Combining Wildlife Occupancy and Attitudinal surveys to improve Al Wusta Wildlife Reserve Management

by

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Abstract

Understanding the interactions between people and the landscape, their resource use, activities and needs is an important component of effective natural resource management, particularly in protected areas (Reserves) that are actively inhabited and used by people. The effectiveness of protected areas is strongly influenced by their inhabitants. In spite of the potential impact of Al Wusta Wildlife Reserve (WWR) on resident Bedouin, and the influence of the local communities on WWR, there have been no attitudinal surveys of people living in the reserve. These surveys could provide insight to reserve management on ways in which to improve biodiversity conservation and maintain traditional use and access to WWR.

Between 2016 and 2020, I conducted a study aimed at understanding the attitudes the local population towards wildlife, their use patterns, current needs and practices in WWR and simultaneously took part in a large-scale camera trapping project to understand the status and distribution of Nubian ibex inside the reserve. The studies aimed to provide insight into better wildlife management based on the results of anthropological evidence and new wildlife distribution data.

Local communities expressed their opinions and stated that wildlife populations had declined in recent times including Nubian Ibex numbers. Respondents reported no gain from being inside the reserve and disliked being managed by the reserve, they thought the reserve was too large and the reserve fence restricted their traditional movements and endangered their animals. Additionally, using camera traps, Ibex were captured at 65 of 163 camera locations giving a naïve occupancy of 39.8%. The number of Ibex visiting these 65 cameras averaged 3.4 Ibex per 100 days indicting a very low-density, dispersed population, with population centres outside of the reserve boundary. Modelling found Ibex occupancy was positively influenced by variables including being on the Huqf escarpment, slope, heat load and ruggedness. However, other than the Huqf variable, variables had very small effect sizes. Future occupancy modelling work in

WWR should explore new variables and variable interactions to better define Ibex habitat use to assist monitoring and management practices.

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Chapter 1: General Introduction

There is a growing recognition that effective management and protection of natural ecosystems is more often about influencing people's decisions and actions, than managing the ecosystem processes themselves (Balmford & Cowling, 2006; Milner-Gulland, 2012). Understanding the interactions between people and the landscape, their utilisation of resources, activities and needs is therefore an important component of effective natural resource management, particularly in protected areas that are actively inhabited and used by people (Fiallo & Jacobson, 1995). The effectiveness of protected areas is greatly influenced by their inhabitants. Positive or negative interactions can arise depending on attitudes and relationships of local people towards protected areas and their objectives, most notably these include either enforcement or engagement with illegal activities, or unsustainable use or active stewardship of natural resources within protected areas (Gillingham & Lee, 1999).

1.1 Al-Wusta Wildlife Reserve (WWR):

Al-Wusta Wildlife Reserve (WWR) is an area within the central desert and coastal Hills of the Al Wusta region of Oman. Within an area of very low rainfall, seasonal fogs and dew support the unique assemblage of desert biodiversity with diverse flora and several endemic plant species. Its rare fauna includes the first free-ranging herd of the Arabian Oryx since the global extinction of the species from the wild in 1972 and has hosted the reintroduction program of this species since1982. The reserve also supports the conservation of threatened animals such as the Houbara Bustard *Chlamydotis undulata*, Nubian Ibex *Capra nubiana*, Arabian wolf *Canis lupus arabs*, Honey Badger *Mellivora capensis*, Caracal *Caracal caracal*, Arabian Gazelle *Gazella arabica*, and Reem gazelle *Gazella marica*.

In an attempt to control poaching within the reserve the WWR is enclosed by a two meter high chain-link perimeter fence. The reserve covers 2,824 km^2 of open, sparsely-vegetated limestone desert including the Al-Huqf escarpment to the east, an uninhabited area of sabka desert and a rocky hills that lead to the eastern coastal region (Stanley-Price, 1989).

In recent decades, the reserve has experienced several impacts due to poaching and overgrazing that have compromised the integrity of the ecosystem. The area has seen numerous die-offs of wildlife populations due to uncontrolled poaching, resulting in the extinction of Arabian Oryx (*Oryx leucoryx)* in the late 1970's and, following reintroduction in the 1990s, a second extirpation in the early 2000s. Arabian Gazelles have fallen from a population of approximately 10,000 to less than 500 in the last twenty years (Al Jahdhami *et al*., 2017). All other wildlife including Nubian Ibex has seen declines due to poaching or secondary impacts due to the decline of the ecosystem (Ross *et al*., 2020).

1.1.1. Nubian Ibex (Capra nubiana)

The Nubian Ibex (figure 1) is the smallest *Capra* species (Groves *et al*., 2011). Males weigh between 55 and 65 kg and are distinguished by long curved horns, while females are much lighter, weighing in the region of 21–27 kg with smaller and thinner horns (Habibi *et al*., 1997; Masoola *et al*., 2008).

The Nubian Ibex is a flagship species for conservation efforts in Oman, alongside other important arid-land ungulates (Grobler, 2002). The species is classified as Vulnerable by the IUCN and is found in small, fragmented populations from the central region down to the southern of Oman with scattered populations ranging from Palestine, Egypt to Sudan (Grobler, 2002; Ross *et al.*, 2020). The Nubian Ibex in the central region is restricted to the Al Wusta Wildlife Reserve (WWR) escarpment, a hyper-arid region (Massalo *et al*., 2008). Nubian Ibex populations are declining in response to poaching, human settlement expansion, feral livestock competition, habitat degradation, diseases and population fragmentation (Ross *et al*., 2020).

Figure 1: A male Nubian Ibex in WWR with the Huqf Escarpment in the background.

1.1.2. Bedouin (Local people):

WWR is inhabited by a low density of nomadic Bedouin who, for centuries, have raised livestock and utilised the local natural resources (Chatty, 1983). Although livestock have always been kept in the area, increasing numbers of livestock and changing practices of local peoples have resulted in livestock grazing becoming unsustainable, leading to overgrazing of resources that are required by the native wild ungulate populations (Gurung *et al*., 2009). Where local peoples actively use protected area resources there is a need to communicate and exchange information with authorities, to inform and develop the best management practices (Kellert *et al*., 2000). This can best be achieved by combining data on human resource use and attitudinal surveys and mapping local utilisation alongside wildlife distribution data. This can provide a basic but effective overview of human-natural resource interactions (McLain *et al*., 2013).

Despite the potential impact of WWR on the Bedouin, and the respective impact of Bedouin on WWR, and an in-depth study of the practices of nomadic pastoralists of the area (Chatty, 1983), there has been no research conducted on ways in which local people and reserve managers can combine information to better conserve biodiversity and maintain traditional use and access to WWR.

