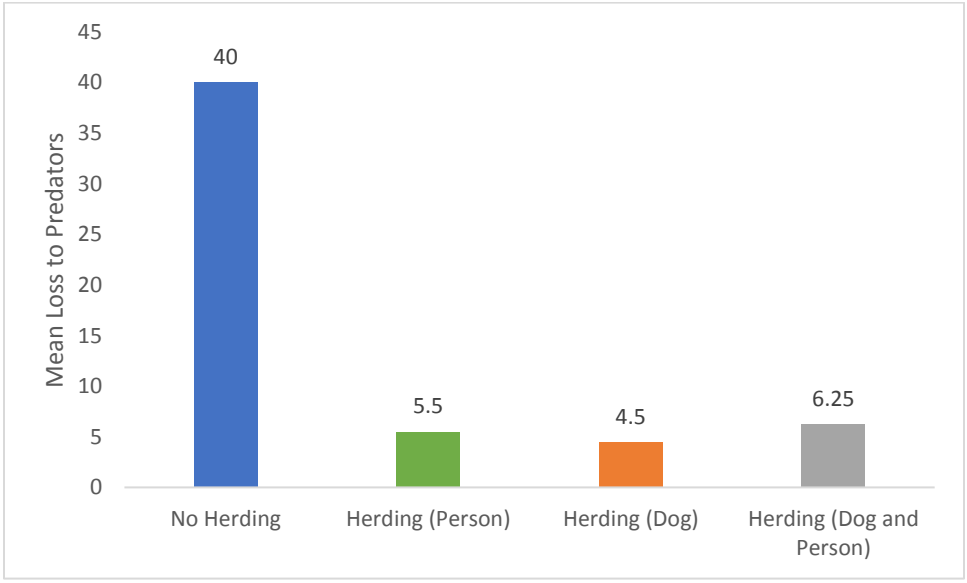


Figure 12 Comparing Mean Small Stock Loss to Predators Under Different Herding Practices

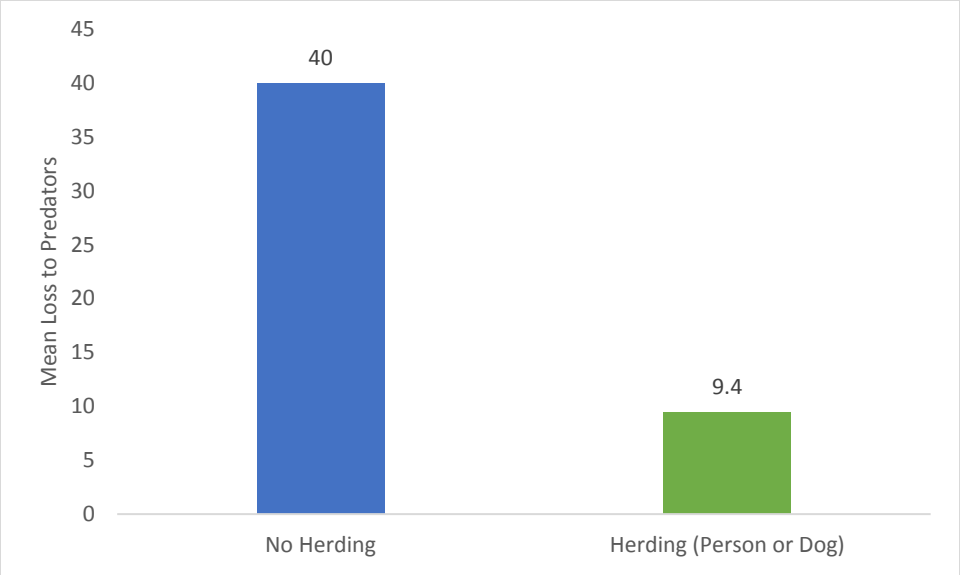


Figure 13 Mean Number of Small Stock Lost to Predators When Using Herd Dog or a Herder (N=12, F=11.2960, P>t=0.0121)

Results reveal no association between vaccination and deaths to disease, drought, or predation. We also ran a Fisher's test due to a small sample size, which also indicated no association between these variables (Table 6).

Table 6 Testing Association Between Vaccines and Livestock Loss

Test	*Prob>ChiSq*	*Fisher's 2-Tail Prob*
Vaccine vs. Disease	0.2207	0.5455
Vaccine vs. Drought	0.2733	0.5152
Vaccine vs. Predation	0.6788	1.0000

We hypothesized that the provision of supplemental feed would enhance animal health, thereby allowing animals to better defend against predators, disease, and drought. However, contingency analyses reveal no association between supplemental feed and any of those outcomes (Table 7).

Table 7 Testing Association Between Supplementary Feed and Livestock Loss

Test	*Prob>ChiSq*	*Fisher's 2-Tail Prob*
Supplement vs. Drought	0.3115	0.5227
Supplement vs. Disease	0.5018	1.0000
Supplement vs. Predation	0.2581	1.0000

Finally, an analysis of the relationship between management practices (vaccine, supplements, herding) and average body condition indicates no statistically significant relationship. However, the difference between the mean body condition of herded animals (2.63) and non-herded

animals (2.17) was comparatively greater than the difference in body condition means for the wo other management practices (Figure 14).

