ASSESSING GREVY'S ZEBRA (*EQUUS GREVYI*) AND LIVESTOCK INTERACTIONS THROUGH SATELLITE TRACKING AND COMMUNITY INVOLVEMENT IN SAMBURU COUNTY (KENYA).

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Abstract

The study's purpose was to delineate seasonal space use variations of the endangered Grevy's zebra (*Equus grevyi*), and to determine the extent of overlap of these areas with livestock grazing zones in order to identify core areas suitable for conservation efforts. *E. grevyi* requires protection as their population size severely decreased in the last century and they continue to suffer from habitat loss. Additional importance lies in reconciling interests of wildlife protection and livestock keeping, as this is the main livelihood for pastoralists in the study area.

Grevy's zebras' movement in Samburu (Kenya) was monitored using GPS-GSM collars between 2006 and 2014. Based on data from 26 animals, areas of highest occurrence within the three community conservancies were identified. Within one area livestock was tracked using GPS collars. These data were overlaid with zebra data. Additionally, livestock movements were discussed and mapped in participatory community group sessions. Important map features were digitized and overlaid with the zebra maps.

Grevy's zebra hot spots were found to overlap in all years and seasons with negligible variation for individual zebras. Area utilisation between the wet and dry seasons showed no major spatial variance in extent nor location of hot spots. Analysis of tracking and community data revealed overlap of livestock and *E. grevyi* grazing zones with no apparent preferences for livestock free zones by Grevy's zebras. Considerable knowledge on the focus species and its interactions with livestock was found in the communities with positive attitudes towards conservation efforts.

It was concluded that scientists and conservationists should apply more caution when claiming pastoralism is a threat to Grevy's zebra survival. This is not only a prejudiced perception but may also put vital support from pastoralist people for conservation at risk. Further it was recommended that community involvement and education programmes are carried forward.

List of Abbreviations

ASAL- Arid and Semi-Arid Land

CDC- Conservation Development Centre

CITES- Convention on International Trade in Endangered Species of Wild Fauna and Flora

ESRI- Environmental Systems Research Institute

GDP- Gross Domestic Product

GIS- Geographic Information System

GoK- Government of Kenya

GPS- Global Positioning System

GSM- Global System for Mobile Communications

GTZ- Deutsche Gesellschaft für Internationale Zusammenarbeit (German Federal Enterprise for International Cooperation; today: GIZ)

GZT- Grevy's Zebra Trust

GZTC- Grevy's Zebra Technical Committee

IFAD- International Fund for Agricultural Development

IISD- International Institute for Sustainable Development

ILRI- International Livestock Research Institute

IUCN- International Union for the Conservation of Nature

KD- Kernel Density

KIPPRA- Kenya Institute for Public Policy Research and Analysis

KWS- Kenya Wildlife Service

MASL- Metres Above Sea Level

MODIS- Moderate-Resolution Imaging Spectroradiometer

MOLD- Ministry of Livestock Development

NACOSTI- National Council for Science and Technology

NRT- Northern Rangeland Trust

SDZ- San Diego Zoo

SNR- Samburu National Reserve

STE- Save the Elephants

UNEP- United Nations Environment Program

WGC- West Gate Conservancy

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Acknowledgements

Declaration

I, Rebecca Younan, hereby declare that this study is a true reflection of my own research, and that this work or part thereof has not been submitted for a degree in any other institution of higher education.

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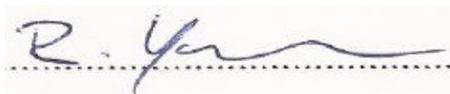
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1. Introduction

Today Grevy's zebra (*Equus grevyi*) are only found in Kenya and Ethiopia although they were once additionally distributed throughout Djibouti, Eritrea, Somalia and possibly Sudan (KWS, 2007). Since the 1970s Grevy's zebra numbers have declined by 81% and it is estimated that today only 2800 Grevy's zebra remain in the wild (KWS, 2012). The *Equus grevyi* is listed as endangered by the International Union for the Conservation of Nature (IUCN) Equid Specialist Group and on Appendix I of International Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES).

Apart from its intrinsic value and beauty and being the largest wild equid, *E. grevyi* is also a key stone species in its arid environment. As with all large grazers, it shapes its environment, especially because of its tolerance to feeding on low quality, coarse plant material (Chrucher, 1993). At the same time Grevy's zebra has a high potential for non-consumptive commercial exploitation, as it is a species that attracts tourists for wildlife viewing (Low, Sundaresan, Fischhoff & Rubenstein, 2009).

A lot of effort has been put into identifying influences on and threats to the survival of the endangered Grevy's zebra (Hostens, 2009; Lelenguyah, Ogol & Muoria, 2010; Low *et al.*, 2009) including interactions with livestock (Low, Muoria, Parker & Sundaresan, 2008). However, there still remains the need to understand in more detail what the main driving factors of Grevy's zebra

movement are. Kenya's strategic plan for their protection stated that its success will rely on reliable information on conservation challenges faced (KWS, 2007). Information gathering will be important for management concepts that aim to successfully protect *Equus grevyi* whilst including and co-operating with the most important stakeholders in the areas: pastoralists.

Of the world's remaining Grevy's zebra population 93% are found in Kenya (Low *et al.*, 2008), mainly in Northern Kenya. Protected areas form less than 0.5% of their range (IUCN, 2014). Their main home ranges lie on community-owned lands, especially in Southern Samburu (Low *et al.,* 2008; Williams, 2002). The extensive overlap with pastoralists and especially their livestock is thought to be disadvantageous to Grevy's zebra survival for reasons such as failure in juvenile recruitment, competition over shared resources and avoidance of humans (Hostens, 2009; KWS, 2007; Williams, 2002).

However, authors (e.g. KWS, 2012) make such claims and take competition between livestock and *Equus grevyi* as a given, without sufficient scientific evidence (e.g. Williams, 2002). Low *et al.* (2009) state that whether the large scale overlap of livestock and Grevy's zebra translates into harmful competition, is an open question, and that it remains to be assessed whether Grevy's zebra avoid livestock. Butt, Shortridge, and Winkler Prins (2009) state that spatial relationships between pastoralists, livestock and the environment remain little explored. Knowledge of how livestock interact with and influence Grevy's zebra survival is crucial for the success of *E. grevyi* conservation. Sundaresan*,*

Fischhoff, Hartung, Akilong and Rubenstein (2007) identify the need for studies including finer-scale data on movements of Grevy's zebra and livestock.

At the same time conservationists have recognised that effective protection of animals, plants and the environment can only be achieved through the support of the people living in the environments targeted. Low *et al.* (2009) argue that by engaging communities in conservation activities of an endangered species, support and knowledge thereof can be promoted. Therefore it is very important to consider their knowledge, perceptions and wishes when implementing conservation strategies. Sundaresan *et al.* (2012) studied pastoralists' perceptions of Grevy's zebra conservation in Laikipia (Northern Kenya) and found that even though community members there received little benefits from *E. grevyi*, they were still in favour of their protection. Within Southern Samburu, Letoiye (2014) also investigated pastoralists' perceptions and found that community members were very aware of competition between their animals and wildlife. Sundaresan *et al.*'s (2012) study found that men had more positive attitudes towards Grevy's zebra conservation than women.

Movement sampling of individual zebras in six different years allowed for identification of zones which are of significant importance throughout years and for all sampled individuals. The aim of the study was to use Geographic Information Systems (GIS) to help determine such Grevy's zebra hot spots. The aim of mapping key habitat areas is in accordance with recommendations for further research made by Williams (2002) and with the third strategic objective of

the current Conservation and Management Strategy for *E. grevyi* (KWS, 2012). At the same time it was important to see how these hot spots are utilized by pastoralists and their livestock.

1.1 Problem Statement

The Grevy's zebra (*Equus grevyi*) is in danger of becoming extinct. Although conservation efforts are being made, Grevy's numbers are not stable. Information gathering on small-scale land utilisation patterns by *E. grevyi* is relevant for conservation planing. Over most parts of the Grevy's zebra range it shares its habitat with pastoralists' livestock. The pastoralist communities are key stakeholders in Grevy's zebra conservation. Yet they are a marginalised people with problems such as poverty and over-dependence on their livestock. In order to improve Grevy's zebra conservation, it was therefore vital to both investigate their interactions with livestock and understand the pastoralists' perspectives on these interactions and Grevy's zebra conservation itself. Only if the awareness for and willingness to conserve the Grevy's zebra comes from within the communities on whose lands Grevy's zebras are found, will their protection be successful and ensure the continuity of their existence; while at the same time providing opportunities to improve livelihoods of those people involved.

1.2 Objectives

The aim of the study was to improve the understanding of Grevy's zebra habitat utilisation within seasons and years, especially in relation to habitat sharing with livestock. The objectives were to

1. employ GPS (Global Positioning System) -GSM (Global System for Mobile Communication) collars and GIS to assess and characterise inter-seasonal and inter-annual Grevy's zebra spatial distribution

2. map wet and dry season livestock movements and relate them to Grevy's zebra distribution through community members' participation

3. investigate pastoralist community members' knowledge and perception regarding Grevy's zebras and their conservation in group discussions

1.3 Hypotheses

Therefore the following hypotheses were formulated:

1.1 H1: Preferred Grevy's zebra grazing zones show significant spatial differences in the wet and dry season.

1.2 H0: The zones overlap in all years studied.

1.3 H0: The over-all most utilised areas are representative of the individuals tracked.

2.1 H1: Grevy's zebras show preferences for areas with restricted livestock grazing.

3.1 H1: Pastoralist communities possess relevant indigenous knowledge concerning Grevy's zebras and their interactions with livestock.

3.2 H1: Knowledge and perceptions about Grevy's zebra differ in relation to gender.

1.4 Significance of the Study

Primarily, organisations such as the GZT, who aim to conserve Grevy's zebra, the Northern Rangeland Trust (NRT), who co-manage community conservancies in Northern Kenya and the Kenya Wildlife Service (KWS), who is Kenya's governmental institution for wildlife management need to know which areas to target when planning their Grevy's zebra conservation strategies. Therefore, the study aimed to demarcate inter-annual hot spot zones for the three community conservancies studied.