1.2. Thesis objective

This study aimed to understand local people's attitudes towards wildlife, their spatial use patterns, current needs and practices in relation to the reserve and its wildlife, especially Nubian Ibex. Nubian Ibex were chosen as a focal species because their population has suffered less than other large mammal species and maintaining the natural population as it stands is a priority. It combined anthropological evidence with wildlife distributional data in order to map, visualise and understand interactions, potential issues and solutions between local people, wildlife and reserve management.

In order to realise these aims, the project has fulfilled the following objectives:

1. Mapping and modelling the current Nubian Ibex population as a bases for understanding its conservation status and potential interactions with human threats.
2. Assessing the perceptions and attitudes of key stakeholders (rangers, local leaders, local Bedouin) about changing land use and biodiversity.
3. Highlighting current conservation issues and potential actions that will improve reserve management and conservation of Al-Wusta Wildlife Reserve, with a focus on the Nubian Ibex.

Chapter 2: Evaluating detection and occupancy of Nubian Ibex in Al-Wusta Wildlife Reserve

2.1. Introduction:

The Nubian Ibex (*Capra nubiana*) is patchily distributed across parts of Africa and Arabia. Currently, there is a lack of population data but evidence suggests that they are extremely rare and in decline in Sudan, Eritrea, Yemen, Saudi Arabia, Jordan, Egypt and Oman (Ross *et al*., 2020). The Global population is suspected to number less than 5,000 mature individuals, and in the last 10 years the population has declined towards numbers more closely associated with the Endangered classification (Ross *et al*., 2020)

The main threats Nubian Ibex populations are facing include illegal and unregulated legal hunting, habitat degradation and direct competition for resources with livestock, disturbance of critical water resources by livestock and their herders, and depletion of water resources due to lowering water tables in the arid areas, genetic threats typical of small population, disease outbreaks and general environmental change (Ross *et al*., 2020)

The use of camera trapping has grown significantly over the last decade (Burton *et al*., 2015). In biodiversity monitoring and ecological research, camera trapping has been used over a broad geographic range, taxonomic diversity, and to address diverse conservation issues (Steenweg *et al*., 2017). Camera trapping has been proven an effective tool for answering various ecological and conservation questions including: species landscape connectivity; evaluating effects of forest fragmentation on tropical species diversity; assessing species richness and recording the loss of specific species (Ahumada *et al*., 2011; Barrueto *et al*., 2014; Rasphone *et al*., 2019)

Keeping in view above threats to Nubian Ibex and other endangered mammals in Al-Wusta Wildlife Reserve, this study was designed to meet following objectives:

1) To understand the distribution and habitat requirements of Nubian Ibex in the study area.
2) Use the resulting distribution maps to understand how we can better manage and conserve Ibex in the area.

3) Understand the interactions between humans and Nubian Ibex in WWR.

2.2. Methodology

2.2.1 Study area

Al-Wusta Wildlife reserve lies in the central desert of Oman and covers 2772 km^2 (Figure 2). Most of the sanctuary is a flat or undulating plateau but the eastern boundary of the plateau consists of a 100 m high escarpment, which leads to the Huqf depression and a series of hills between the escarpment and the coastline. The escarpment runs for about 150 km north–south. The plateau and saline flats of the Huqf depression are waterless, but there are small freshwater seepages on the escarpment and eastern hills.

The climate is hyper-arid, where the average monthly temperature reaches 23 °C in January and 45 °C in June. Annual rainfall is 50 mm (Fisher & Membury 1998). As a consequence of the proximity of the sea and the presence of cold water offshore, dewfall and fog are common in spring and autumn in the reserve and the escarpment (Stanley Price *et al.* 1988).

Vegetation is characterized by annuals and ephemerals, principally dependent on rainfall, and perennials that survive extended drought by utilizing dew and fog precipitation. Trees of *Acacia tortilis* are found above the escarpment and *Prosopsis cineraria* and *Acacia ehrenbergiana* are common below the escarpment and coastal hills, providing an important nutritional component of ungulate diet in this region (Tear *et al.* 1998). Ground cover is dominated by perennial shrubs and grasses, in particular, *Crotalaria aegyptiaca, Rhazya stricta, Heliotropium kotschyi* and *Pulicaria apollinea,* and long-lived and short-lived perennial grasses such as *Lasiurus hirsutus, Cymbopogon schoenanthus, Panicum turgidum* and *Stipagrostis* spp. (Ghazanfar 1998).