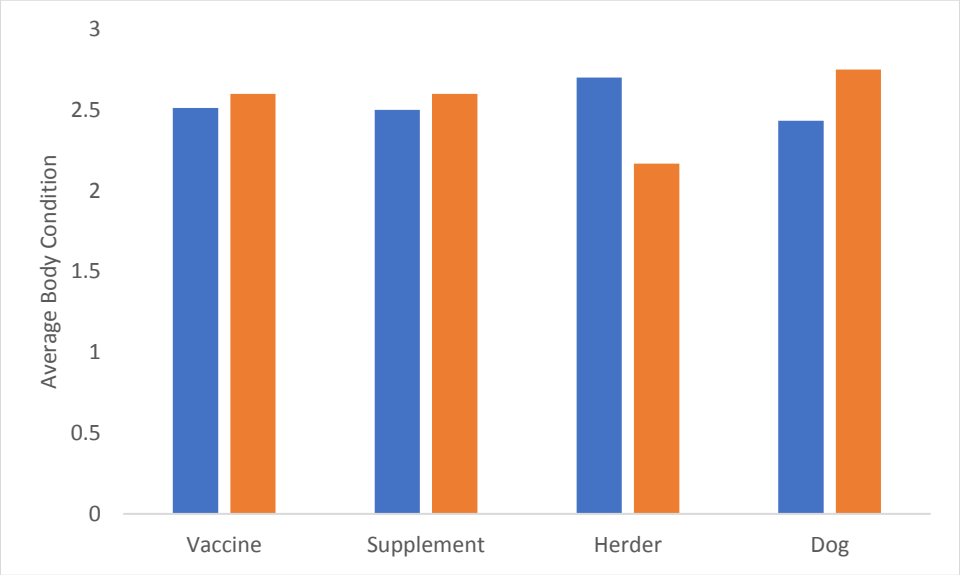


Figure 14 Mean Small Stock Body Condition When Using Vaccines, Supplements, Herder, or Dog. Blue for Yes, Orange for No (N=12, F=0.0218, P>t=0.5569; N=12, F=0.0493, P>t=0.8299; N=12, F=0.9148, P>t=0.3688; N=12, F=0.1027, P>t=0.7569).

Perceptions of Namib-Naukluft National Park Policies

Results from the surveys of Topnaar farmers and the semi-structured interview with Mr. Solomon revealed differing perceptions and interpretations of NNP policies on predation and movement of livestock (Table 8).

	NNP Legislation	Mr. Solomon Interpretation	Topnaar Community Interpretation
Livestock Movement	Movement is restricted to only a 200km^2 multi-use area in the Lower Kuiseb River valley.	Livestock should not stray very far from Topnaar settlements.	Livestock are mostly free to move as far as they need to.
Human-Wildlife Conflict I: Predation Response	Topnaar farmers can kill predator animals only if they catch the animal in their kraal. They must report the incident to MET within 10 days. They can never use a gun (MET 2013).	Topnaar farmers shouldn't kill predator animals but if they do, he is unlikely to follow-up on the incident, unless it is very serious.	Farmers have no agency to do anything about predators.
Human-Wildlife Conflict II: Compensation	There is no compensation given for livestock losses due to predation under normal circumstances. MET will send an investigating officer to the site of HWC if a complaint is filed.	MET investigates all reported incidents of HWC. Compensation is only distributed if a community trust fund is established, which has not happened yet for the Topnaar.	Compensation is never given and MET does not respond to their reports of HWC; MET does nothing

Table 8 Differing Perceptions of Park Policies Based on Positionality

Examining Topnaar Livestock Demographics Over Time

Using historical data from Gobabeb Research and Training Center, we assessed changes in the total Topnaar cattle population over the last forty years. There are multiple gaps in the livestock census data, especially during the period from 1996 to 2002. Nevertheless, the cattle population has grown by a factor of 22: from 30 animals in 1978 to 658 by 2013.

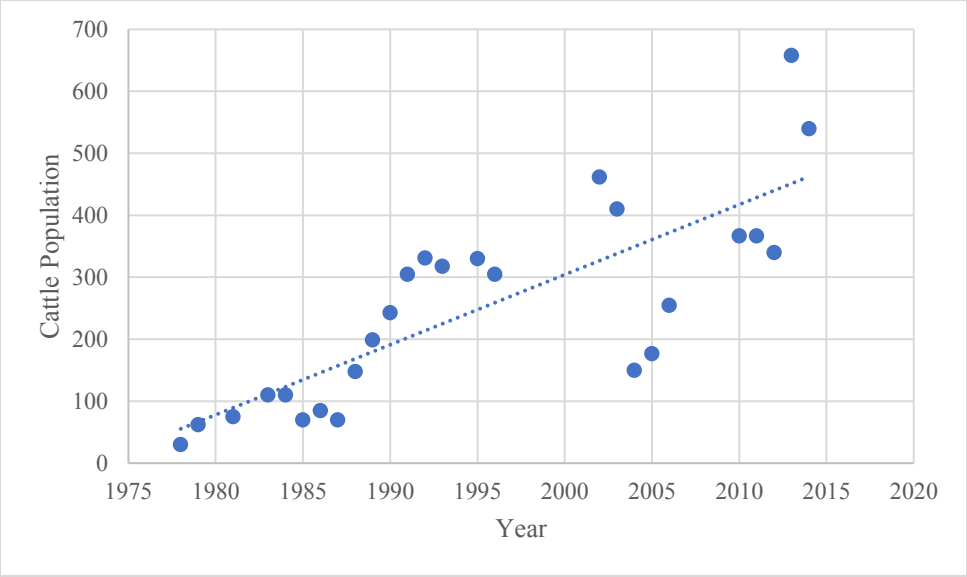


Figure 15 Change in Topnaar Cattle Population Over Time; R^2= 0.39, p-value = 0.0043

There are also multiple gaps in the historical census data for Topnaar small stock. This is especially true for the period between 1997 and 2001. Like cattle, small stock populations have increased over the past 40 years. The number of small stock grew from 1475 in 1978 to 2367 in 2014: an average growth by a factor of 1.6.

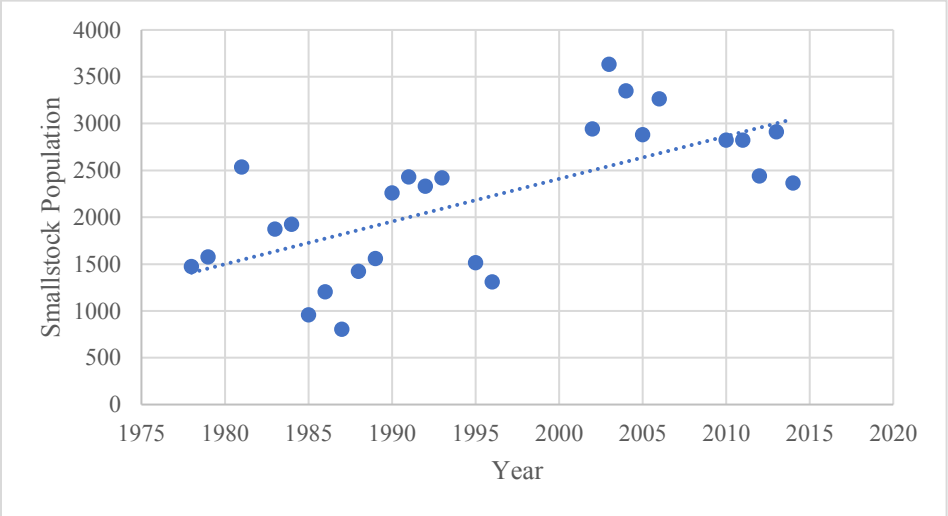


Figure 16 Change in Topnaar Small Stock Population over Time; R^2= 0.42, p-value = 0.0027

An analysis of the relationship between seasonal flood magnitude and Topnaar livestock populations, both small stock and cattle, was insignificant.