At the same time the study focused on the importance to involve pastoralist communities into conservation planning, by exploring their understanding of interactions between their domestic animals and Grevy's zebras and their perspectives on conservation. For appropriate planning and integration of the different genders into conservation work, it was investigated whether perceptions varied through the different social groups of elders, women and warriors (young men). The study aimed to contribute to the improvement of spatial aspects of Grevy's zebra conservation, as well as community involvement and support.

1.5 Scope and Limitations of the Study

The Grevy's zebras sampled in this study are representative of the North Kenyan rangelands, as they roam far beyond the study area. As Northern Kenya is the most important remaining stronghold for the world E. grevyi population, the sampled Grevy's zebras are representative for the entire population. However, sampling is not random as mostly females are targeted for collaring. The identified hot spots are very site specific for the community conservancies, yet identified features of space utilisation by Grevy's zebras are thought to be general observations, which should hold true in other areas as well.

Information gathered from the community conservancies' members are specific to the conservancies studied. However it is assumed that members of neighbouring conservancies with similar environmental conditions and on-going conservation and grazing management activities would express similar opinions.

As will be further explained in the method section (3.3) the study was severely limited through harsh environmental conditions. Additional limitations included short comings with the tracking technology used and a flawed approach in templates used for the participatory mappings. These and other limitations will be elaborated on further in the discussion (section 5).

2. Literature Review

2.1 Tourism and the Economic Landscape

Kenya's tourism industry is the largest part of the service sector in the country's economy, contributing almost 6% to the total Gross Domestic Product (GDP) in 2011 (KER, 2012). Otuoma, Kinyamario, Ekaya, Kshatriya and Nyabenge (2009) note that 0.8 billion US dollars revenue are created annually, mainly by wildlife viewing in the rangelands. After record-breaking tourist visits, with for example close to 1.5 million people visiting Kenya in 2005 (Bruyere, Beh & Lelengula, 2008), the country's tourism industry experienced declining growth rates in the past years due to an unfavourable political climate and recent terrorist attacks. However, tourism remains vital to the Kenyan economy with more than 1.7 million visitors in 2012 (KER, 2012) and by offering 12% of the country's employment opportunities (WTTC, 2012). These numbers do not even include revenues generated and jobs created in the informal sector (UNEP, 2009).

However, it is important to note that main revenues of tourism go to non-Kenyan companies and are spent for imported goods, while less than one third of revenues contribute directly to the Kenyan economy. And as little as 5% trickle down to the local people in low paying jobs (Akama, 2000; Kiss, 2004; Thompson & Homewood, 2002).

Bruyere and his colleges (2008) carried out interviews with the Samburu and other ethnic communities in Northern Kenya. They found that the communities

felt they were only receiving negligible financial benefits, especially as most money is spent in lodges, for food and in gift shops within the protected areas from which the communities feel excluded.

Akama (2000) also criticises that economic goals to expand the tourism industry and increase visitor numbers have often neglected the social and environmental dimensions. The lack of environmental considerations and consequent degradation of the natural beauty and reduction of wildlife habitat in many areas in turn had negative impacts on visitor numbers (Akama, 2000). Social impacts included lodges polluting rural communities' water sources, disrupting traditional life-styles and reducing available agricultural land (Akama, 2000; West, Igoe & Brockington, 2006).

In addition to the World Conservation Union stressing "the need for both local participation in decision-making processes and the equal distribution of conservation related benefits" (Bruyere *et al*., 2008, p. 49); community conservancies may be an appropriate solution to include rural communities in decision making and increased participation in the tourism sector to counter-balance negative effects (Akama, 2000). In order to achieve this Treves, Wallace, Naughton-Treves and Morales (2006) call for stronger cooperation between social and environmental scientists. Even though the authors were concentrating on human-wildlife conflict, they mentione social science tools applicable in a wide range of environmental management practises, such as participatory planning, measuring perceptions, and understanding socio-economic practices.

Akama (2000) notes that tourism is a form of development which has the potential to diversify a country's economy and reduce intensive dependency on raw material exportation. Additionally, Kenya's Vision 2030 formulates the goal for Kenya to become one of the top ten world wide destinations for tourists in the near future (UNEP, 2009). Tourism industry is in a position to actively promote endangered species conservation to its clients. It also provides a wildlife-based income to landowners thereby supplementing the income needed for their conservation operating costs and diversifying their economic base away from pure livestock keeping (KWS, 2007).

2.2 Protected Areas and Resource Conflicts

The number of protected areas worldwide is over 100 000 which accounts for around 12% of the Earth's land surface (West *et al.*, 2006). This does not include various forms of non-governmental protection but it also does not indicate how well protected areas are actually serving biodiversity conservation (Chape, Harrison, Spalding, & Lysenko, 2005).

In Kenya the 75 238 km² (UNDP, 2005 & WDPA, 2007) of the state protected areas (almost 8% of the country's area according to Boyd, Blench, Bourn, Drake & Stevenson, 1999) are managed by the KWS, whereas national reserves such as the Samburu National Reserve (SNR) are protected and managed by the county councils (Bruyere *et al*., 2008). Additionally, there are various forms of

community held, trust and private ownership forms (CDC, IISD & Saferworld, 2009). According to CDC, IISD & Saferworld (2009) land designated as group ranches in the ASALs (arid and semi-arid lands) is only a small percentage, but it is the land tenure form that currently proves most effective for community conservancies. In contrast to the few group ranches most of Kenya's state run national parks and game reserves are found in the ASALs (UNEP, 2004).

In 2010 Kenya adopted a new constitution which was praised by environmentalists for incorporating environmental management measures (Mwenda & Kibutu 2012). Provisions are made for a clean environment in Article 42, as well as "sustainable exploitation, utilisation, management and conservation" and benefit sharing of natural resources according to Article 69 (GoK, 2010). Within the same article the constitution lays the ground work for public participation in and management of protected areas.

Historically and in popular view national parks are seen as the fortresses of wildlife protection (Rutagarama, & Martin, 2006). Firstly, the historic perspective is skewed. What was once thought by European settlers to be the archetype of African savannah devoid of human or livestock interference, is today considered as an aftermath of an imported Rinderpest epidemic that killed over 90% of cattle in East Africa and subsequently caused a hunger crisis (ILRI, 2014). Nevertheless, the presence of cattle in protected areas is viewed as "unnatural" by conservationists and tourists (Butt, 2011). However, that wildlife and pastoralists' livestock have co-existed on East Africa's plains for millennia can no longer be

questioned.

Secondly, fortress conservation approaches have been heavily challenged, not only due to the impossibility of implementation but also because of their ethical flaws. Kumar (2007) chalks up the fortress model's lack of socio-political considerations and points out its failure in halting biodiversity loss around the world.

Apart from their intrinsic values, there are many other reasons why conserving Africa's wildlife is essential. In addition to the contribution of wildlife tourism to Kenya's GDP, Butt and Turner (2012) also mention the essential role of mega fauna in structuring the ecosystem and contributing to its function. East Africa harbours the highest densities of ungulates and other large mammals in the world (Butt & Turner, 2012). Separating wildlife and areas of human use was a concept introduced from the Western world and in East Africa, resulted in uneasy relationships between pastoralists and conservationists (Galvin, Thornton, Roque de Pinho, Sunderland & Boone, 2006). This is unfortunate because due to the relatively small sizes of many protected areas, adjacent rangelands are indispensable for the local survival of wild animals (Rannestad, Danielsen, Moe & Stokke, 2006). Additionally, ecological function and biodiversity beyond the borders of protected areas impact on the parks despite adequate management (Hansen & Defries, 2007). These functions include the availability of annual life history requirements of wildlife within the park, seasonally important habitats outside parks and movement corridors, amongst others.

Butt (2011) describes how pastoralists residing around protected areas access them on a regular basis, despite the fines they face in case of apprehension by park authorities. Reasons for this behaviour include loss of grazing area to land under protection as well as privatisation of land for cultivation and commercial agriculture due to increasing demographic pressures, resulting in the reduction of rangeland resources (Boyd *et al*., 1999). This reduced the space essential for mobile livestock keepers to cope with the environmental variability they face (Butt, 2011). Additionally, so-called key resource areas can be found within parks which can function as critical dry season grazing reserves and have been used by pastoralists for so long, it has become tradition (Butt, 2011). These aspects made it evident that "protected areas will always be in need of active defence" (Kumar, 2007, p. 5316) because the presence of livestock inside national parks is thought to endanger wildlife by degrading their grazing areas. In addition, the presence of livestock also lowers the perceived quality of wildlife viewing, thus threatening wildlife viewing fee incomes (Butt, 2011). Beale *et al*. (2013) describe how in South Africa poor relationships with immediate neighbours to protected areas and strict exclusion created hostility and promoted illegal activities. Butt *et al.* (2009) found that encroachment into parks for the purpose of herding occurred all year round in the Maasai Mara, especially in the dry season.

Rannestad and his colleges (2006) were able to show that in Uganda wild ungulates were found in higher densities on the dairy farms surrounding a national park than in the protected area itself. This is a sharp contrast to many

studies (e.g. Prins, 2000) describing severe declines of wild ungulates exposed to people and livestock outside protected areas. Rannestad *et al.* (2006) conclude that cattle ranching may be more compatible with wild ungulates than assumed and that wild ungulates could even profit from pastoral activities adjacent to the protected area depending on seasonality.

Financial incentives for pastoralists residing around protected areas have proven effective, but available resources are often insufficient. Thompson and Homewood (2002) found that up to 19% of the revenues reach the local communities but this number is highly dependent on conflicts, disagreements, fraud as well as political and logistical constraints. Additionally, as mentioned before, Butt (2011), amongst others adds that many land owners did not feel that their benefits from protected areas are adequate. Honey (2008) indicates that only very little revenue from park fees and other tourism sources reached local communities, while at the same time financial losses are suffered through crop damage induced by wildlife and loss of livestock to predation.

Sundaresan *et al.* (2012) found that pastoralists in Grevy's zebra areas appreciate economic benefits received through the conservancies. However, they do not usually receive these directly (see 3. Methods) and so the authors express their concerns that indirect incentives may at some point no longer be enough to satisfy conservancies' members in order to ensure their on-going support.