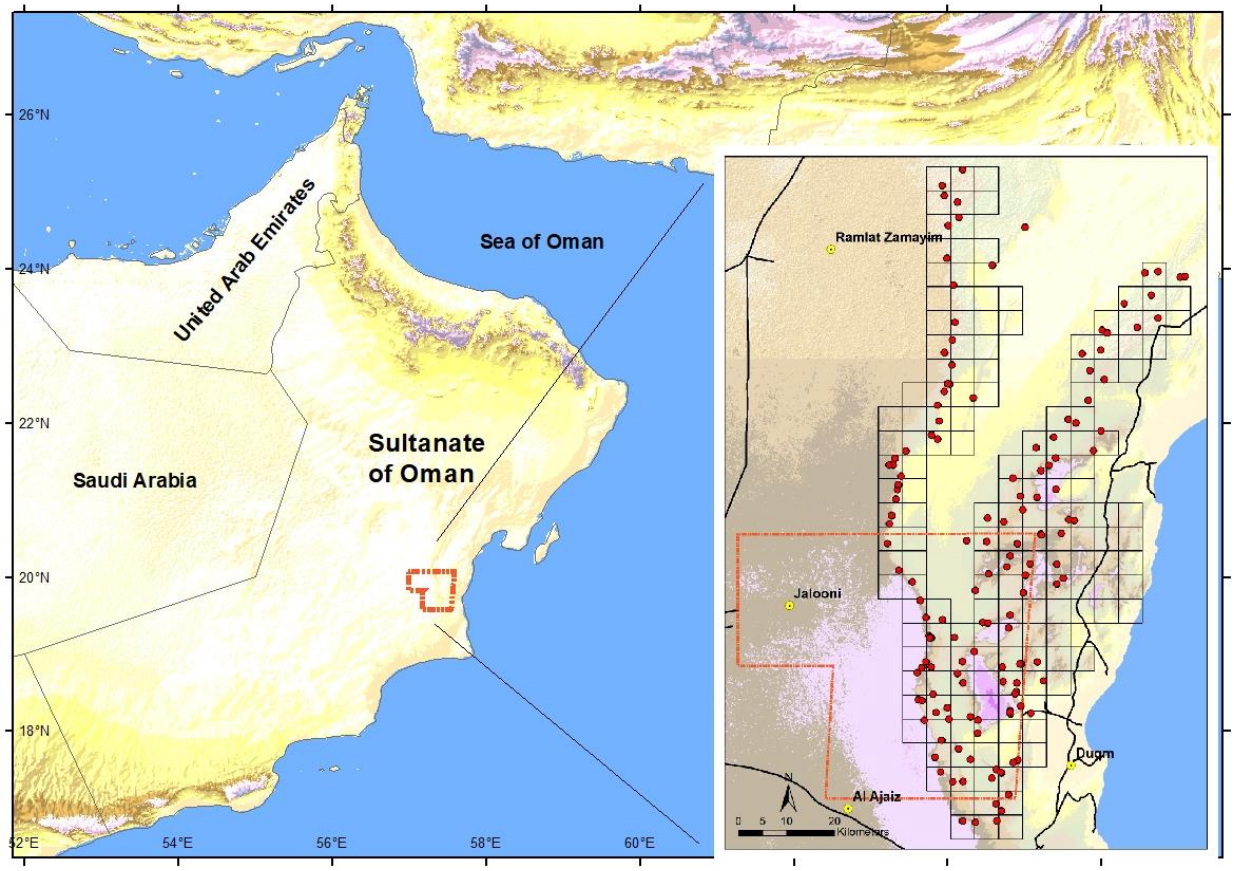

Figure 2: Study area showing a 5 x 5 km survey grid used for camera trap placement and camera traps (red dots) that have been used to create wildlife distribution maps based on occupancy.

2.2.2. Camera-trap surveys

Camera traps (Bushnell Trophy Cam, Kansas City, USA) were used to collect data on ibex occupancy across the Huqf Escarpment and Janabi Hills. Cameras were attached to rocks, 30-60 cm above ground level, and set using normal trigger sensitivity, with three photographs per event and a 5-second delay between captures. To gain inference about the entire escarpment we sampled the study area using a systematic random approach aided by a 5 x 5 km grid. We tried to sample each grid square at least once to obtain a good spatial distribution and to determine the current distribution of Nubian Ibex. We also aimed to sample all available habitats to allow sufficient habitat variability to analyze habitat occupancy. In this research, cameras traps were spaced at a minimum of 500 meters apart, with the majority separated by over 4 km and not linked by linear habitat features. The cameras were classed as independent sample units. The

distance between camera traps was designed to be large enough to avoid the risk of s spatial autocorrelation (Wegge, 2004; Dillon and Kelly, 2007).

Camera traps were operational throughout the year but to avoid possible violation of the population closure assumptions we included only data from the winter season (October–April), spanning 180 days. Closure was a reasonable assumption for our study species given the short winter survey period and because Nubian Ibex are non-migratory and maintain consistent home range areas (Ross & Al Said, unpubl. data).

2.2.3. Environmental variables

I hypothesized that environmental covariates would predict Nubian Ibex occurrence across the study area. The covariates were chosen based on their known influence on other mountain ungulates, or because they had been hypothesized to influence the Nubian Ibex (Gross, 2002; Hamel & Côté, 2007; see table 1). Variable values were compiled in a geographical information system database spanning the study area using ArcGIS version 10.3 (ESRI).

Elevation, aspect and slope maps were obtained at a 10 m resolution using governmental imagery from 2017. We measured land surface rugosity (RUG) as a continuous measure of roughness and terrain complexity; derived from surface ratio, using digital elevation model surface tools for ArcGIS (Jenness, 2013). We used the mean surface ratio within 50 m and 300 m radius buffers from the camera location to represent two different scales of influence. The Heat Load Index, indicating the influence of sunlight on surface temperature, was calculated from slope, aspect and latitude at sites using the equation of McCune & Keon (2002). The distance to water was measured from the camera trap to the nearest water source. A binary covariate was assigned to identify camera sites that were inside Al Wusta Wildlife Reserve or outside the boundary, and whether the camera was located in the Huqf escarpment or Janabi Hills. We derived a measure of vegetation productivity using the normalized difference vegetation index (NDVI) at a 10 m resolution using Oman Governmental satellite imagery from November 2017.

Table 1: Summary of covariates used to model ibex distribution

Covariate	Abreviation	Resolution (m)	Data Source (Oman Governmental satellite imagery (Nov 2017)
Elevation	Ele	10	Digital Elevation Model
Aspect	Asp	10	Digital Elevation Model
Slope	Slope	10	Digital Elevation Model
Rugosity	Rug	50 and 300	Digital Elevation Model
Heat Load Index	HL	10	Digital Elevation Model and a
Distance to Water	Wat	10	Based on field collection locations of all known water points
Protected Area Status	Prot	10	Based on camera being in or outside of protected area
Geology (Huqf or Janabi Hills)	Huqf	10	Based on whether camera was in or out of these two areas
NDVI (Vegetation Productivity)	NDVI	10	Calculated from Landsat data 2017

2.2.4. Occupancy modelling

Occupancy is a robust framework for analysing the distribution and habitat preferences of species without relying on individual markings (MacKenzie, 2006). Camera trap samples produced encounter histories suitable for calculation of occupancy, using a method that calculates the proportion of an area occupied by a species while accounting for imperfect detection. Occupancy can also be interpreted as habitat suitability by using habitat variables to explain the observed occupancy distribution (MacKenzie, 2006).

Each sampling occasion was set to a 7-day period and a 1 or 0 recorded to indicate the presence or absence of Ibex over the 7-day sampling occasion. A table of presence absence records for all camera traps for the 180-day period was imported to PRESENCE software v.12.40 (Hines, 2006). Variables for each camera location were also imported to act as model variables.

Simple occupancy models were run without covariates. I then inserted each covariate variable sequentially to understand which variables influenced occupancy (ψ). Model performance was

assessed using Akaikes Information Criteria (AIC) and variable performance assessed by whether 95% confidence intervals of the beta coefficient overlapped with zero, which is equivalent to the odds ratios overlapping with one (Arnold, 2010).

2.3. Results

2.3.1 General findings

From May 2016 to October 2019, we set a total of 171 cameras at separate locations. We successfully retrieved data from 163 cameras, representing total of 86,524 trap nights. Ibex were captured at 65 of the camera locations giving a naïve occupancy of 39.8%. The number of Ibex visiting these 65 cameras averaged 3.4 Ibex per 100 days, indicting a very low-density, dispersed population.

2.3.2. Occupancy Modelling

A number of occupancy models were run. Importantly models which included covariates fit better than the null model without effects, and also fit better than the Full Identity model (delta AIC = 38.87), which indicated that detection does not vary between survey occasions (Table 2). The modelling found few habitat variables that influenced ibex occupancy (Table 3). The best model was a basic one with a binary predictor of whether the camera was in the Huqf Escarpment or the Janabi Hills. Odds ratios suggest that that ibex are 3.74 times (95% C.I.: 1.78 – 7.83) more likely to occupy areas within the Huqf than in the Janabi hills (Table 3). Slope and heat load were also within 2 AIC of the best model. Slope and heat load had a small influence on occupancy with 95% confidence intervals overlapping zero but had some explanatory power and when included substantially improved model fit in comparison to the null model. The inclusion of variables NDVI, Elevation, Aspect and Slope did not improve model fit over the null model. Other than Aspect this may have been due to the lack of variability in these parameters between sites.