Discussion

Current Topnaar Livestock Management Practices

Our interviewees who owned cattle were not purposefully increasing the size of their herds. This is substantiated by the fact that, out of one hundred cattle in the households that we interviewed, there was only one calf, and no cattle had been purchased. One farmer cited extreme drought as a reason for not breeding his cattle. He recognized a decreased carrying capacity in the system, due to the lack of cattle fodder under drought conditions, resulting in cows that were too thin to reproduce. Past studies support this link between severe drought, reduced fodder, and decreased cattle carrying capacity in the system, identifying drought conditions in Namibia as the primary limiting factor in wild fodder production. Subsistence farmers, including our Topnaar survey respondents, are especially vulnerable to drought, as a large portion of their livestock fodder comes from foraging (Sweet and Burke 2000). Like Topnaar, livestock farmers in Namibia's Omaheke region perceive drought as a main cause of cattle mortality (Figure 7). Omaheke cattle travel 6km and 10km in search of fodder under drought conditions—much further than their usual range (Hangara et al. 2011). Similarly, one of our Topnaar interviewees explained that she had not seen her cattle in weeks because they had ventured as far as Walvis Bay—roughly 100km from her home. As drought reduces the carrying capacity of cattle's typical foraging areas, the animals must travel longer distances in search of fodder.

While drought conditions made cattle exchanges less attractive to Topnaar farmers, 54 (of 355 total) small stock were bought and 23 were sold in the past year. Perhaps these larger figures for buying and selling can be explained by the relative resilience of small stock in drought conditions. Our comparisons of small stock and cattle body condition scores showed that small stock had a 0.3 higher condition score on average, despite our use of a five-point scale for cattle and a four-point scale for livestock and a small cattle sample size (see Table 2). The difference between these body condition scores would have been still higher had we used the same metric to assess small stock and cattle body condition. A greater cattle sample size would also render our data more representative of the actual differences in livestock body condition. Previous literature and also suggests that small stock are better suited to handle extreme drought conditions than cattle. Goats and sheep have comparatively smaller body sizes and require less fodder, which allows them to survive under conditions that cattle cannot. Goat digestive physiology makes them especially well-suited to drought, as they have low metabolic requirements and an exceptionally efficient digestive system that responds quickly to change. Moreover, goats' ability to rapidly change the volume of their fore (anterior) gut in response to environmental changes allows them to maximize food intake and utilization in drought (Silanikove 2000). Topnaar key informants did not reference any physiological adaptations of goats to drought, but did comment that many farmers were switching from cattle to small stock to reduce animal mortalities (S. Kooitjie, *pers. comm.*, 3 November 2017).

While small stock may be more resilient to drought and its aftermath, both herding practices and livestock mortalities demonstrate that they face greater threats from predation than cattle and donkeys. Two thirds of survey respondents employ either a human, a dog, or both, to herd their

sheep and goats (see Table 3). Cattle, in contrast, are infrequently herded, and donkeys are not herd animals. Different foraging distances could partially account for this disparity in management practice. While cattle travel long distances in search of fodder, sheep and goats remain close to their kraal, where most return every night (see Figure 6). However, greater susceptibility to predators could also drive this relatively stringent control of small stock movement (see Figure 7). 83% percent of goat farmers and two thirds of sheep farmers reported that some of their animals died from predation in the last year, while only 17% of cattle and donkey owners reported such deaths. This discrepancy aligns with findings that subsistence farmers in Namibia tend to herd sheep and goats in areas where predator and theft risks are high, but allow cattle to occupy a spot far from the village (Sweet and Burke 2000). Moreover, Topnaar farmers perceive black-back jackals, which prefer to prey on small stock, with the greatest frequency (see Figure 8). Notably, our team encountered potential sources of error regarding perceived and actual causes of livestock mortality throughout the data collection process. For example, during this study period, another Dartmouth research team (Cervenka et al. 2017) encountered a dead goat that was bloated and foaming at the mouth. The following day, the goat's lower half had also been consumed by predators (see image below). While the animal originally perished from disease, a farmer could interpret this scavenging as evidence of death by predation. These misidentifications may manifest as errors in our data.

Figure 17 Misleading Signs of Predation

Nevertheless, statistical analyses indicate herding can significantly decreases predation risk for small stock (see Figures 12 and 13). While our results indicate no difference between canine and human herders, dogs are the most cost-effective option (see Table 9). Note that the average small stock per capita and average loss to predation may be skewed due to a small sample size. Further research can verify the results suggested in this table.

	Herding (Person)	Herding (Dog)	No Herding
Herding Costs (/month)	500-800	200	0
Small Stock Price (/goat)	600	600	600
Average small stock/capita	29.58	29.58	29.58
Worth of Average Stock (N$)	17,748	17,748	17,748
Stock Worth After Herding Costs (N $)	9,948	15,348	17,748
Average Loss to Predation (#)	5.5	4.5	40
Average Loss to Predation ($)	3,300	2,700	24,000
Net Stock Worth	6,648	12,548	-6,252
# of Stock Needed to Sell to Offset Losses	5.5	4.5	40
# of Stock Needed to Sell to Make Profit	18.5	8.66	40

Table 9 A Hypothetical Cost-Benefit Analysis of Herding.

Interestingly, within villages, small stock farmers often identified the same predation sites (see Figure 9). However, the small number of farmers that we interviewed in each settlement provided little opportunity for contrasting data. We also employed a gradient buffer in our final map that both reflects the varying nature of predator movement and increases the margin for error. Similar studies have also used geographic information systems (GIS) software to map the movements of wildlife, but contextualized participant responses with field observations and historical data, including aerial photographs (Steklis, Madry, et al. 2005; *GIS For Wildlife Conservation* 2006). These multi-layered approaches mitigated the bias inherent in using only one type of data, while maximizing the capability of GIS technology to show many layers of spatial data in a single frame. Though historical predator mapping of areas surrounding Topnaar communities does not exist, it would be useful to ground our participants' responses in current field observations or aerial imaging.