According to Jones, Stolten and Dudley (2005) it has often occurred that privately conserved areas are established adjacent to government reserves. Reasons for this

are that animals roam beyond the boundaries of parks due to their ecology (e.g. "seasonal dispersal ranges", p.72) and the absence of fencing. Additionally, private properties next to formally protected areas can harvest benefits through pre-existing tourism infrastructure. Jones *et al*. (2005) go on to state that government protected areas are insufficient in protecting many species, as they do not provide the necessary space. However, social and economic development goals especially in low-income countries often do not allow for the establishment of additional national parks. This is where community-based conservancies can form an important link. Duffy (2006) states that community conservancies are a form of land use driven by global environmental governance ideals. If benefits for communities can be harvested, ecotourism is a tool to promote support for conservation. This is however only the case if the compromises made do not interfere with the conservancies' members' main livelihoods (livestock keeping) too much (Kiss, 2004).

In the case of Samburu, conservancies associated with the NRT consist of community-owned group ranches that joined their lands together to manage both livestock husbandry and wildlife conservation (Low *et al*., 2009). Group ranches are generally occupied by indigenous inhabitants that jointly own a land's freehold title and produce livestock on this land (Western, Groom & Worden, 2009).

At the 5th IUCN World Parks congress in Durban (South Africa) private protected areas were defined as land parcels protected without governmental recognition in

order to conserve biodiversity, and governed by individuals, communities, corporations or non-governmental organisations (Jones *et al*., 2005). Furthermore, the IUCN's World Commission on Protected Areas and the Commission on Environmental, Economic and Social Policy defined community conserved land as biodiversity rich, ecologically and culturally significant areas conserved voluntarily by indigenous, mobile and local communities through means such as customary laws (Jones *et al*., 2005). Various definitions also highlight the importance of the local communities as the main beneficiaries of conservation (Greiner, 2012).

In the late 1980s community-oriented conservation approaches first became known to the wider public (Kumar, 2007) and since the 1990s they have increasingly been recognised as a valid strategy (Greiner, 2012). Around this time the KWS promoted community-based conservation and resource management, aiming to protect the 60% to 75% of Kenya's wildlife population living outside protected areas (Barrow, Gichohi & Infield, 2000). Leading principles include communities' sense of ownership over natural resources and sustainable use thereof with positive consequences in the social and economic dimensions. However, this may only be achieved if land ownership is clarified and in consequence non-group members may be excluded from using the area under protection (Greiner, 2012).

Although excellent in theory, community conservancies have struggled for several reasons; key issues includ the apparent incompatibility of conservation

and development, financial and other limitations to strict implementation of protection (Kumar, 2007), and the imposition of ideologies onto rural communities. Sufficient local community involvement is often highlighted as a leading principle. However, it cannot be easily determined whether it is merely symbolic (Galvin *et al*., 2006) and it can even become a source of potential conflict (Bruyere *et al*., 2008). Some governing elites and other state agents have not been willing to hand over control to local communities, as community conservancies attract foreign donor money which may result in corrupt activities (Nelson & Agrawal, 2008). Indigenous management may be effective as it is done by those people most dependent on the natural resources. However, traditional forms of access lose their effectiveness under the increasing human densities as they were devised when human populations were a lot smaller (Kumar, 2007). Changes in lifestyles and the loss of traditional practises have made the pastoralists' management schemes and natural resource management decisions of the past ineffective and inadequate to control communities (Letoiye, 2014).

Kumar (2007) reviewed integrated conservation and development projects from around the world and found their performance and success rates to vary. Internal differences make the need for individually tailored approaches obvious but it must be recognised that human behaviour everywhere, including wildlife exploitation, is driven by opportunistic self-interest (Kumar, 2007). In conclusion, as Beale *et al*. (2013) formulate it, the future of African wildlife conversation will be driven by socio-economic as well as ecological issues within and around

governmentally and privately protected areas and will therefore depend on support from local communities.

2.3 Pastoralism

One-half of the world's pastoral people are found in Africa (Fratkin, 2001). In Sub-Saharan African 50 million people are agro-pastoralist and pastoralist (Kraetli, Huelsebusch, Brooks & Kaufmann, 2013).

Evidence for extensive pastoralism in some parts of Eastern Africa dates back at least 2000 to 3000 years ago (Herlocker 1999; Lamprey & Reid, 2004) and it extended over the entire region around 1000 years ago (Voeten & Prins, 1999). Pastoralism is treated under its cultural or traditional aspects by many policy makers (UNEP, 2013), neglecting its economic and environmental importance.

A pastoralist household's livelihood consists of 50% to 100% mobile livestock keeping in communal pastures and relies on strong kinship ties for mutual benefits such as herding management or security (Fratkin, 2001). In the case of Samburu this refers to some 75 000 people that pack up or abandon their homesteads to move with their families and livestock to more suitable pasture in dry seasons and return after it has rained sufficiently in their home area. However, throughout Sub-Saharan Africa there is a tendency towards a more sedentary lifestyle as infrastructure such as schools make mobility less desirable and offer new ways of making money. This results in land use change (Wheeler, 2013).

Between 60% and 70% of Kenya's livestock is found in the ASALs (GoK, 2004). About 34% of Kenya's population (10 million people) depend on livestock for their livelihoods in these areas (MOLD, 2010). The ASALs cover about 70% of the country (Fratkin, 2001). Of the agricultural GDP 40% is derived from livestock husbandry and 50% of people working in the agricultural sector are employed in the livestock industry (MOLD, 2010). In 2010 the country's livestock population was estimated at 12.2 million cattle, 8 million sheep, 10 million goats and 0.9 million camels (MOLD, 2010).

The ministry seeks to increase productivity further and calls for commercial instead of subsistence livestock keeping for the domestic as well as the export market (MOLD, 2010). Rangeland livestock was valued at around one billion US dollars in 2009 (Otuoma *et al.*, 2009), additionally, a lot of informal transactions take place and are not documented in any trade statistics. Rangeland livestock accounts for 10% of Kenya's GDP according to Otuoma *et al.* and 12% according to MOLD (2010).

Recently still perceived as "an embarrassing relic of underdevelopment" (p.13, UNEP, 2013) and a problem in terms of administrating people and maintaining cross-border security, the nomadic lifestyle has not been supported by many government officials (Chatty, 1998). Today, calls are made for the restoration of pastoralists' traditional rights, such as access to water and pasture, rights-of-way to travel and unhindered passage across borders, as well as recognition of their right to self-government (Fratkin, 2001). For example in the Samburu

Community Protocol (2009), the Samburu Local Livestock Keepers state:

"Our pastoral way of life promotes the conservation of our important indigenous breeds of livestock alongside world renowned wildlife. We have a right to continue to live according to our values that promote the sustainable use of our livestock while ensuring conservation of the wider environment. From the Kenyan Government: We demand to be respected as keepers of important livestock breeds and as custodians of wildlife according to national and international principles and laws."

Little (1996) describes how historically, governments would use measures as extreme as violence to discourage pastoral practises. During the British colonial rule many tribes were confined to specific "tribal grazing areas" (Fratkin, 2001, p. 10) thus preventing movement and laying the ground work for intricate environmental and social conflicts to follow. Other measures discouraging pastoralists' mobility have included demarcation of grazing boundaries, unsuitable provision of bore holes, disregard of traditional land tenure agreements and promotion of agriculture (Fratkin, 2001). But more recent biological scientific evidence has challenged these views and is gradually leading to a complete turnaround in this regard (Behnke, Kerven, & Scoones*,* 1993; Boyd *et al.*, 1999; Chatty, 1998; Little, 1996; UNEP, 2013).

In tropical Africa mobile pastoralism is more sustainable and productive than any other land use form on extensive rangelands. It is described as the most important economic activity in the ASALs by the African Union (2010). Because of the

strategic movement, animal production in protein kilogram per hectare per year is more intensive than commercial, sedentary ranching could be (Kraetli *et al.*, 2013; UNEP, 2013). Not only can pastoralists cope with high climatic variability and react to geographically widely distributed resource availability, but they are also less dependant on the availability of man-made water sources and irrigation than agriculture in these specific regions. Pastoral migration systems evolved over many centuries, incorporated into millennia old wild animal migration patterns. Their livestock distribution schemes in space and time have been described as being "as technically sophisticated and effective as any 'modern' commercial scheme" (UNEP, 2013, p. 14). In an environment in which one area may experience resource scarcity whilst another can provide plentiful resources, livestock production through migration is the answer to discontinuous variation (UNEP, 2013). Although their livestock may seem in poor condition, the pastoralists' animals are hardy and can survive periodic drought and sparse vegetation (Fratkin, 2001). The ability to take advantage of productive periods and vegetation flushes thus depends on the availability of places to go to and the necessary space associated with such movements.

In a comparison made by the UNEP (2013) between migratory cattle and cattle owned by sedentary farmers the former significantly out-performed the latter in all aspects, such as annual calving rates and heifers' age at first calving, total and calf mortality rates and meat production. Ocaido, Muwazi and Opuda-Asibo, (2009) concur by stating that per hectare returns of pastoralist production systems

were almost seven times higher than on ranches. The UNEP report goes on to state that, for example, the pastoralist Maasai in Kenya have a 185% higher annual per hectare protein production rate relative to other farming systems in East Africa.

Pastoralist production system also have the potential to play an important role in carbon storage. Primarily it is a low-carbon production system compared to more intensive systems and it does not require cultivated fodder inputs (Steinfeld, Mooney, Schneider & Neville, 2010). Additionally, Dabasso, Taddese and Hoag (2014) found average stored carbon amounts in Northern Kenya to be high enough to play an important role for the levels of atmospheric greenhouse gases. The authors go on to discuss studies, which showed that cultivation reduced the amount of carbon stored in the soil due to disturbance and they argue that other land use forms than pastoralism would, too. The rangelands' contribution to carbon storage is also remarkable due to its shear size. Even though Dougill *et al.* (2012) point out that this contribution is rarely acknowledged, it could be seen as a potential, yet to be harvested benefit generator through carbon credit trading.