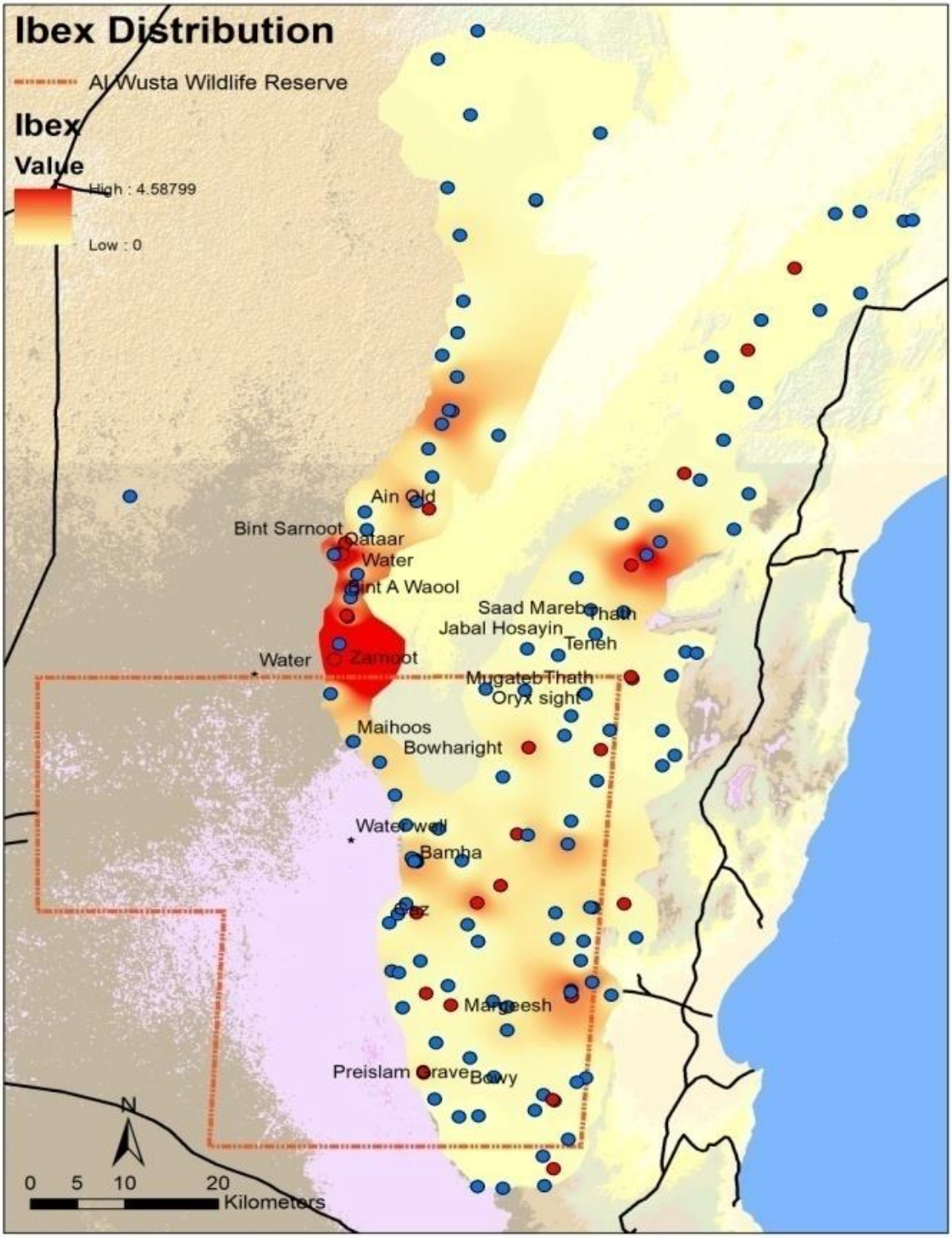

Figure 3: The distribution of presence records (Red = present, blue = absent) of Nubian Ibex and a heat map showing the relative intensity of captures by camera traps. The red line denotes the boundary of WWR.

Table 2: Occupancy models with model performance and fit indicated by AIC and AIC weight.

Model	AIC	deltaic	AIC weight	Model Likelihood	no.Par.	LL
psi(Huqf),p(.)	1204.29	0	0.5638	1	3	1198.29
psi(Huqf, + slope),p(.)	1206.15	1.86	0.2224	0.3946	4	1198.15
psi(Huqf + HL),p(.)	1206.26	1.97	0.2105	0.3734	4	1198.26
psi(Slope, Rug),p(.)	1216.55	12.26	0.0012	0.0022	4	1210.55
psi(Slope.),p(.)	1216.78	12.49	0.0011	0.0019	3	1210.78
psi(HL),p(.)	1217.1	12.81	0.0009	0.0017	3	1211.1
psi(.),p(survey)	1243.16	38.87	0	0	27	1189.16
psi(.),p(.)	2861.16	1656.87	0	0	2	2857.16

Table 3: Beta coefficients and standard errors (SE) as well as the odds ratios and 95% confidence intervals for the occupancy covariates in the three best-performing occupancy models. An odds ratio of 1 suggests that a change in the covariate has no impact on the occupancy. Ratios of less than 1 suggests that an increasing covariate value decreases the likelihood of occupancy and a ratio of greater than 1 suggest that increasing covariate value increases the likelihood of occupancy. Values for Huqf are taken from the psi (Huqf),p(.) model but are similar across models.

Variable	B	SE	Odds	95 CI
Huqf	1.319	0.377	3.74	1.79 - 7.83
Slope	0.005	0.012	1.01	0.98 – 1.03
Ruggedness	0.49	0.79	1.63	-1.06 –2.03
Heat Load	0.045	0.260	1.05	0.63 – 1.74

Mapping of the camera trapping success and captures across the study area provided insight into ibex distribution and relative abundance (Figure 3). Although ibex occupied WWR in many

locations, high density areas with the highest camera trap success were all located outside of the reserve close to the northern boundary.

2.4. Discussion

2.4.1. General findings

The majority of the ibex population was found located outside of the protected area. This was most likely due to habitat associations rather than any threatening processes influencing their distribution. It was noted that, conversely, Arabian Gazelle were mostly recorded within the protected area boundary. The most important hotspot for ibex conservation appears to be just north of the reserve boundary. Notably, the areas Ibex were concentrated had good access to surface water and excellent hiding cover due to the cliffy escarpment and numerous large rocky areas that provide excellent disruptive cover, which is a common association noted in other populations (Taddese & Kortler, 2010; Ross *et al*. 2020). Other than the presence of water in the ibex hotspots, it was not clear what other habitat features were important to the ibex population. Although models were informative, they gave less insight than expected due to the poor explanatory power of the variables used. This may have been due to the lack of variability of habitat variables sampled across the study area, which is quite homogeneous with the exception of the difference between the Huqf escarpment and other areas. Indeed, the Huqf variable was significant indicating the preference of Ibex for the escarpment over other available areas. As may be expected for a mountain goat, slope, ruggedness and heat load also had positive influences on Ibex occupancy. Although the relationship between occupancy and these later variables was quite weak indicated by 95% confidence intervals overlapping zero.