Urbanization trends present another complexity in the Topnaar livestock management system. According to survey results, all of our respondents' household members live at home in rural settlements. However, this finding is likely misleading; demographic survey questions asked for other people currently living in the respondent's household, thus excluding relatives living and

working in urban centers. Anecdotal evidence from survey respondents indicates that many young Topnaar have left rural settlements to work or attend school in the nearby port city of Walvis Bay. This follows the broader trend of rural to urban migration in southern Africa's local and indigenous communities, partially motivated by climate change conditions that render rural livelihoods less attractive (Serdeczny et al. 2017). Some elderly people are limited in their ability to care for livestock; conversations with survey respondents revealed a pattern of elderly household members who declined to participate in labor-intensive management practices like herding. Those with financial flexibility often hire young herders from other regions. For example, we interviewed one hired herder from the Ovambo region of Namibia, and two from Angola. Herders from other areas may employ different management practices than traditional Topnaar farmers. For example, subsistence livestock management practices in Angola are more water intensive, as the presence of rivers and lakes eliminates water scarcity (*Angola Country Commercial Guide* 2017). This study suggests that urbanization may exert an influence on management practices, but the dynamics of this relationship require additional research,

Challenges Faced and Outcomes Generated by Topnaar Livestock Farmers

Survey results indicate that goats are more susceptible to drought than sheep (see Table 4). However, this finding is likely inaccurate, as our data is skewed due the far greater popularity of goats relative to sheep. According to one Topnaar farmer, this phenomenon is a result of better responses to drought in goats than sheep. While previous research suggests that small stock are more likely to survive drought than cattle, authors do not differentiate between goats and sheep (Jonsson 2010). This, too, is an area for future study.

Disease—especially lung sickness (*bovine pleuropneumonia*) —is the most significant perceived cause of mortality for Topnaar cattle and donkey (see Table 4). However, there is no significant relationship between vaccinating cattle and death from disease (see Table 6). High cattle vaccination rates can be partially explained by their high value relative to smallstock. However, they are also susceptible to disease; lung sickness is one of the largest threats to cattle in southern Africa (Table 2, Amanfu 2009). Conversely, few farmers vaccinate donkeys (see Table 2). In fact, surveyed Topnaar farmers were incredulous when asked if they vaccinated their donkeys. This reaction reflects the idea that most donkeys are resilient to adverse conditions and are not perceived as highly susceptible to illness (Smith and Pearson 2005). One Topnaar interviewee compared his donkeys to wild animals, as they move freely, do not return home at night, and experience comparatively few losses to predation, disease, and drought (see Figure 7). These behaviors are common across southern Africa reflect the donkey's physiological adaptations; as selective foragers, donkeys spend less energy finding food and obtain a higher quality diet than cattle (Smith and Pearson 2005).

We also examined the relationship between vaccinating small stock and losses to disease, drought and predation. While a small sample size prevented statistical analyses from indicating significance between any of these factors, anecdotal evidence suggests that many Topnaar farmers are suspicious of vaccinations (see Table 6). One respondent informed us that he avoided

vaccines because they make animals sick. Many farmers also face financial and spatial barriers to purchasing vaccines at the Agra Store in Walvis Bay. Likewise, a small sample size resulted in an insignificant relationship between the use of supplementary fodder and small stock losses (see table xx). However, we realized that "supplementary fodder," takes on a variety of meanings to our Topnaar respondents. Some farmers provide *Faidherbia albida* seed pods collected from the nearby ephemeral riverbed to young sheep and goats who are too small to leave the kraal. Other farmers with greater financial resources provide purchased, nutrient-enriched feed to all of their livestock. Field observations indicate that the latter group of livestock enjoy greater body condition.

Qualitative Assessment of the Socio-Ecological System

The Namib-Naukluft National Park (NNP) governance structure also impacts the Topnaar socio-ecological system. However, Topnaar perceptions of relevant NNP policies are characterized by a lack of knowledge. These misperceptions are complicated by non-standardized application and enforcement of these policies, which subject to individual interpretation by park wardens and other MET employees (R. Solomon, *pers. comm.,* 3 November 2017). NNP policies have restricted the land area occupied by Topnaar people to only a tenth of their range through the creation of a multi-use zone in the park. This multi-use zone is the only legal space for livestock farming (MET 2013). While we expected Topnaar farmers to criticize this land reduction, most farmers did not believe that the NNP restricts the movement of their livestock (see Table 8).

In contrast, we predicted relative satisfaction with NNP predator policies. While civilians are not permitted to carry firearms within Namibian National Parks, flexible enforcement allows Topnaar farmers to kill predators if the animal is found consuming livestock within the kraal, so long as they report the incident to MET within ten days (Met 2013, R. Solomon, *pers. comm.,* 3 November 2017). However, most Topnaar farmers do not perceive that they have any agency in dealing with predators, and feel frustrated by the NNP's lack of a compensation policy for livestock lost to wildlife (see Table 8). The NNP does not compensate Topnaar farmers for livestock losses under most circumstances, though they will send MET officers to deal with problem predators (R. Solomon, *pers. comm.,* 3 November 2017). Perhaps Topnaar have gradually come to terms to their reduced land area, but are unable to accept regulations on predator management, since predation continues to be a major cause of small stock mortality (see Figure 7). It is imperative to standardize the application of NNP human-wildlife conflict policies, and to ensure that Topnaar farmers fully understand their rights within the constraints of these policies.

Another confounding component of the Topnaar socio-ecological system is water allocation. In the early 1970s, the Topnaar traditional leader provided water for his 300 livestock from a shallow hole in the riverbed near his residence in Homeb. However, a dropping water table pushed him into a series of government negotiations to acquire hand-pumped, then diesel-generated, boreholes for the region upstream of the Swartbank mountain range. The chief's livestock herd substantially declined following the pattern of the water table due drought-inflicted decreases in fodder vegetation. Chief Kooitjie also commented that differences in water

table levels result in more productive trees in the upstream area where he lives, and less vegetation around the downstream settlements. These water table differences are both geographic and political in nature; mountains form a "bowl" in the water table around the chief's upstream settlement, and the parastatal NAMWATER tends to overdraw water from its downstream boreholes. As a result, recent drought conditions have proven more deleterious for downstream livestock than for their upstream counterparts. (S. Kooitjie, *pers. comm.*, 3 November 2017).