How livestock and their grazing is managed depends on a combination of socio-economic, biophysical, constricting and promoting variables and factors. These all interact at different spatial and temporal scales which results in a "multiplicity of movement patterns" (UNEP, 2013, p. 32) that may seem random at first but actually reflect complex strategies to maximise productivity. Coppolillo (2000), for example, found that herd size changes herding strategy, because animals in a

large herd move faster and are less likely to settle down in a patch, affecting the herding radius. This does not affect cattle's intake rates in too negative a way but does decrease lactation rates. However, it may influence how herds are split or aggregated in different seasons because independent of herd size, intake rates decrease in the dry season proportionally to stepping rate. The strategic movement of pastoralists' herds allows them to give the livestock diets higher in nutrition than the range vegetations' average (Kraetli *et al*., 2013). The distance and time travelled by a herd was found to increase during the dry season in Maasai pastoralist herding systems (Butt, 210). Herd splitting also allows pastoralists to manage their animals according to species specific needs. Water availability can also determine in which direction herds move, as Coppolillo (2000) described by finding skewed grazing movements toward perennial water in the dry and away from it in the wet season. Settlement distribution affects the distribution of grazing on the landscape level (Coppolillo, 2000). For example, if settlement density is high, herds must range further because grazing resources are likely to be depleted in such areas of high use. Additionally, livestock will graze closer to settlements in the wet season (Butt, 2010).

There are two major herding decision scales in relation to time and space. Decisions to move must obviously be made in accordance to seasonal variation in order to seek areas in which rainfall allows for good pasture to develop. However, on a day-to-day basis resource niches allow for a variation in small scale exploitation on a local opposed to the landscape level (UNEP, 2013).

Pastoralists have co-existed with wildlife for millennia, Herlocker (1999) notes that the grasses and the domestic as well as wild bovids co-evolved in East Africa due to their strong interactions. Strong parallels can be found between the resource use of pastoralist livestock and wildlife and Thompson & Homewood (2002) gave a number of references stating that extensive pastoralist systems and wildlife conservation in unfenced areas could be highly compatible, namely in the Serengeti-Mara ecosystem. Honey (2008) adds that pastoralism is the only land use form that does not require exclusive use of the land. However, due to small and widely dispersed human and livestock populations, there used to be less potential for conflict than today (Boyd *et al*., 1999).

Stating that pastoral practises have degraded rangelands and endanger ecosystems and their biodiversity is a dangerous and biased simplification. Large grazing mammals including domestic grazers can increase plant diversity on grass lands, which forms the base for diversity on higher trophic levels. This may occur through their roles as seed and nutrient dispersers over long distances. The frequent moderate disturbances they create across the landscape may give rise to less dominant plants according to the intermediate disturbance hypothesis. However, for domesticated large grazers this is only the case at low stocking rates, with high stocking rates being more likely to decrease diversity. Mechanisms include non-selective grazing and strong disturbances which in turn favour only some few very tolerant plants (Olff & Ritchie, 1998). Stocking rates vary strongly with seasonality but there is an obvious upward trend alongside the

human population increase. Multiple traditional pastoralist practises actually benefit biodiversity, such as abandoning "bomas" (settlements) which develop into nutrient-rich vegetation hot spots, sought out by many herbivores. It must be noted that this depends on a suitable density of settlements and a long enough recovery time for succession to develop (Stelfox, 1986). Concerning settlements, Western *et al*. (2009) found that wildlife numbers declined significantly more in the presence of permanent compared to seasonally mobile settlements and clustering of settlements only displaced wildlife in one area as compared to scattered settlements. Other positive pastoral practises include rangeland burning which improves grass quality, as well as deforestation of certain areas which creates safe pasture with high predator visibility (Riginos *et al.*, 2012). Lindsay (1987) assumes that it is not a coincidence that pastoralists, their livestock and East Africa's highest mammalian wildlife densities are found in the same area. Western *et al*. (2009) in their study in Southern Kenya, attribute a sharp decrease in wildlife population numbers to subdivision and sedentarisation on a privatised ranch. Opposite trends were found on the adjacent land where mobile pastoralism was continued. Distribution and site occupation of wild animals is shaped by human activities but effects can be species-specific and either positive or negative (Erb, McShea & Guralnick, 2012).

Common negative effects of pastoralism on biodiversity include the reduction of wild ungulates and their habitat, as well as bush encroachment, invasive weeds and land degradation triggered through over-grazing (Riginos *et al*., 2010).

Orodho (2006) lists four inter-connected factors determining the availability of long-term grazing resources for pastoral production systems; including rainfall variability, how rainfall affects available forage, how domestic and wild herbivores use grazing resources and the relationship of its quantity and quality. Boyd *et al.* (1999) and Behnke *et al.* (1993) suggest that with climatic variabilities being the main constraint to rangeland productivity, stocking rates and grazing pressures were less severe factors than previously assumed. Therefore, rangeland conservation is best served by not trying to control traditional pastoral stocking rates and movements.

In Southern Samburu initiatives by the non-governmental organisation NRT seek to use high livestock densities to target and restore degraded land (KWS, 2012). Community livestock programmes improved the rural pastoralists' access to markets. Livelihood diversification has been targeted to enable for controlled grazing to improve the livestock's condition without increasing their numbers which in turn benefits wildlife and its range (KWS, 2012).

Many decision-makers continue to operate under misconceptions that wildlife and livestock keeping are incompatible and conflicting land use forms. Fritz, De Garine-Wichatitsky and Letessier (1996), a UNEP report (2013) and many other sources emphasise that "mixed cattle and wildlife ranching" (p. 7) in the ASALs have the potential to be the most ecologically and economically productive land-use form if managed appropriately. Mixed herbivore communities display complementary use of various vegetation components (Galvin *et al*., 2006). This

can apply both to livestock and mixed wildlife and livestock systems, which results in per unit higher biomass productivity than other land use forms and reduces risks associated with single species production systems. This principle has been recognised and understood by traditional pastoralists since many centuries (Herlocker, 1999).

2.4 Grevy's Zebra

2.4.1 Taxonomy and Physiology

There are seven extant wild equid species, found in Africa and Asia of which three have prominent black and white stripes (plains zebra, *Equus burchelli*; mountain zebra, *E. zebra*; and Grevy's zebra, *E. grevyi*) (Caro, Izzo, Reiner, Walker & Stankowich, 2014). The Grevy's zebra (*Equus grevyi*) is the largest of all wild equids.

Linaeus (1758) was the first to propose the genus name *Equus* to include asses and zebras. Together with horses they form the family Equidae (Groves, 2013). The name *Equus grevyi* was coined by Oustalet in 1882 (Groves, 2002). Today, most equids especially those of the desert ecosystems are threatened or vulnerable (Moehlman, 2002).

All equids are large bodied hind gut fermenters which according to Saltz (2002) dictates them to live in open habitat and feed in bulk. This means they need to

feed about twice as much as ruminants of the same size (Groves, 2013). Equids belong to the order Perissodactyla and as such walk with all their weight on their central third toe (Groves, 2013). They are also all highly social as well as polygynous (Saltz, 2002). Within the genus *Equus* the zebras form the subgenus *Hippotigris* with their distinct feature of black and white stripes. These stripes are visual attraction clues and important for early age social interactions (Kingdon, 2013). Chrucher (1993) also suggests they may serve as camouflage, making the zebra less visible in moon light (SDZ, 2010) or to confuse predators in various ways (Caro *et al.*, 2014). Additional reasons for explaining the evolutionary advantages of zebra stripes that are often cited include tsetse fly avoidance and heat regulation (SDZ, 2010). Caro *et al.* (2014) in a grand scale comparison between equids with and without stripes as well as present and historical conditions in their habitats only found evidence for the biting fly hypothesis.

A male Grevy's zebra's weight ranges from 400 to 450 kg and females have an average weight of 350 kg (King, 1965). But their only real sexual dimorphism according to Groves (2013) is the absence of canines in females. They can reach a body length of up to three meters and the average shoulder height is 1.35m (SDZ, 2010). In comparison to their much more abundant cousin, the plains zebra (*Equus quagga*, former *burchelli*) *E. grevyi* is larger, has a longer snout, rounder ears and a narrower stripe pattern as well as a white underbelly. Groves (2002) pointed out that their skull is a lot more elongated than in any other equid.

Compared to *E. quagga,* Grevy's zebras form much looser social structures. They

can be found solitary or in small herds of 20 animals or less (Kingdon, 1979) but occasional formation of herds of several hundred animals does occur. Pregnant and lactating females form stronger ties with con-specific than non-lactating females (Williams, 2002). But movement decisions are generally made on an individual level (Williams, 2013). Mixed herds with plains zebras have also been observed (SDZ, 2010), and hybridisation with generally sterile offspring can occur (Duncan & Groves, 2013). The gestation period for *E. grevyi* is 13 months or 330–390 days (Saltz, 2002). There seems to be insufficient information on *E. grevyi*'s maximum life expectancy in the wild as well as for all equids in general but Saltz (2002) approximates it at 25 years with many individuals dying before the age of 16.

According to the IUCN (2014) and Williams (2013) home range size of non-territorial Grevy's zebras is up to 10 000 km² and especially bachelors can roam up to 80 km a day. In the Southern Samburu study areas analysed by Letoiye (2014), there was no specific temporal movement within a year. But Williams (2013) states that dispersal of individuals is pronounced in wet seasons and in drought, whereas aggregation occurs in the dry season. Male *E. grevyi* defend territories of 2-12 km² with watercourses and other natural features forming the territories' borders (Kingdon, 1979; Williams 2013). Con-specific males are tolerated within these territories unless females in oestrous are present (Kingdon, 1979). Females' oestrus is triggered by high resource availability (Williams, 2002).

2.4.2 Ecology

Over 90% of the global wild population of *E. grevyi* is found in Kenya (KWS, 2012). Kingdon (1979) describes their niche as an inter-zone between where the arid-adapted wild ass (*E. africanus*) and the water loving *E. quagga* are found. Because *E. grevyi* requires less water than *E. quagga* or for example cattle (Churcher, 1993). *E. grevyi* overlaps with *E. quagga* in the South and *E. africanus* in the North of its range (Caro *et al*., 2014). *E. grevyi* is thought to be highly adapted to this very dry habitat which is less suitable for the other two wild East African equids (Churcher, 1993). But Moehlman (2002) emphasises that all equids "persist in some of the harshest climates and terrains in the world" (p. ix).