It is concerning that camera trapping found that the best Ibex habitat is outside of the reserve area and so is unprotected. Although rangers do monitor the area, the population is more at risk from hunters and potential developments (e.g., oil and gas operations) than if it was inside the reserve area. In addition, two major industrial developments are happening close to the identified Ibex hotspots in the north. A gas pipeline has been built in the north to connect gas operations in the desert with Duqm Harbor. As well as having a major impact on the ancient landscape as a whole and the continuity of the Huqf escarpment, the pipeline has created a blockage on the escarpment which will reduce connectivity for Ibex and other mammals. In addition, an access

road was built next to the pipeline which will result in easier access to the escarpment and will potentially increase poaching in the area. This is unfortunate and needs to be addressed by reserve management by increasing patrolling of the area. It will be important to monitor the areas to see if these developments affect the Ibex population.

2.4.2. Modelling

Models were informative in terms of understanding the general habitat choices of Nubian Ibex. However more exploration of variables is required as, other than the Huqf variable, variables had weak associations with the occupancy of Ibex. Like all animals, Ibex are creatures of habitat and future modelling should attempt to create new variables and assess the scale of choices made to improve model predictions. Wildlife conservation problems can be solved with the proper application of habitat selection theories (Morris, 2003b). Habitat suitability index models can be further linked with theories of optimal foraging and patch use (Verner et al., 1986; Fabricius and Mentis, 1991; Morris, 2003b) to assess the underlying causes of population dynamics in Nubian ibex in WWR and its vicinities. Optimal foraging theory may also provide a unique avenue with which to explore the adaptive behaviors of Nubian ibex related to resource densities over different habitats (Morris & Mukherjee, 2007). Future work should be directed at developing new novel variables that aid the understanding of local scale habitat choices within the study area. Incorporating seasonal pattern and gender preferences may assist in model development in the future and interactions between variables may provide improved models that assist in the prioritization of habitat protection and the conservation management of the reserve.

Chapter 3: Local attitudes towards Al Wusta Wildlife Reserve

3.1. Introduction

The Sultanate of Oman, is a country on the southeastern coast of the Arabian Peninsula in Western Asia and the oldest independent state in the Arab world. Oman has a very long history and was known as Magan to ancient Persian and Mesopotamian civilizations and was an important producer of copper and ornamental stone. The Arab tribes in Oman adopted Islam during the lifetime of the prophet Muhammad (c.570–632) and forced the Persian colonizers to leave. Since then, Oman has generally remained an independent Arab Muslim entity.

The modern Sultane of Oman is a union between the historical Oman of the north and the southern region of Dhofar with the two areas separated by hundreds of kilometers of gravel plain desert. Traditionally, this desert is a homeland of Bedouin (Harasis and Janabi tribes), with the Harisis tribe (Harsousi) occupying Al Wusta Wildlife Reserve (Chatty, 1983).

The Harsousi historically had no permanent homes, with most nomadic families living in portable tents (isbas). Camels were their main means of transportation, while sheep and goats were traded. Dairy products were the main food source of the Harasis with milk from camels and goats being made into yogurt and butter. Many of these former traditional practices are maintained today by the Harasis. Although all Harisis now have dwellings in villages and travel using cars they still practice goat and camel herding using seasonal isbas (tents) and have maintained their language and traditions, although most also speak Arabic as well as Harsousi.

Since the establishment of WWR in 1982, there has been an ongoing process of adjustment between local people, and wildlife manangement. Although many issues have been settled, concerns still exist between local people and WWR managment which will be evalauted, analysed and discussed in this chapter.

This chapter describes the results of a survey of local attitudes towards natural resources, wildlife and WWR. Such a survey has not been conducted before in this area, thus the aim is to use this new understanding of attitudes to determine and prioritize connections between the local people and natural resources and understand how their needs could be incorporated into protected area management. At the end of this study, a series of recommendations will be concluded to guide

WWR towards improving their relationship and understanding of local needs, so that they can be adequately incorporated into management decisions.

3.2. Methodology

3.2.1. Study area:

The WWR area (Figure 1) contains no permanent human settlements other than the protected area headquarters but is used frequently by nomadic pastoralists to herd camels and to a lesser extent domestic goat. Some of the Harasis are employed at WWR as rangers. So, these pastoralists, rangers and local leaders were our key respondents.

3.2.2. Human Attitudes and Spatial Survey

The local interviews were conducted using a semi-structured interview style where discussion surrounding the questions was initiated. Each interview was in one camp (isba), or family unit (4-6 people). The Harasis are very traditional people and cultural sensitivity was required. These sensitivities meant that we could not carry out separate interviews with multiple people from the camp out of respect for the elder in the camp. Whilst the main male elder was the principle interviewee, several family members often were present, and the family elder reflected the opinions of others within the family unit, the sample unit was the family. While this may create an unaccountable bias in the dataset, it was unavoidable and represents a often-utilised interview method when working with many traditional communities (Cole *et al*., 2006).

Figure 4: Visits of Isbas and interviewees conduction with local people (Harasis) at WWR

3.2.3. Data Analyses of Interviews

Interviews were recorded in an audio format, and the interview structured by using the questionnaire to standardise the format (see Appendix 1).

The data analyses used recorded interviews to understand and answer the research questions. Data extracted from interviews using the following steps:

1. Interviews listened to in order to label segments of the interview according to the questions discussed.
2. Direct answers to questions recorded on a spreadsheet when available.
3. Other information provided and surrounding the discussion topics coded under categories, such as conservation, poaching, and positive or negative attitudes towards the way the reserve is being managed.

4. Outcomes communicated using diagrams, and simple visual tools such as charts and graphs. Due to the nature of the data, sample size and our protected area management objectives, complex statistics were not required.
5. Write an interpretation of the patterns was found and the relationships between local attitudes and reserve management.

3.2.4. Local interviewee groups

Nomadic Bedouin families – primary users of natural resources in the area with historic tenure and residency in and around the reserve area – live in nomadic camps (Isbas).

Local Rangers – Rangers are employed by the reserve from the local area, they have excellent traditional ecological knowledge of the area and often have family inside or close to the reserve.

Local leaders – Bedouin with responsibilities to look after the local peoples affairs and act as the voice of local people in meetings and decision making.