Conclusion

All aspects of Topnaar livestock management are components of the dynamic socio-ecological system composed of Topnaar people, the ephemeral Kuiseb River basin, and the Namib-Naukluft National Park (NNP). Our interactions with this system and our subsequent analyses produced findings that can inform future livestock management.

First, we found that small stock are more popular than cattle among Topnaar farmers. One explanation is the comparative resilience of sheep and goats to current drought, as evidenced by their physiology. These animals also experience greater controlled inflows and outflows to their standing stock, as they are bought, sold, and slaughtered more frequently than cattle. Predation, another small stock outflow, is one of the most serious challenges for Topnaar livestock farmers. Compounded by inconsistent NNP policy applications, Topnaar residents perceive that they have little agency in dealing with predators. Going forward, it is essential to standardize the application of NNP policies and to educate farmers accordingly. Herding small stock was the only practice shown to significantly mitigate livestock mortality from predation. Topnaar farmers do not typically herd cattle. Our theoretical cost-benefit analysis suggests that herding with a dog is maximizes profits and small stock health.

Disease is another threat to Topnaar livestock, especially cattle. The most common disease is *bovine pleuropneumonia,* colloquially known as lung sickness. Two-thirds of Topnaar farmers vaccinate their livestock, but those who do not face significant spatial and financial barriers. Donkeys, in contrast, are the most resilient species of Topnaar livestock. Farmers compare them to wild animals, and they are notorious across Namibia for their resilience to drought and perceived immunity to illness.

Other components of the socio-ecological system also impact management practices. As climate change makes it unattractive to pursue traditional rural livelihoods, some young Topnaar migrate to Walvis Bay for employment. Their absence may impact management practices. Politicized distribution of water scarcity also impact the system, as Topnaar settlements enjoy uneven access to government boreholes and parastatal NAMWATER pumps. This disparity in water allocation systems raises major issues for livestock farmers.

At present, Topnaar livestock management systems are responding to the current, severe drought, while working to mitigate the impacts of disease and predation. Going forward, optimal livestock management will devolve agency to farmers while maximizing profitability of drought-

adapted livestock. Future research is needed to determine which management practices are optimal for unpredictable and imminent climatic changes.

Suggestions

For future Dartmouth groups:

1. When conducting interviews, avoid broad, open-ended questions, as they produce a variety of responses that are difficult to analyze. Moreover, these questions can be overwhelming to respondents. Stick to concise, specific questions, preferably with answer choices, as these frame your participants' answers.
2. Before conducting surveys on the ground, in local communities, it is invaluable to receive feedback from a member of that specific community. We received feedback from two Topnaar staff members employed at Gobabeb. Without their input, the survey we initially drafted would have been far less appropriate for the Topnaar community.
3. Clarify your research focus before drafting survey questions. Every question that you ask should be directly pertinent to the goals of your project, as you want to respect individuals' time and create a survey that is concise and informative. In a few circumstances, we interviewed individuals with limited time, resulting in incomplete survey responses. While it is better to have a partially-completed survey than no survey at all, a concise document should prevent this from occurring.
4. Time limits the scope of your project, as you only have a week to collect data. It is helpful to amass as many interviews as possible. Carefully planning and scheduling your interviews with your community liaison will allow you to do this. However, you must remain flexible, as your interviewees have limited time and their schedules are subject to change.
5. We found it valuable to present survey respondents with tangible compensation for their time. We gave every household that we surveyed a bag filled with basic household necessities, including tea, coffee, sugar, flour, and cooking oil. While we do not want to reinforce the negative association between western tourists and handouts, it is important to show appreciation for your interviewees' generosity with their time and knowledge.
6. If working in a group composed of four or more students, it is best to split the group in a 2-2 or 3-2 arrangement for conducting interviews. While two or three students remain at the research base, two can go with the community liaison or translator to interview households. This technique reduces the risk of overwhelming interviewees, while increasing the efficiency of the data entry process. Group members remaining at the research base should be compiling data from previous interviews and working on other aspects of the project.

To inform Topnaar livestock management:

1. There is a marginally significant negative correlation between herding and livestock losses due to predation. This means that herding livestock probably decreases deaths from predation. More data and future studies can substantiate this relationship. It follows

that, if a Topnaar farmer can afford to hire a herder, or can herd livestock individually, he or she would benefit from doing so.
2. There is some discrepancy between written NNP legislation, Chief Warden Solomon's interpretation of these policies, and Topnaar community perceptions of how these regulations impact their livestock management. It would be beneficial to clarify and standardize some of this legislation for all parties involved, especially policies concerning compensation for the loss of Topnaar livestock due to predation. Topnaar farmers should understand their legal rights when dealing with predators, and they should be familiar with the reporting protocol for human-wildlife conflict. We hope that these clarifications might reduce animosity between Topnaar community members and employees of the National Park.
3. Surveying the Topnaar community revealed a possible relationship between the type of livestock and sustainability of management under drought conditions. For example, some farmers identified smallstock as better acclimated to the post 2011-flood environment in the Kuiseb River Valley, whereas cattle required higher amounts of food and water that are no longer sustainable for this community.

For continued research:

1. Investigate the suitability of different livestock species to the current drought conditions in the Lower Kuiseb River Valley. This would involve a comprehensive analysis of how sheep, goats, donkeys, and cattle respond to different challenges presented by the drought (ie lack of fodder for grazing and browsing and susceptibility to predation and disease).
2. Identify the most common disease for each species of livestock managed by the Topnaar, and establish if Topnaar farmers are vaccinating against this disease. Our research attempted to address this topic, but failed to obtain comprehensive results. We did not survey enough farmers, leading to a lack of significant data.
3. Analyze how other Namibian National Parks have worked with their resident and neighboring local communities to govern multi-use areas. Discuss opportunities for increased understanding of current NNP policies, and the possibilities for development within the constraints of multi-use areas.
4. Identify which demographic of Topnaar herders (either young, adult, or elderly) experiences the most success with livestock management, quantified by number of losses due to disease, predation, and poisonous plants. Investigate possible reasons for the success of this demographic.
5. Investigate the politics of extraction from the Kuiseb River water table. Especially focus on the differing interests and positionalities of actors such as the nearby cities of Walvis Bay and Swakopmund, the commercial farms, mines, and industries, and local communities such as the Topnaar.