Williams (2002) describes Grevy zebras' habitat as semi-deserts or semi-arid grass and shrub land. Low vegetation (1 m) or scattered low (3-4 m) *Acacia* bush with herbs and grasses are found in their habitat and Grevy's zebras depend on a permanent water source. Low *et al*. (2009) describe Grevy's zebras' favoured habitat in Northern Kenya as short grass open savannah. In their study period of two years Sundaresan *et al*. (2007) observed most studied animals in green grass locations and note a preference for locations with short grass across all reproductive classes. Apart from lactating females they also found most Grevy's tend to avoid dense bush. Avoidance was strongest for shrub grassland and bushland in the 2008 survey (Low *et al*.). But due to resources scarcity and possibly displacement, *E. grevyi* can be found in unsuitable -for example- bushy

habitat (Letoiye, 2014).

The Grevy's zebra is predominantly a grazer but its nutrient intake can comprise of up to 30% of browse if necessary (IUCN, 2014). Their physiology requires them to pass grass and other plant material through their digestive tract at a very high rate (Duncan & Groves, 2013) and therefore they can spend up to 62% of their time grazing (Williams, 2013). Sundaresan *et al*. (2007) found that an animal's individual reproductive state largely impacts on forage quality and quantity as well as the preferred habitat type. For example, although Grevy's are bulk feeders, lactating females and bachelors were found to seek higher-quality but lower quantity forage. In females with foals this is attributed to specific nutrient demands during lactation (Sundaresan *et al*., 2007).

For all equids to maintain high population numbers, they require large tracts of land. Also sensitivity to site specific extreme conditions (such as drying up of water sources) can be an extinction risk (Saltz, 2002).

Historically, when *E. grevyi* was thought to be the most abundant grazing herbivore in its ecosystems it "potentially played an important role in the biodiversity of the region"; significantly impacting on "the structure and composition of the rangelands" (Williams, 2002, p.14). Nowadays these effects can no longer be determined due to the low number of remaining Grevy's and because the high density of livestock may have modified the landscape in much of their range.

2.4.3 Conservation

E. grevyi has "undergone one of the most substantial reductions of range of any African mammal" (KWS, 2012, p.8). Their historic range throughout the Horn of Africa stretched from East of the Rift Valley in Kenya to Western Somalia as well as Northern Ethiopia, up to North-East of Lake Turkana in Ethiopia to North of Mt. Kenya and South-East down the Tana River in Kenya. Once found in Djibouti, Eritrea, Somalia, Ethiopia, Kenya and possibly Sudan, Grevy's zebras today persist only in Kenya and Ethiopia (KWS, 2007). Their range has become discontinuous (Williams, 2013).

Latest estimates put the total population of Grevy's Zebra remaining in the wild in Kenya and Ethiopia at approximately 2800 animals (KWS, 2012). This number represents an up-ward trend of the last twelve years in which population numbers have been increasing slowly (KWS, 2012). According to the IUCN (2014) the Grevy's zebra population declined by some 55% to 68% between 1988 to 2007. The KWS claims an 81% decline in numbers since 1970 with the most rapid decline in the 1970s and 1980s from an estimated 15 000 animals to the present few thousand. However both sources agree that populations seem to be stabilizing and increasing, although Mwasi and Mwangi (2007) point out that this may have also been due to increased and improved observation and monitoring in the 85 000 km^2 of savannah (Parker *et al.*, 2011) they are scattered across. The IUCN (2014) mentions hunting for skins as the main contributor to population decline in the late 1970s. This stopped with the hunting ban in 1977 (KWS, 2007). After

trade in skins had ceased, and due to a cultural taboo in many ethnic groups towards consuming ungulate meat, hunting is no longer common. However, killing of the species may occur in ethnic groups without such regulations and for medicinal purposes especially in areas inhabited by Turkana, Borana and Somali people (KWS, 2007; Lelenguyah *et al*., 2010).

The IUCN (2014) goes on to state that present day threats to the remaining *E. grevyi* seem to be "low recruitment due to low juvenile survival" due to reduction of available water sources, habitat degradation and loss due to overgrazing, competition for resources and disease, especially Anthrax (Williams, 2002). Other diseases may include equine herpes virus (Borchers *et al.*, 2005).

To date, protected areas form less than 0.5% of the Grevy's zebras' range. (IUCN, 2014). "The majority of Grevy's zebra are found on community-owned lands of Southern Samburu" (Williams, 2002 in KWS, 2007). Low *et al.* (2008) note that in their survey 60% of all sightings occurred on community land. Given that these areas (shared with pastoralists) comprise greater than 99.5% of the historic range of Grevy's zebra, overall recruitment is thought to be problematic, which would highlight the importance of the protected areas (Williams, 2002). Williams (2002) also states that the largest and most stable population is found in the area of the Buffalo Springs, Samburu, and Shaba National Reserves, which is the Southern end of their historic range.

The KWS (2007) notes that most on-going and earlier conservation work targeted the Samburu populations and Williams (2002) adds that studies have focused

especially on this region since the 1980s. Community-led conservation has been of particular importance and successful through establishing community conservancies within *E. grevyi*'s habitat (KWS, 2007). This is due to these arid habitats also being home to human populations which need to be able to participate in and benefit from wildlife conservation (Williams, 2002). Tools such as education and awareness concerning Grevy's zebra conservation are being applied continuously (KWS, 2007). Since around 1998, the Grevy's zebra has become "a focal species for many programmes, not just for wildlife conservation but also for community development because the fates of both Grevy's zebra and human livelihoods are inextricably linked to the fragile semi-arid and arid ecosystem of Northern Kenya" (KWS, 2012, p. 14).

The strength of conservation outside state protected areas has been highlighted as "community goodwill, participation and improved attitudes towards Grevy's zebra conservation" (KWS, 2007, p. 18). Weaknesses include problems with communication and collaboration especially with neighbouring non-conservancy communities (KWS, 2007). Which wildlife species is being targeted for conservation influences local people's perspectives and ultimately support (Sundaresan *et al*., 2012). Numerous studies found a trend to positive attitudes of the community members towards wildlife. However, the community members' gender, level of education, wealth or number of livestock owned and benefits received can significantly shape attitudes (Sundaresan *et al*., 2012; Treves *et al.*, 2006).

While in Ethiopia the Grevy's zebra is legally protected, Williams (2002) challenges the effectiveness of this status. In Kenya the status of "Game Animal", under the Wildlife Conservation and Management Act No 376 of 1976 (Part II of the First Schedule), has been under revision for at least six years to date (KWS, 2012; Williams 2002). The aim is to change this status to legally "Protected Animal" (IUCN, 2014). But as game hunting is not practised in Kenya this is not an acute threat.

The IUCN (2014) categorises the Grevy's zebra as endangered. This means they are facing a very high risk of extinction in the wild, based on the definition of a species decline in area occupancy, extent and or quality of habitat and a population size reduction of 70% over the last (in the case of *E. grevyi*) three generations. Another part of the definition for critically endangered species includes that the cause for the population size reduction may have not yet ceased or has not been fully understood (Moehlman, 2002).

Global commercial trade of Grevy's zebras is prohibited by CITES, which lists them on Appendix I (SDZ, 2010).

2.4.4 Interactions with Livestock and Humans

Many forms of human-wildlife conflict are known and increase in severity with the growth of human populations and the decline of habitat for wild species (Butt & Turner, 2012). The Grevy's zebra is not known to be a problem species as it does not attack people nor their livestock or property and mostly does not occur

in areas where crop raiding would be an issue. Despite little direct conflict between humans and zebras having been reported, Sundaresan *et al.* (2012) point out that zebras have similar food and water resource needs as livestock and are therefore of interest to local people.

It is evident that extensive spatial overlap of *E. grevyi*'s lowland population, pastoral people and their livestock exists. The KWS (2007) states that they are sympatric over 99.5% of the zebras' range. In one study Grevy's zebras were spotted most often with small stock and camels, but less frequently with cattle and almost never with donkeys. Low *et al.* (2009) conclude that this common spatial proximity may result in potential competition. Management decisions at large have been "based on the perception that wildlife and livestock compete for food, yet there are virtually no experimental data to support this assumption" (Odadi, Karachi, Abdulrazak & Young, 2011).

Compared to cattle (*Bos primigenius* f. *indicus*) *E. grevyi* needs less water evidenced by fibrous dung documented by Kingdon (1979). The IUCN (2014) notes that the zebras' and the cattle's diets are most similar to each other in comparison to other wildlife species in the East African savannah but the *E. grevyi* is a bulk feeders. Saltz (2002) suggests that its ability to survive on low-quality forage makes it less sensitive to environmental changes in forage quality. Zebras, just like horses, are well adapted to extracting nutrients from grass, but ruminants are more adapted to dealing with detrimental plant chemicals and can therefore feed on a wider range of plants (Duncan & Groves, 2013). Grevy's

zebras can feed on high fibre grass not tolerated by livestock (Williams, 2013). Which leads to positive facilitation of zebras that can crop and digest dead grass stem cover and thereby make the pasture suitable for cattle as well as other ruminant species (Herlocker, 1999; Odadi *et al.*, 2011). Inter-specific facilitation may even be pronounced in more stressful environments but only if an ecosystem's productivity is high enough (Odadi *et al.*, 2011).

Furthermore, drought is thought to favour *E. grevyi* over domestic animals since the high mortality of livestock during drought would relieve the zebras from competition pressures (Williams, 2002). The IUCN (2014) notes that if there are extremely dry conditions, degraded pastures or high competition, Grevy's zebra can switch from consuming grass to consuming up to 30% browse in order to maintain their nutritional intake. Kleine (2010) states that she found Grevy's to eat only about 50% grass in an area of high levels of unmanaged livestock in contrast to two conservation and research farms in a similar area. She also found that the basic plant types consumed differed, with Grevy's eating significantly less C4 grasses and more C3 browse with increasing livestock presence. However, preference for browsing and grazing also differs between reproductive classes (Sundaresan *et al.*, 2007).