3.3. Results

Approximately fifty Harasis camps are active within the protected area, though as they are nomadic, they are not always resident. Interviews were completed at thirty camps over the course of the year.

3.3.1. Population characteristics and land use

One of the family members interviewed resided permanently within the study area whereas the other moved seasonally into the area. Most activity in the area is seen over the winter season (December to February) when vegetation and conditions are generally better for grazing.

Tensions between livestock owning families were reported as they are competing to get the food for their animals and they are accusing each other for damaging the reserve fence, which has resulted in numerous large holes in the fence reducing the ability to control entry into the reserve.

A significant number of respondents (30%) blamed other people from different tribes for the troubles inside the reserve, saying they envied the Harasis and that they are aiming to rob their animals and to destroy the place.

3.3.2. Perceptions of, and Attitudes towards, Local Environment and Wildlife

Biodiversity was reported to be an important element of the local culture and worthy of conservation by all respondents. Furthermore, all respondents stated that wildlife populations had declined in recent times including Ibex numbers. None of the respondents reported improvements in natural or socio-economic factors, with reductions in the amount of rain being reported by 60% of respondents. Declining quality and availability of flora and fauna because of increased use of the reserve by strangers was reported by 30% of respondents. These people were reported to be using the reserve for illegal activities such as hunting. The interviewees were unwilling or unable to provide information about who was carrying out illegal activities within the reserve, though one Harasis said the first people to start hunting Arabian oryx (*Oryx leucoryx*), leading to their eventual local extinction, were two people from the Janabi tribe, however as this event occurred over 40 years ago this was not relevant to contemporary wildlife management.

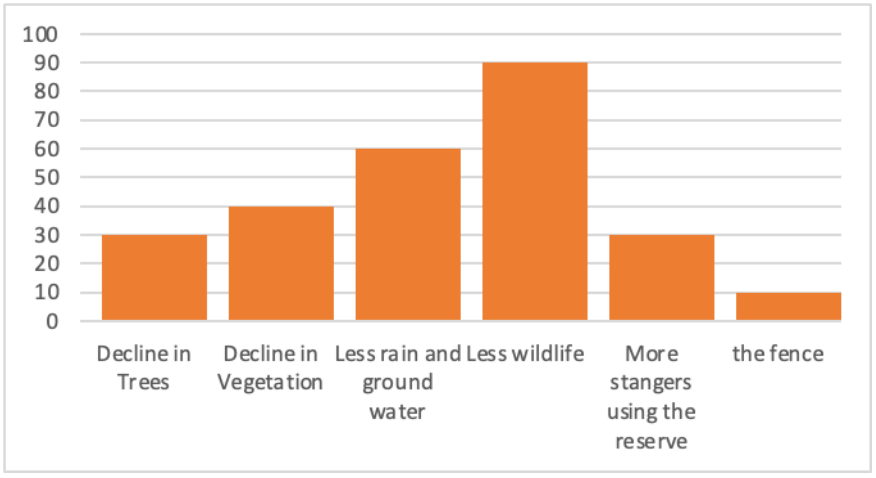

Figure 5: percentage of respondents reporting environmental and societal changes in the study area.

Hunting was perceived as the biggest driver of wildlife losses, cited by 90% of respondents as a perceived factor in the decline of wildlife. A lack of forage was also suggested as a factor by the

majority (60%) of respondents. The fence surrounding the reserve was suggested as a causal factor by three respondents in declining wildlife while one cited current development of oil and gas as a factor (figure 6).

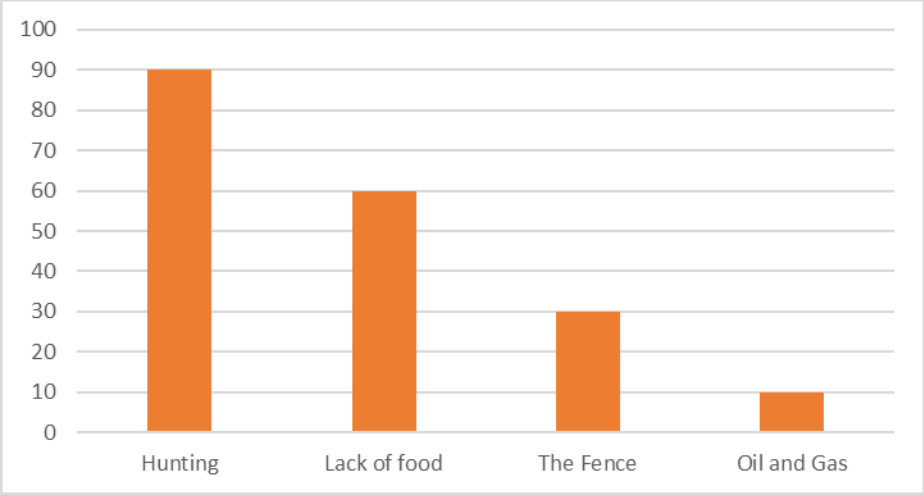

Figure 6: Percentage of respondents reporting different factors as drivers of wildlife population declines in the study area

3.3.4. Attitudes towards the Wildlife Reserve

All respondents reported that the reserve is considered by the Harasis as an honour from His Majesty Sultan Qaboos (the former Sultan of Oman). It has given them many benefits, which they are thankful for including employment opportunities and the continued presence of wildlife in the area.

However, all respondents reported feelings of anger that the reserve was implemented to protect wild animals, and although they do use the reserve, in theory they are not allowed to use the reserve for their livestock. As much of the Jiddat Al Harasis is inside of the reserve, and this area is the traditional lands of the Harasis tribe, this has been a long-standing conflict between the reserve and the local community, and the reason the Harasis refuse to give up their rights to use the reserve.

The fence surrounding the protected area was reported to be a big problem for local communities, being highlighted by all respondents active within the area. The respondents

reported that they saw no benefit for the people or visitors of the fence as they cannot move freely in the area and they cannot use the area well. Indeed, the fence has long been thought to have increased discontent among local communities.

Prior to the establishment of the reserve fence, it was reported that the Harasis played a role in saving the wild animals, but after the fence was constructed, it was understood that the government has no need for the local people to save the wildlife as the fence will be saving them. Although all rangers employed by the reserve are Harasis, it is likely that the larger Harasis community also had a larger role, than is seen now, in discouraging illegal activities in the reserve in the past.

As well as the negative aspects of the reserve, many respondents (60%) did attribute positive value to it, referring to the reserve and, in particular, the oryx as 'gold' due to its value. Value was described in terms of financial value via employment as rangers and tourism and the cultural value in terms of the preservation of the Jiddat Al Harasis, which they realise, would be open for anyone to use (for grazing) if the reserve did not exist.