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Appendices
Appendix I

COMMUNITY LIVESTOCK SURVEY 2017

We are university students from Dartmouth College in the United States. When Dartmouth students visited Topnaar communities last year, we learned that they were most interested in learning more about livestock management. We are working with Gobabeb this week to collect information about livestock in your community. We hope that what we learn from you all can help you and other community members with livestock management. We will also give this information to Joel Kooitjie and Chief Kooitjie to address your concerns about your livestock.

All the answers you give us are completely confidential. We'll write up a summary of what we learned as part of a report that we'll give to Gobabeb, Chief Kooitjie, and Joel Kooitjie. However, we will not include your name in the final results or share your specific information with anyone.

Household demographics

1. Interviewee

Name	Age[1]	Gender	Position[2]

2. Household[3] composition

#	Age	Gender	Live at home?	Manages livestock?
2		M F		
3		M F		
4		M F		
5		M F		
6		M F		
7		M F		
8		M F		
9		M F		
10		M F		

[1] Young (0-15), Adult (16-60), Senior (60+)
[2] Owner, herder, etc.
[3] Household: Any person who sometimes lives in this house

3. Settlement: _____

Livestock demographics

4. Do you share your kraal with other people not in your household? Y N

   If yes: How many other people? _____

5. How many animals do you manage?

	Goats	Sheep	Cattle	Donkeys
Adult females (#)				
Adult males (#)				
Young (#)				

6. In the last year, how many of livestock in this kraal were bought, sold, or eaten?

	Goats	Sheep	Cattle	Donkeys
Eaten				
Bought				
Sold				
If sold: Why?				
If sold: Where?				
If sold: How did you get your livestock there?				

7. Why do you have your goats/sheep/cattle/donkeys?

	Goats	Sheep	Cattle	Donkeys
Milk				
Meat				
To sell				
Cultural purposes				
Inheritance				
Other				

If other: What reason?				

8a. In the past year, were any of your goats killed by predators? Y N

If yes:

How many? ____

Which predators? (Pictures)

[Cheetah] [Leopard] [Jackal] [Hyena] [Caracal] [Not sure] [Other]

If other: Specify: _____

Where this year? (Map)

8b. In the past year, were any of your sheep killed by predators? Y N

If yes: How many? ____

Which predators? (Pictures)

[Cheetah] [Leopard] [Jackal] [Hyena] [Caracal] [Not sure] [Other]

If other: Specify: _____

Where this year? (Map)

8c. In the past year, were any of your cattle killed by predators? Y N

If yes: How many? ____

Which predators? (Pictures)

[Cheetah] [Leopard] [Jackal] [Hyena] [Caracal] [Not sure] [Other]

If other: Specify: _____

Where this year? (Map)

8d. In the past year, were any of your donkeys killed by predators? Y N

If yes: How many? ____

Which predators? (Pictures)

[Cheetah] [Leopard] [Jackal] [Hyena] [Caracal] [Not sure] [Other]

If other: Specify: _____

Where this year? (Map)

9a. In the past year, were any of your goats killed by disease? Y N

If yes: How many? ____

Which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

If other: Specify: _____

If not sure: What symptoms? _____

9b. In the past year, were any of your sheep killed by disease? Y N

If yes:

How many? ____

Which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

If other: Specify: _____

If not sure: What symptoms? _____

9c. In the past year, were any of your cattle killed by disease? Y N

If yes: How many? ____

Which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

If other: Specify: _____

If not sure: What symptoms? _____

9d. In the past year, were any of your donkeys killed by disease? Y N

If yes: How many? ____

Which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

If other: Specify: _____

If not sure: What symptoms? _____

10a. In the past year, were any of your goats killed by poisonous plants? Y N

If yes:

How many? ____

Which plants? _____

Where do you find them? [Dunes] [Gravel plains] [Riparian zone]

10b. In the past year, were any of your sheep killed by poisonous plants? Y N

If yes:

How many? ____

Which plants? _____

Where do you find them? [Dunes] [Gravel plains] [Riparian zone]

10c. In the past year, were any of your cattle killed by poisonous plants? Y N

If yes:

How many? ____

Which plants? _____

Where do you find them? [Dunes] [Gravel plains] [Riparian zone]

10d. In the past year, were any of your donkeys killed by poisonous plants? Y N

If yes:

How many? ____

Which plants? _____

Where do you find them? [Dunes] [Gravel plains] [Riparian zone]

11a. In the past year, were any of your goats stolen? Y N

If yes: How many? ____

11b. In the past year, were any of your sheep stolen? Y N

If yes: How many? ____

11c. In the past year, were any of your cattle stolen? Y N

If yes: How many? ____

11d. In the past year, were any of your donkeys stolen? Y N

If yes: How many? ____

12a. In the past year, were any of your goats killed by drought? Y N

If yes: How many? ____

If yes: What effect(s) of the drought kill your goats?

[Fewer pods on trees] [Trees flower at the wrong time] [Less vegetation] [Lack of water] [Other]

12b. In the past year, were any of your sheep killed by drought? Y N

If yes: How many? ____

If yes: What effect(s) of the drought kill your sheep?

[Fewer pods on trees] [Trees flower at the wrong time] [Less vegetation] [Lack of water] [Other]

12c. In the past year, were any of your cattle killed by drought? Y N

If yes: How many? ____

If yes: What effect(s) of the drought kill your cattle?

[Fewer pods on trees] [Trees flower at the wrong time] [Less vegetation] [Lack of water] [Other]

12d. In the past year, were any of your donkeys killed by drought? Y N

If yes: How many? ____

If yes: What effect(s) of the drought kill your sheep?

[Fewer pods on trees] [Trees flower at the wrong time] [Less vegetation] [Lack of water] [Other]

13a. In the past year, were any of your goats lost for some other reason? Y N

If yes:

What reason? _____

How many? ____

13b. In the past year, were any of your sheep lost for some other reason? Y N

If yes:

What reason? _____

How many? ____

13c. In the past year, were any of your cattle lost for some other reason? Y N

If yes:

What reason? _____

How many? ____

13d. In the past year, were any of your donkeys lost for some other reason? Y N

If yes:

What reason? _____

How many? ____

Livestock management

14a. Does someone herd your smallstock? Y N

If yes: Who? _____

If no: Why not? _____

14b. Does someone herd your cattle? Y N

If yes: Who? _____

If no: Why not? _____

15a. Does a dog go out with smallstock? Y N

15b. Does a dog go out with cattle? Y N

16a. Do you vaccinate your smallstock? Y N

If yes:

Against which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

How often? _____

Where do you get the vaccines? _____

Who pays for the vaccines? _____

If no: Why not? _____

16b. Do you vaccinate your cattle? Y N

If yes:

Against which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

How often? _____

Where do you get the vaccines? _____

Who pays for the vaccines? _____

If no: Why not? _____

16c. Do you vaccinate your donkeys? Y N

If yes:

Against which diseases?