According to the KWS (2007) local people who are unaware of *E. grevyi*'s conservation status and who do not receive livelihood improving benefits from their conservation, perceive them as a competitor with livestock. Those livestock keepers with large cow and goat herds in particular seem to perceive Grevy's

zebra as a competitor for the rangeland resources they require for their domestic animals (Sundaresan *et al.*, 2012). Letoiye (2014) found a high consistency of community members agreeing that Grevy's zebra and their livestock compete for grass and water, especially since the zebras feed day and night. However, he also reports community members indicating that they feel that *E. grevyi* "poses little threat to their livelihood and is a friendly animal that can easily co-exist with humans" (p. 101). Claims were made that herdsmen persecute zebras and thereby displace them from critical resources (KWS, 2007). Williams (2002), too, describes how closing off water holes with thorny branches by pastoralists is common, making the water inaccessible for wildlife, especially during the dry season. Adult Grevy's zebras can tolerate not drinking for two to three days. However, lactating females require water everyday (Williams, 2002). This is why competition over critical resources with pastoral people and their livestock is often cited as the main reason for low recruitment due to low juvenile survival.

It must also be kept in mind that a main concern for pastoralists is that the largest water source in Northern Kenya is diminishing, forcing them to exclude wildlife (Williams, 2002). This is due to irrigation schemes upstream of the Ewaso Nyiro River reducing the water flow by up to 90% since the 1960s.

Apart from actual water availability, several studies found that there are changes in the time of day in which Grevy's zebras visit water when pastoralists are present. For example, Sundaresan *et al.* (2007) found that if undisturbed they will drink four hours around midday, possibly to avoid predation. However, if high

livestock densities are present they will instead come to water at night (Williams, 2013). Wheeler (2013) notes similar behavioural changes in association with high settlement densities. But her data suggests that *E. grevyi* naturally visit water throughout the day and night. Therefore human and domestic livestock presence may not entirely reverse the zebras' activity pattern but there are strong indications for daytime displacement. That water sources are critical overlapping points is also made clear by Low *et al*. (2009) who found a strong correlation of livestock presence and proximity to water, when zebras were sighted with livestock in 49% of sightings near water and 38% away from water. On the community conservancy Kalama the importance of making water available to wildlife became very evident, when after establishing a water point in the core conservation area more than a hundred Grevy's zebra were found, where five years earlier they were rarely seen (Low *et al.*, 2008).

Williams and Low (2004) emphasise that increasing resource scarcity as a result of over-exploitation is one of the primary threats to *E. grevyi*'s survival. They, too, included loss of access to critical resources to livestock as a contributor to their population decline. In the revised Kenyan conservation and management strategy for Grevy's zebras, the KWS (2012) and contributing stakeholders list "competition for resources with livestock, reduction of water sources and restricted access to water" (p. 12) as the second most important threat. In this they include relatively high densities of domestic livestock, limited resources, particularly in the dry season, upstream water abstraction from the river, growing

human presence near water, falling water tables, and habitat encroachment and harassment of Grevy's zebras by herders amongst other aspects (KWS, 2012).

The problem of unsustainable use of the Ewaso Nyiro river is an issue caused upstream of the river in Kenya's highlands. The main threat relating to pasture is one too well known throughout Sub-Saharan Africa: over-grazing. Over-grazing occurs when relatively high densities of domestic livestock are grazed in an area over a long period of time and result in vegetation community changes and soil erosion (KWS, 2012). Overgrazing is listed as the primary cause of degradation in Northern Kenya by, for example Herlocker (1992). It can result in land degradation and desertification. It occurs when grazing pressures over weigh plants' and ultimately ecosystems' regenerative capacities. Williams (2002) cites livestock stocking rates, the choice of unsustainable domestic livestock species for dry areas, an inappropriate distribution, and high grazing pressures going on for too long as probable causes. Butt and Turner (2012) claim that dry sandy soils are relatively insensitive to grazing pressure and that in the dry season vegetation is merely reduced but not affected otherwise. This is however not the case if grazing is so heavy that bare soil is exposed, initiating the process of erosion. Additionally, they point out that grazing during the growing season affects the entire system's productivity and may lead to shifts in species composition, nutrient cycles and soil formation.

In Grevy's zebra's range, the consequences of land degradation impacting on plant communities include an increase in woody cover (tree, shrub, and dwarf shrub), a

reduced herbaceous and grass cover and a decrease in the quality of the herbaceous layer (less perennials, more annuals) (Williams, 2002). The rise of shrubby and woody vegetation may have been due to factors such as a reduction in the pastoral grazing range, a 97% increase in livestock population density between 1980 and 2000 and decline in the population of browsing wildlife amongst others (Otuoma *et al*., 2009). Only medium grazing pressures would have the potential to enhance primary production and give perennial grass species an advantage over woody vegetation (Herlocker, 1999).

In a study on the Meibae conservancy, Grevy's were found significantly more in dry season livestock grazing areas than in wet season in relation to their availability (Letoiye, 2014). Williams (2002) also states that observed movement of Grevy's away from lowlands, was a result of vegetation changes and erosion caused by grazing pressures. Additionally, Prins (1992) as well as the KWS (2007) point out a reduction in Grevy's zebra's range as a result of development and urbanisation, resulting in habitat loss. Apart from environmental and land scape changes, the sharing of pasture by Grevy's zebras and domestic livestock again also impacts on *E. grevyi* behaviour.

Williams (2002) found that in a survey in Ethiopia most Grevy's were recorded in a part of the wildlife reserve, away from high densities of domestic livestock and in areas without any humans or domestic livestock on the Alledeghi plains. Additional indicators for avoidance of humans are given by Sundaresan *et al*. (2007) where zebras on a commercial ranch were found to avoid active cattle

corrals. Young *et al.* (2005) show that zebras use habitat shared with livestock nearly 50% less than livestock-free land. In their experimental design they were also able to show the reduced grass cover correlated with cattle presence and thus zebra absence. However, Rannestad *et al.* (2006) found that different wild ungulates were displaced more strongly by human presence than by livestock grazing but that zebra and impala actually preferred the grassland habitat on inhabited land. But in the conservancies of the study area, Letoiye (2014) found an 85% negative correlation between Grevy's zebra movement and human settlement.

Even though different ungulates or other species may graze on the same patch, they may not effectively be sharing the same resource (Butt & Turner, 2012). Voeten and Prins (1999) hypothesise that due to evolutionary processes, wildlife partition their resources amongst each other, while livestock was introduced much later and encroaches into other animals' pastures, especially zebras'. Competition is likely to occur between cattle and zebra mainly in the early wet season (Voeten & Prins, 1999). Whilst the underlying motives may yet be unclear, Sundaresan *et al.* (2007) conclude that for Grevy's zebras parts of the landscape seem unavailable or unsuitable for use. Due to the mobility of pastoral people's settlements this would result in "a shifting mosaic of preferred habitat" (Sundaresan *et al.*, 2007, p. 363). Furthermore, the reproductive classes behave differently. The more mobile and less water dependant reproductive classes were observed less often in close proximity to livestock and Wheeler (2013) attributes

this to their ability to range further from water than cattle to find unused foraging areas. However, the reduced availability of forage may result in higher energy costs for animals as they need to move further between grazing patches or settle for fodder with reduced quality (Butt & Turner, 2012).

The literature makes it clear that Grevy's zebra is not unaffected by the presence of people and their livestock. However, referring to the paper published by Butt and Turner in the journal "Pastoralism" in 2012, it remains unclear whether interactions between *E. grevyi* and domestic livestock results in competition. They note the "great deal of controversy surrounding the characterisation of wildlife–livestock relationships" (p. 3). In general wildlife and livestock interactions are variously described as competitive for natural resources (e.g. Low *et al*., 2009 or Young *et al*., 2005); facilitative; avoidance; as non-competitive; a co-existence or a combination of facilitation and competition (Odadi *et al*. 2011). Butt and Turner (2012) note that often presence as well as absence of spatial overlap are used as arguments for competition. They elaborate on the high degree of inconsistency and confusion in the literature. And that poor understanding of what competition actually is has influenced decision making associated with conservation and development with likely negative effects for wildlife and livestock. They further acknowledge that the abstract theory of competition is well understood but that it is hard to study empirically. Because spatial displacement of competition, selective grazing by animals and temporally displaced and highly climatic dependant vegetation response form an extremely

complex relationship. Or to reformulate; how much biomass of humans, livestock and wild mammals can be supported in an area depends on its carrying capacity, which fluctuates from year to year depending on the rainfall and previous grazing pressure (Happold, 1995).

As Sundaresan *et al.* (2007) note, the specific factors of why Grevy's react the way they do are not yet understood; factors may include the response to the presence of humans or cattle or to water and forage competition. Butt and Turner (2012) conclude their paper by remarking that "greater spatial specificity of livestock and wildlife grazing and browsing patterns" (p. 9) needs to be understood for example by documenting grazing orbits of pastoral-managed livestock and by using information about landscape change and the interactions of domestic and wild ungulates in the bush provided by pastoralists or community groups themselves. In the case of Grevy's zebra, Sundaresan *et al.* (2012) as well as Letoiye (2014) repeat that due to shared resource needs with livestock, Grevy's zebra habitat protection would benefit them, too and that improved range conditions may result in enhanced livelihoods for the pastoral people.

2.5 Definition of Terms Used

A home range is an area an animal traverses on a regular basis in order to forage for food, mate or raise its offspring. It excludes occasional exploratory movements beyond this range. This definition was proposed by Burt in 1943. In the following study the home range did not refer to the entity of the area

utilised by Grevy's zebras, but was confined to and focused on the areas of this form of utilisation within the study area.

Hot spots are areas that "feature exceptional concentrations of endemic species" (p. 45, Levin, 2000). In this study the endemic species refers to the Grevy's zebra. When referring to "hot spots" in the following, it is meant to be understood as a zone within the home range that the *E. grevyi* utilised the most.