Concerns were raised by 50% of respondents about the logistics of the protected area in relation to its extent. They stated that the protected area is a huge place that no one can protect; such a big area can and should only be protected by the Harasis. Most Harasis suggested reducing the size of the reserve so it can be controlled easily and well secured and be used for livestock grazing. However, it was difficult to separate genuine feelings from their aspirations for more freedom to use the land for grazing.

Grievances are still felt concerning recent reductions in investment into the area. It was reported that foreign employees working on the original White Oryx Project, initiated by the Sultan, used to give money to the Harasis to compensate them for lost grazing rights and to incentivise them to help protect the oryx in the early days. The money slowly disappeared as budget for the reserve was reassigned. However, the subsequent drop in income demotivated local people and their interest and engagement with the aims of the reserve.

Opportunities for increasing economic benefits derived from the reserve are an important topic for local communities, with greater provision of employment and/or land seen as being most desirable. While the area is highly suitable for tourism activities, action is required from the government to initiate the development of alternative incomes.

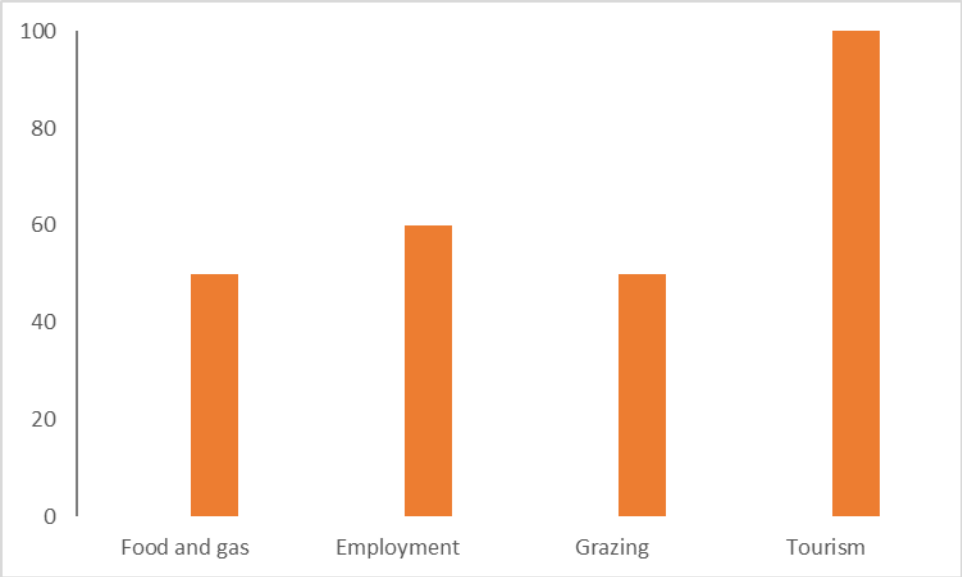

Figure 7: Benefits the Harasis would like to receive from Al Wusta Wildlife Reserve.

3.4. Discussion

Although most of the questions were answered in a generally positive manner, discussion surrounding the questions made it clear that the majority of interviewees were angry about the reserve; they felt angry because of the following reasons:

1- The fence of the reserve controlled the movement of the people and their animals from entering to the reserve.
2- Harasis people felt that the land does not belong to them due to the restrictions they face.
3- The reserve administration does not allow people to enter the Isbas (livestock camps) into the reserve.
4- The size of the reserve is too big it takes all places for grazing their livestock.
5- Many of their animals have died because of the fence as they get stuck and lost.
6- The reserve area has stopped providing them with the gas and food for their animals.

7- The reserve is applying rules to force them to leave the reserve.
8- The reserve is locking the gates and forcing them to use the main gate.
9- The reserve is trying to make entry to reserve by permission only.

It was also apparent that interviewees primary concern was with their Isbas and their livestock. This is not necessarily surprising as all they have and their future security is dependent on these resources, only the rangers see real monetary benefit from protecting wildlife through their salaries. Such attitudes could be due to lack of understanding of how to gain opportunity through wildlife and natural resources, such as wildlife tourism or geo-tourism, which rely on a functioning reserve and environment. As the reserve needs the Harasis, and their knowledge of the area, perhaps more should be done to create such opportunities that are dependent on natural resources. If such a new appreciation of the reserve resources could be fostered the Harasis the tribe may be more interested in working under the rules and conditions that the reserve has implemented.

Throughout the interviews, it was surprising to discover local people's opinions. It was expected that young people may be more interested in wildlife protection. However, the lifestyle has changed, and other factors have played a role in reducing the interest of this generation towards saving the wild animals, such as lack of rain and the difficulties and expense of keeping livestock. People are now busier moving around looking for grazing areas. Wildlife is perhaps not an immediate concern. In addition, the interviewees were asking to reduce the size of the reserve so they can use the area for their livestock and Isbas.

The information I gained from the interviews could help reserve management to provide some options. These may include reducing the size of the reserve or providing an area inside the reserve especially for the Harasis. However, while reducing the size of the reserve would make it easier to manage it could be viewed negatively as it will open discussion about industry exploiting the reserve area. Another option, which can help the reserve management, is to provide permits that will control the strangers' entrance. The number of cars and people will be counted and controlled. In applying such a procedure, all the doors should be locked except the main gate so visitors can use one gate only and the procedures will be more controlled. This

latter option has not been popular with Harasis who resent being controlled in a land they view as their own.

Difficulties were faced to conduct the surveys including:

1. It was not easy to find nomadic people as they are always on regular movement looking for animals.
2. I faced difficulties to deliver and explain the questions with respondents whose Arabic was limited and whose understanding of modern management practices is limited.
3. There was a language barrier as the Harasis Tribe has a different language and accent (in Arabic).
4. Difficulties 2 & 3 made for lengthy interviews that took nearly one day to conduct one survey.
5. A long time was needed to find different camps with no direction signs or paved roads.
6. Many Harasis did not want to be interviewed.

While most of these difficulties were overcome, difficulty number six, where some Harasis did not want to be interviewed resulted in difficulty fulfilling sample size requirements but also may have resulted in some bias. It is possible that those who were willing to be interviewed were more sympathetic to the protected areas goals. This may have caused biases in favour of the protected area. It is also possible that those who had a complaint with the protected area were also more willing to be interviewed to enable their voice to be heard. There are undoubtedly biases involved in this work and overcoming and interpreting the information is complicated by this fact. Nevertheless, I was thankful for the Harasis Tribe as I thought they might refuse to be interviewed, but they were helpful and made time to accommodate my questions and discuss the reserve with me.

Conclusion and Recommendations:

The findings of this study highlighted a number of aspects that could help improve reserve management and conservation. Locals perceived that wildlife populations had declined in recent times. Although this included the Nubian Ibex, peoples understanding of this species was more limited than other less elusive species such as Gazelle and Oryx. Although little was said about the Nubian Ibex, people readily voiced their opinions about resource and wildlife management. However, the camera trapping project made progress in understanding the Nubian Ibex by establishing the previously unknown distribution of Nubian Ibex, hotspot areas where the species is more abundant across the landscape and habitats associated with Ibex occupancy. These scientific facts can feed directly into assisting reserve management and focusing resources where they are most needed.