[Ticks] [Lame sickness] [Lung sickness] [Rabies] [Other] [Not sure]

How often? _____

Where do you get the vaccines? _____

Who pays for the vaccines? _____

If no: Why not? _____

17a. Do you know where your smallstock eat and drink? Y N

If yes: Where? (Map)

17b. Do you know where your cattle eat and drink? Y N

If yes: Where? (Map)

17c. Do you know where your donkeys eat and drink? Y N

If yes: Where? (Map)

18a. Do you use supplementary feed for your smallstock? Y N

18b. Do you use supplementary feed for your cattle? Y N

18c. Do you use supplementary feed for your donkeys? Y N

19a. How often do your smallstock come home?

[Every night] [Few times a week] [Few times a month] [Hardly ever]

a. *If every night:* What time do your smallstock leave in the morning, and what time do they come home at night? _____

19b. How often do your cattle come home?

[Every night] [Few times a week] [Few times a month] [Hardly ever]

b. *If every night:* What time do your smallstock leave in the morning, and what time do they come home at night? _____

19c. How often do your donkeys come home?

[Every night] [Few times a week] [Few times a month] [Hardly ever]

c. *If every night:* What time do your small stock leave in the morning, and what time do they come home at night? _____

20a. What picture looks most like your goats? ____

20b. What picture looks most like your sheep? ____

20c. What picture looks most like your cattle? ____

20d. What picture looks most like your donkeys? ____

Park policies

21. Can your livestock move freely within the park?

_____

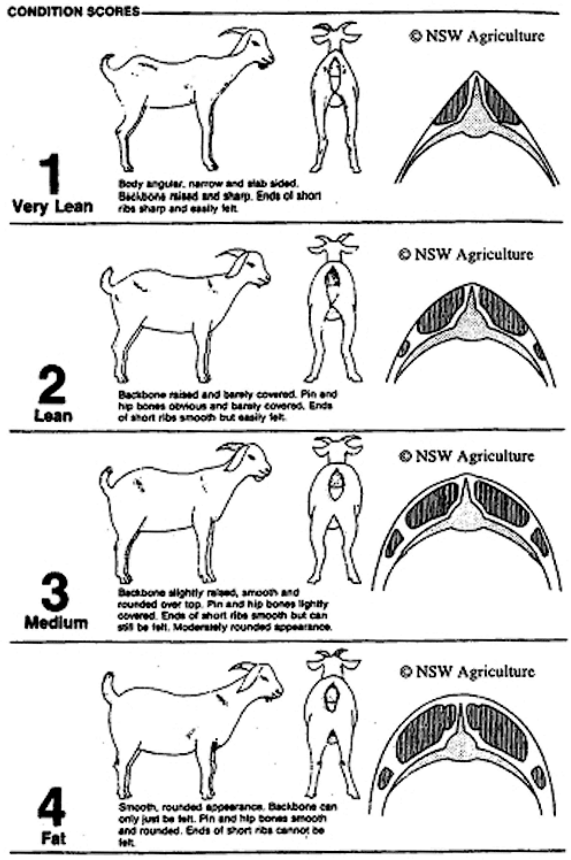
22. How does living in a national park impact the way you handle predators, if at all?

_____

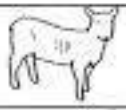
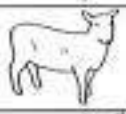
Appendix II

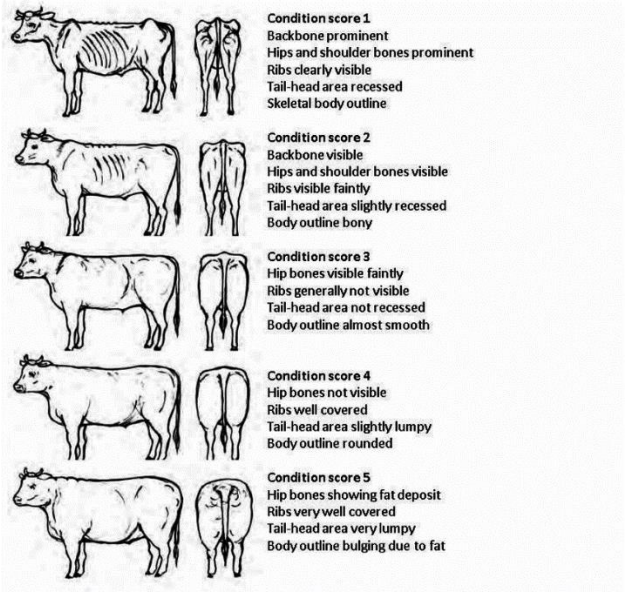
Livestock Body Condition Tables

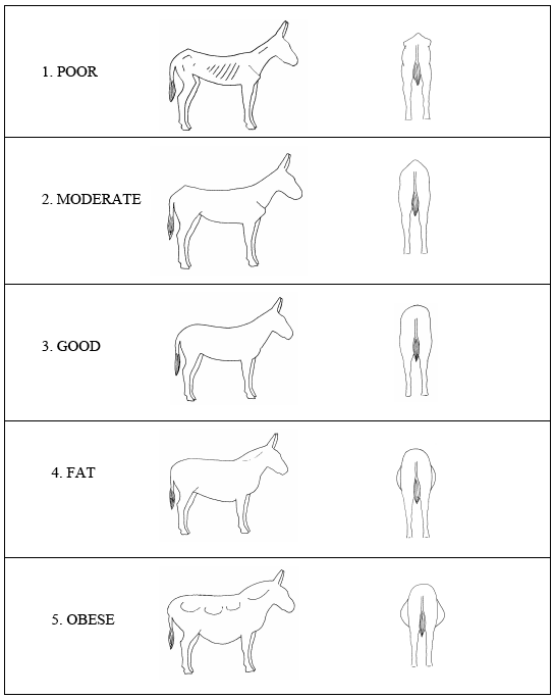
APPENDIX 1



Further reading: Condition Scoring of Goats, The New South Wales Department of Agriculture, Agfact A7.2.3