3. Methods

3.1 Study Area

Kenya lies in the East of the African continent and South of the Horn of Africa. It expands over a size of approximately 584 000 km^2 (Orodho, 2006). According to the WRI (2007) almost 40% of Kenya's ecosystems are savannah and grassland. More than 75 238 km^2 (or 13%) of the land surface is set aside as national parks and game reserves (WDPA, 2008). With at least 359 known species Kenya is the second highest ranking African country (after the Democratic Republic of Congo) for mammal species richness (Survey of Kenya 2003), of which 33 are threatened (IUCN, 2006).

Kenya is divided into seven agro-climatic zones; two-thirds of the country belong to the zones IV to VII which include semi-arid to arid regions. The ASALs constitute about 80% (MOLD, 2010) of the country in which 20% of the population is found (FAO, 2014). These rangelands are "characterized by poor vegetation cover, fragile soils, high temperatures and frequent wind storms" (Orodho, 2006, p.12). The area does not support sustainable crop production on a meaningful scale. Growing sedentarisation of humans in semi-arid lands has reduced livestock mobility and increased prolonged heavy grazing. In consequence, woody plants now dominate over the herbaceous species in many regions. This has led to open wooded grassland to be replaced by bush land in large areas of Northern Kenya (Otuoma *et al.*, 2009).

Within Northern Kenya, the Samburu County (formerly a district in the Rift Valley Province) expands North from the Ewaso Nyiro River to the South of Lake Turkana over an area of 21 000 km² (Raizman, 2013; UNEP, 2013). Its topography includes lowland around 1000 metres above sea level (MASL), plateaus at around 1200 MASL and two mountain ranges (Herlocker, 1999). Bruyere *et al.* (2008) describe the Ewaso Nyiro as "the major perennial water source" in the arid landscape of Northern Kenya. It is the third largest stream in the country.

The following ethnic groups are important stakeholders in nature conservation in Northern Kenya: Samburu, Rendille, Borana, Gabbra, Maasai and Somali. There are a growing number of community conservancies in key Grevy's zebra home ranges, now managing their land for wildlife conservation (KWS, 2012 & NRT, 2014). Orodho (2006) estimates that about 50% of wildlife residing outside national parks in Kenya is found in these areas. As the community conservancies described in the following, are areas of high *E. grevyi* occurrence, they were chosen for this study. Another factor being, that the GZT has established itself in these communities and required further understanding of social and ecological dynamics on the ground.

Raizman *et al.* (2013) state that "resident Samburu pastoralists...dwell in communal homesteads where different families and clans share grazing resources with wildlife" (p.77). They go on to describe how the Samburu are semi-nomadic and their homes (so called manjatas) are made up of temporary livestock

enclosures and semi-permanent houses.

Within Southern Samburu, North of the SNR which borders Isiolo County, and West of the Matthew ranges, three adjacent conservancies formed the study area, as shown in figure 1. These are the Kalama, Meibae and West Gate community conservancies. The area is located at about 37.07° East and 1.25° North. It is a dry, hot savannah with highly variable bimodal rainfall with an average of 375 mm per annum. Most commonly, annual rainfall occurs during April and May and from November to December (Lelenguyah *et al.*, 2010).

The landscape North of the Ewaso Nyiro River is dominated by soils derived from ancient basement complex rocks. With some areas having sediments covered by recent fluvial and alluvial deposits of red sands. Most soils in the area are well drained sandy loams (Barkham & Rainy, 1976). Soil with high organic carbon, as well as clay content can be found and phosphorous levels differ greatly. According to NRT, soil organic carbon is low in some of the study sites creating critical conditions for plant growth but there is variation amongst sites. Soil erosion rates in the area are extremely high and patches of bare soil can be found, although these vary between years and seasons (NRT, 2014).

Based on classified satellite images, the study area has relatively low vegetation cover (NRT, 2014). Acacias are the dominant tree genus such as *Acacia tortilis* and *Acacia xanthophloea*. Species such as *Commiphora africana* and *Boscia coriacea* can be found in the area but most trees only occur along river beds. Shrubs dominate the rangelands including *Acacia mellifera*, *Cadaba farinosa*,

Grewia tenax and *Cordia sinensis*. *Acacia reficiens* is the species most mentioned in relation to bush encroachment (NRT, 2014) and as a nuisance species. Under-storey dwarf shrubs in the study area include species such as *Lippia carviodora* and *Indigofera spinosa* (Birnie & Noad, 2011; Dharani, 2002; Maundu & Tengnaes, 2005). Forbs and grasses forming the herbaceous layer include *Ipomoea plebeia*, *Oxygonum sinuatum*, *Ocimum americanum, Pupalia lappacea* and *Cynodon* spp. (Low *et al.*, 2009). Common perennial grasses include *Sporobolus nervosus, Chrysophogon plumulosus* and *Oropetium minimum* (Hostens, 2009).

Figure 1: The study area within Kenya (Samburu centroid at 1.321358°N and 37.109318°E and Kenya centroid at 0.623192°N and 37.848209°E). Source: NRT; Cartography: Author.
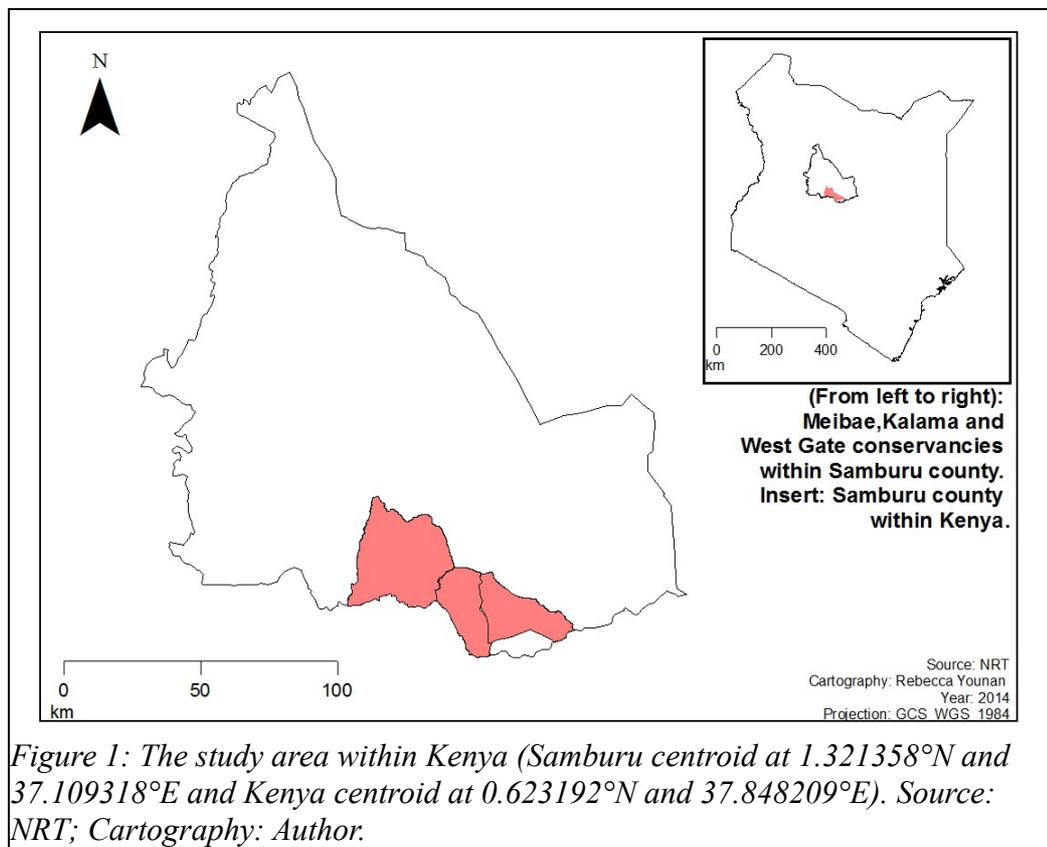
The three community conservancies were founded and are managed with the help of the NRT. The conservancy management and board members are elected from within the communities. All conservancies are financially supported by the county government. Projects aimed at improving people's livelihoods and, or their environment include, women's micro enterprises, livestock markets, capacity building, pasture reseeding, bush clearing, holistic planned grazing and control of invasive plants to restore degraded rangeland (Lekalaile, 2013). The conservancies are not fenced, not even towards the SNR.

Kalama in the South-East of the study area covers 496.74 km². Its centroid lies at 0.717375°N and 37.568839°E. Kalama is established on the Gir Gir Group Ranch. Some parts of Kalama have soils with pH values unfavourable to plant growth (NRT, 2014). In comparison to the other two conservancies it has the most extensive *Acacia-Commiphora* woodlands. The conservancy is an important migratory route between the SNR, the West Gate conservancy and Northern Samburu, espeically for wildlife. It is the least remote of the three conservancies, as it borders with the town of Archer's Post and lies on the main road towards Maralal. The approximated 4000 inhabitants make a living of livestock keeping and through tourism activities. The conservancy has an income through fees charged for the use of the airstrip. This income is redistributed to the communities as bursaries given to students, through the benefits of a community vehicle and medical services. Various other projects, partly supported by non-governmental and other aid organisations include provision of infrastructure such as building

schools, boreholes and dams (NRT, 2014). Conservancy members are rarely given cash payments.

The West Gate conservancy (WGC) is 400.54 km² in size and lies on the Ngutuk-Ongiron group ranch but does not hold the title to the land (NRT, 2014). It is the most central of the three conservancies in the study area (centroid at around 0.754732°N and 37.351575°E) and has around 5000 inhabitants. There is some disagreement about land allocation on the Western border of Kalama and the Eastern border of the WGC resulting in an overlap of the areas. However for the purpose of this study it was irrelevant as Grevy's zebra hot spots were concentrated in the Eastern part of Kalama and the wet season hot spot in the West was therefore processed with the WGC data. The landscape in the WGC is dominated by Acacia woodlands, grass plains and rock outcrops. Organisation of community management and benefit distribution to members is similar to practises in Kalama.