There was a strong discontent among respondents with the reserve as a whole. Peoples' main issues included restrictions to their and their animal's movement due to the fence and control measures implemented by the reserve, the reserve area being too large and there being little or no economic benefit of the reserve to them. On the whole discussions gave the impression that respondents felt as the reserve was on their traditional lands they should not have to answer to reserve management.

The feeling of being dispossessed is understandable, and although the reserve has accommodated Harisis isbas and employed rangers from many of the families traditionally resident in the area, the reserve should continue to find ways to help the Harisis. Further engagement with the community is required to improve community relations. Engagement may be used to increase mutual understanding of the needs of domestic and wild animals and communicate the issues the reserve must deal with in terms of poaching and other threats and how management is geared towards limiting these negative impacts.

A second issue communicated by respondents was the size of the reserve, which was seen as being too large and beyond the ability of the reserve to control. However, the reserve was formally much larger than it is now. In 1992 the Arabian Oryx reserve was declared and covered an area of 27,500 km^2. The reserves size was a reflection of the Arabian oryx' need for large

uninterrupted areas to facilitate large movements to dispersed foraging resources. Oryx movement is known to be influenced its ability to detect rain 100 s of kilometres away (Stanley-Price, 1989). The reserve was reduced to its current extent in 2007 when Oman decided to reduce the reserves size by c. 90% following the near extirpation of the oryx population due to poaching. Considering the loss in area and the effects a further loss of reserve area could have on the potential to sustain a viable Arabian oryx population, from a conservation perspective reducing the reserve area further would be a bad idea. However, to mitigate the impacts of the reserve on local livelihoods new management methods are required.

One potential solution to issues of livestock use implemented in other parts of the world is protected area zoning (Geneletti & van Duren 2008). Zoning promotes spatial management and allows the prioritisation of habitat resources into those of greatest value to wildlife populations and prioritising areas of lesser value to wildlife for livestock. Zoning is attractive as it focuses operations in areas where management is most required and if done in negotiation with local Harasis, the Harasis could be tasked to independently manage a livestock zone. Self-management may also promote caring for the vegetation resources within the zone. Zoning also adds scope to add further zones to manage Nubian Ibex which are manly located a short distance outside of the reserve area. Zoning is likely to have many complications and disagreements associated with it, however these complications are unlikely to exceed the current arguments or issues and would allow the reserve to operate more efficiently and may allow more adaptation to local community needs.

Another main complaint of the Harasis was the lack of economic benefit to many Harasis from the reserve area. Thus far WWR as not exploited its potential to act as a tourism destination. Given the recent growth of the nearby port of Duqm, recreational opportunities in the region are sought after and the reserve could offer many attractions for different types of tourists. Tourism ventures could take advantage of geotourism facilitated by large areas of fossilized coral reef, intertidal zones, fossilised trees, the sabka and numerous other geological wonders contained in the reserve area, which are fascinating to most people. Ecotourism has a lot of potential, the reserve has recently reinforced the Arabian oryx population, Arabian Gazelle and Reem Gazelle and as a result wildlife viewing is now feasible. Hiking trips to the escarpment to view Nubian

Ibex could be completed, and the whole area has a unique bird population particularly associated with water bodies. Visiting caves and hiking would be of interest to adventure tourists and organising a visit to a Harasis isba would facilitate potential cultural tourism opportunities. While all of these opportunities are viable they are difficult for the reserve to implement by themselves, due to a lack of resources and capacity to manage business. However, collaborating with local tourism operators from Duqm or elsewhere could facilitate new opportunities. An important part of the process would be ensuring that tourism is done responsibly. This could be achieved through drawing up explicit contracts with operators to ensure cultural sensitivity, respecting places, refraining from littering or removing fossils. Each tourist operator should also employ local guides from the Harsousi Tribe to facilitate benefits to the local community and provide the tourists with an authentic and interesting insight of the local landscape and its ways. Much of these processes could be implemented as part of Oman's Vision 2040.

The above actions will benefit the conservation of the Nubian Ibex through greater interest and valuation of the natural resources contained in WWR. As the Ibex population has a patchy distribution our new understanding of where populations exist can also facilitate ranger operations in these areas, particularly in the hotspot area just north of the reserve boundary. The Ibex population currently exists at an extremely low density and considering ranger local knowledge of the population, it appears the population has seen a large decline recently. As WWR has a breeding centre facility it may be wise to develop specialized enclosures for Nubian Ibex breeding, with the goal of population reinforcement. However, considering the small and highly threatened nature of the WWR Ibex population it would be advisable and likely easier to capture Ibex from the much larger Dhofar population, which is approximately 100 km south of the reserve. Genetic testing of the Dhofar population would be necessary to confirm the populations are not distinct, however considering the distance and pre-development connectivity, it seems highly likely the Dhofar Ibex are genetically very similar.

Continuation of Ibex population monitoring using camera traps is also advisable. As Ibex are elusive and generally unseen by rangers remote monitoring of the population is the only way we can understand if the population continues to decline or sees a recovery, having a long-term baseline camera dataset is an important part of interpreting these population trends. The camera-

trap data could be crucial for decision making to promote conservation management of the central desert Nubian Ibex population into the future.

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APPENDIX

Questionnaire:

Interview questions delivered through discussion

1	Note gender? Answer: M/F
2	What is your age? Answer…….
3	How do you use the reserve area and how long do you spend inside (on average) per year? Answer…….
4	How long have you used the reserve area? Answer…….
5	And over that time have wildlife populations increased or decreased? All or which animals? Answer…….
6	What are the reasons for increases or decreases in wildlife? Answer…….
7	Over the time you spent in the reserve has grazing food for your livestock increased or decreased? Answer…….
8	What are the reasons for the increases or decrease? Answer…….
9	Do people visit to the reserve do they have a positive or negative impact on the wildlife?

	Answer…….
10	Do you support the control of people entry into the reserve? Answer…….
11	what about tourists do you think tourists would be good for the area? Answer…….
12	Should there be rules inside the reserve to ensure that people do not damage the area for future generations? Answer…….
13	How does the reserve benefit you and are there any negative impacts? Answer…….
14	Do you have more livestock now or in the past? What about other isbas? What are the reasons for the changes? Answer…….
15	What do you think about releasing new wild animals into the reserve, such as Oryx, what do you think are some of the challenges and benefits of doing this to you? Answer…….
16	What other things do you think the reserve should do? 1) to improve relationships with local people? And 2) to better manage the reserve? Answer…….
17	What role could Bedouin inside the reserve play in order to protect the wild animals? how do you think this could be implemented? Answer…….