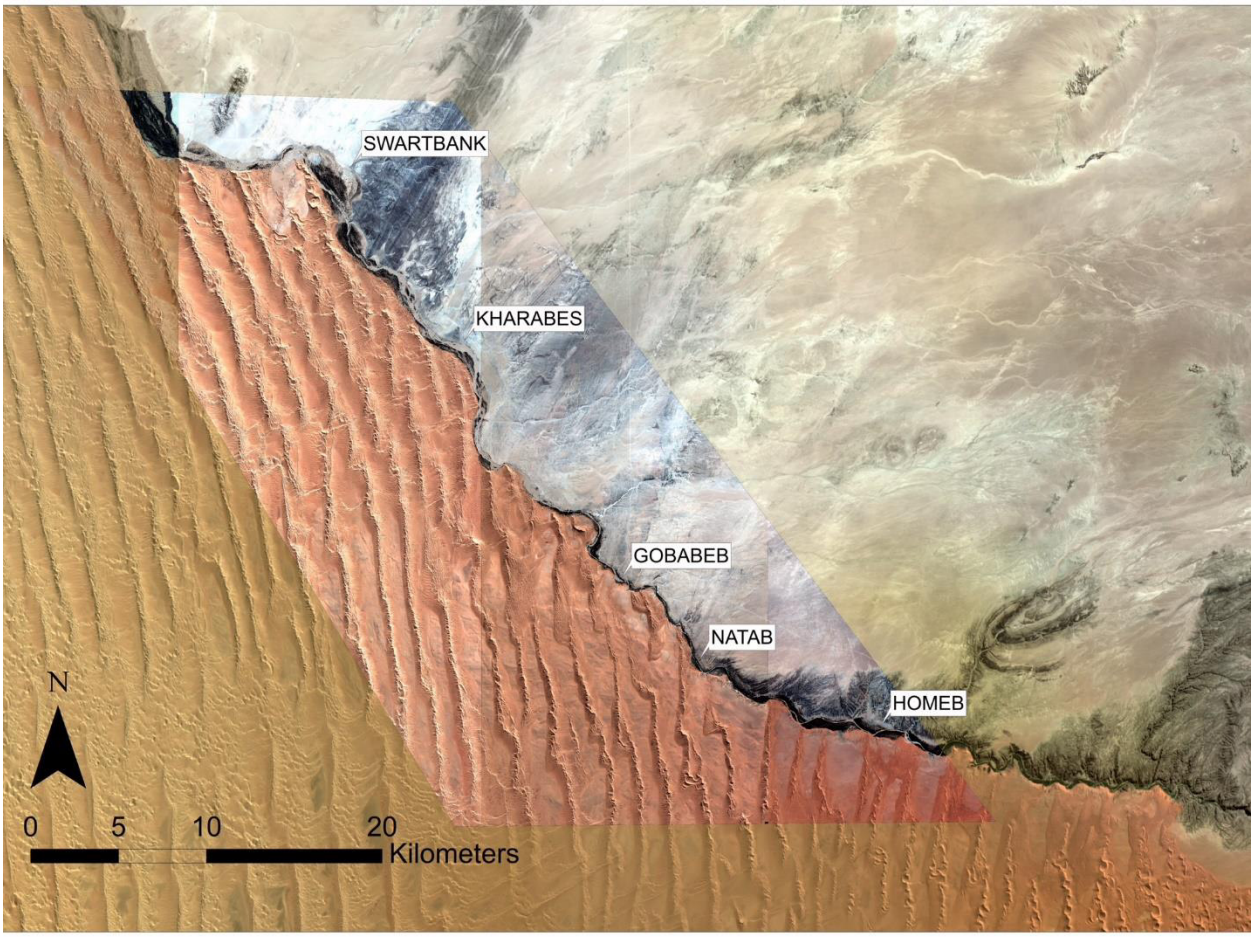
Score		Description	
1		Spine sharp, back muscle shallow.	Lean
2		Spine sharp, back muscle full, no fat	
3		Spine can be felt, back muscle full, some fat cover	Good Condition
4		Spine barley felt, muscle very full, thick fat cover	Fat
5		Spine impossible to feel, very thick fat cover, fat deposits over tail and rump	


Condition score 1
Backbone prominent
Hips and shoulder bones prominent
Ribs clearly visible
Tail-head area recessed
Skeletal body outline
Condition score 2
Backbone visible
Hips and shoulder bones visible
Ribs visible faintly
Tail-head area slightly recessed
Body outline bony
Condition score 3
Hip bones visible faintly
Ribs generally not visible
Tail-head area not recessed
Body outline almost smooth
Condition score 4
Hip bones not visible
Ribs well covered
Tail-head area slightly lumpy
Body outline rounded
Condition score 5
Hip bones showing fat deposit
Ribs very well covered
Tail-head area very lumpy
Body outline bulging due to fat


1. POOR
2. MODERATE
3. GOOD
4. FAT
5. OBESE

Appendix III

Spatial Mapping Exercise



Map 1: High definition map used to pinpoint where predators prey on livestock.

Appendix IV

Interview questions for Chief Seth Kooitjie

1. Have Topnaar livestock demographics and management practices changed during your tenure as chief?
2. How has the ecology and climate of the Lower Kuiseb changed in your lifetime?
    a. What political factors impact water availability here?
3. Is it easier to raise livestock in some Topnaar settlements than others?
4. Do you perceive any conflict between the national park and the Topnaar interests?
5. Do Topnaar livestock owners face more difficulties during certain times of the year?

Appendix V

Interview questions for Chief Warden Riaan Solomon

1. According to the Namibian Human Wildlife Conflict Policy, there is no compensation for livestock loss due to wildlife, in national parks, unless the park is zoned into multi-use areas. I believe the NNP is zoned, and that the lower Kuiseb River Valley, where the Topnaar live, is in zone four. Is this correct? If so, how does this change the way that Topnaar are compensated for lost livestock? Specifically, when a Topnaar farmer loses a cow, donkey, sheep, or goat to wildlife, what happens?
2. What changes have you observed in livestock management in the Topnaar?
3. What, in your opinion, is the biggest problem animal? Why is this the case?
4. What would be the consequences of poaching predator?
5. Are communities allowed to own guns in the national park?
6. Can the Topnaar shoot/kill problem animals within official MET/park regulations?
7. Do you think that the community is aware of these park policies on predation?
8. Have noticed any changes in perceptions of the park occurred over time?
9. Have you seen any changes in the ecosystem during your time working for the Park service?