The community conservancy in the Noth-West of the study area is the largest of the three conservancies with 1016.48 km²; Meibae consists of the group ranches Nkaroni, Sesia, Lpus and Ltirimin and its centroid lies at 0.913502°N and 37.141192°E. It also includes community land around Resim. Land ownership of the community conservancy is not formalised. Of the three conservancies it faces most political instability as initially not all inhabitants supported the establishment of a community conservancy. It is also the most remote area and therefore has almost no tourism endeavours and does not have a lodge. The

population is estimated at 12 500 inhabitants (NRT, 2014). Variable vegetation communities are found across Meibae but it is most distinguished from the other two conservancies by large patches of *Sansevieria* succulents. Like the WGC, Meibae, too, has many rock outcrops. The NRT and other organisations also implement projects such as grazing management, livelihood diversification and infrastructure establishment in Meibae.

In all three conservancies, members are stipulated to comply with grazing regulations and neither encroach on core conservation areas nor on grazing areas set aside for later use. Financial fines are imposed on offenders, such as one goat for first time offenders encroaching on restricted zones. The conservancies can also dictate settlement schemes.

3.2 Grevy's Zebra Hot Spot Identification with GPS-GSM Wildlife Collars

All zebra tracking data was kindly provided by the Grevy's Zebra Trust, all other data was collected by the researcher. Using GPS-GSM Wildlife collars (Savannah Tracking$^®$) 21 *E. grevyi* were monitored between 2006 and 2007 and from 2010 to 2014. The total number of locations collected in the three conservancies resulted in 108 308 data points over a total period of 301 months (excluding 2014 data which was only relevant for the Naibelibeli zone). In Kalama, the locations for 17 different animals in all six years could be recorded. Data for 14 animals were recorded in Meibae, excluding any points in 2010 and 2013. In West Gate, data were recorded between 2006 and 2007 and between 2010 and 2012 for 13

animals in total. A table depicting the number of locations recorded per animal in each conservancy can be found in Annex 1. Annex 1 does not include the 2014 records as these were used for a different part of the research (see 3.3).

Females were chosen for collaring because their paths more closely track the distribution of resources in the landscapes, compared to males which are typically territorial (Rubenstein, 1986; Sundaresan *et al.*, 2007). Only one male was collared in September 2006. The first generation of collars were dispatched by the Save The Elephants' Tracking Animals for Conservation project (STE, 2009). In 2010 animals were collared by the Grevy's Zebra Technical Committee (GZTC) including the Grevy's Zebra Trust (GZT) and the KWS. The choice of which *E. grevyi*s to sample was made by members of the GZTC in the field, based on which animals could be located during collaring exercises, their gender, physical conditions and the age of a foal if the female had one.

The collars obtained GPS fixes at hourly intervals. These were sent to a server through the cellular network for mobile phones. If the zebras were outside areas with network coverage, the location data would be stored and sent once the network was re-entered (Savannah Tracking, 2013). For this study the information was downloaded from the server using Savannah Data Manager (www.savannahtracking.co.ke) software.

All spatial analysis was performed using ArcMap 10.2.2 (ESRI, 1994-2014). The locations were separated into seasonal categories of dry and wet month in each year. The months were classified according to the Koeppen climate classification, for tropical climates. Months with an average precipitation of 60 millimetres or more are classified as wet, as well as months with 50 millimetres bracketed by two months with 60 millimetres or above. The rainfall data were acquired through the Global Livestock Early Warning System for the years 2006, 2007 and 2012-2013. Averages of six weather stations in Southern Samburu and Northern Laikipia were calculated to determine monthly precipitation. For the years 2010 and 2011 rainfall data were taken from the District Agriculture/ALRMP II weather station – Samburu. According to NRT (2014) the region experienced especially dry periods in 2008, 2009 and 2011. This was not reflected by the Koeppen classification, according to which all years apart from 2009 had either above or average rainfall.

Kernel Densities (KDs) were computed for each season and location specific data set, using an output grid of 1.6 and a search radius of 13.3 km according to Tupper (2011). The KDs were classified into areas of 11-50% and 51-100% use intensity, referring to the density of points recorded in close proximity to each

Figure 2: A= core area, covering 51-100% of points; B= home range; covering 11-50% of points; C= outliers; covering 1-10% of points.

other. According to literature on KD the common thresholds chosen are usually 50% as the core area with a likely hood of detecting the animals here half of the time and a 95% or 99% threshold which is considered as the total home range (e.g. Kenward, 2001). For processing the KD rasters were first transformed into floating points. These rasters were then converted into simplified polygons. This process reversed the classifications, which even though seemingly confusing at first, makes no difference for the outcomes. Therefore the 51-100% use intensity zone in this study represent the core area, which are the top 50% of the KD and known as the core area. And the 11-50% represent the home range, which are 40% of the KD. The polygons had to be created separate, but evidently the core area always lies in the centres of home ranges, which thus in total covers 90% of all space used by the tracked zebras in terms of likelihood of occurrence or time spent there (for clarification see figure 2). The 11% threshold was chosen in order to eliminate far outlying points. The 100% instead of 95% or 99% had to be included to avoid the polygons having a hole in their very centre.

Different KDs were computed with the data sets. In the first version all data points were merged for animals and years according to dry and wet seasons. The KDs for the three conservancies (Kalama, Meibae and West Gate) were then computed as specified above, thus creating overall density distribution maps for the three study areas.

In the second version KDs were computed on the most detailed level possible for the Meibae conservancy. Each animal was separated by wet or dry season of each

year. All animals within the same season and year were overlaid. The resulting KD hot spot areas in Meibae for 51-100% use intensity in the wet and dry seasons were compared to the over-all merged KDs, to determine whether the merged KDs are representative of individual animals and years.

In addition one density was created for the Naibelibeli zone in the WGC by merging four animals which were tracked for a total of 41 days from late March to May 2014. For these animals 605 data points were collected. This KD was compared to the livestock tracking data from Naibelibeli.

The hot spots identified for the three conservancies through KD analysis were overlain with further available features. Settlement and water point features were taken from Wheeler (2013). She identified active semi-permanent settlements from Google Earth maps and mapped permanent water points on the ground. The hot spots were also put in relation to vegetation classification maps from Hostens (2009), created from a reclassified Africover map and MODIS satellite images, as well as an overall Grevy's zebra habitat suitability map from her Master's thesis.

3.3 Livestock Tracking in the Naibelibeli Area of the West Gate Conservancy

GPS Tracksticks (Telespial Systems Inc., 2009) were used to monitor livestock movement in Naibelibeli grazing zone in the North West of the WGC (figure 3). The Naibelibeli grazing block expands over an area of nearly 29 km². Four camel herds and nine small stock herds were monitored, producing 7649 data points between 19th of March and 21st of May, 2014. A Trackstick powered by two AAA

batteries was attached onto the bell collar of one animal in each herd. The small stock herd sizes varied between 22 and 450 heads of goats and sheep. The camel herds did not exceed 20 animals and in one case an individual lactating female was tracked. The Tracksticks recorded the animals' location every 15 seconds and powered-off if the animal was not moving for a prolonged period of time to save battery. The data could be downloaded from the tracking devices to the computer using the Trackstick Manager Software (Version 3.1.1, Telespial Systems, 2005-2011).

Again using ArcMap 10.2.2 for desktop version (ESRI, 1994-2014), all livestock points were merged and a KD for area use intensity (number of recorded points per location) was computed with a 1.6 cell size output grid and a 13.3 km search radius. The polygons for the areas incorporating 11-50% and 51-100% of all points were computed as described above for the zebras.

Figure 3: Naibelibeli study area. Source: NRT; Cartography: Author.
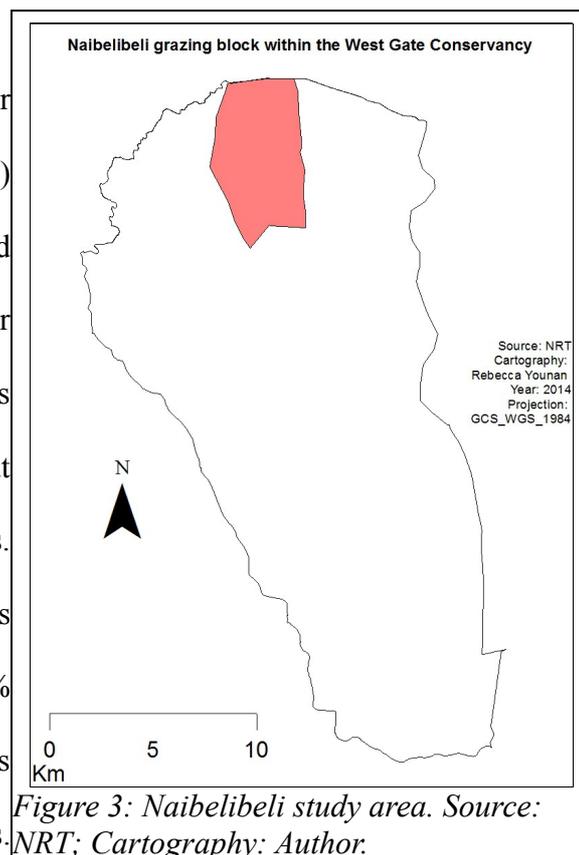
These polygons were overlaid with the merged data set for zebras in the Naibelibeli area. Percentage of spatial overlap of the polygons was calculated (according to Raizman, 2013).

However, due to a drought in the study area the vast majority of livestock owners migrated away with their animals in April and May 2014. They relocated to areas inaccessible by car and thus rendered the continuation of livestock tracking impossible. The necessity of changing the tracking devices' batteries and downloading the data manually on a regular basis proved to be an obstacle that could not be overcome. Access to remote dry season grazing zones was only possible by walking on foot for several days. The herds were also constantly on the move. Continuous tracking would have required more sophisticated technology, as well as an expansion of the study area. Due to the relatively small amount of tracking data collected at the time at which livestock started migrating, an alternative method had to be applied to acquire more spatial information concerning livestock movement within the area. Therefore, participatory mappings with community members from Kalama, Meibae and the WGC were undertaken.

3.4 Group Discussions and Participatory Mappings

Interviews with individual community members were held between February and April 2014; this included women, elders, youth and children of eight years and above. The experience gathered was later applied to design the group discussion. This included valuable lessons such as asking for a relative rather than total number of livestock owned and achieving better answers when making it clear in the introduction that the interviewer had no donor money to spend. Some

questions were reformulated after initial testing and others omitted.

Figure 4: Meeting points for group discussions and participatory mappings. Source: NRT; Cartography: Author.
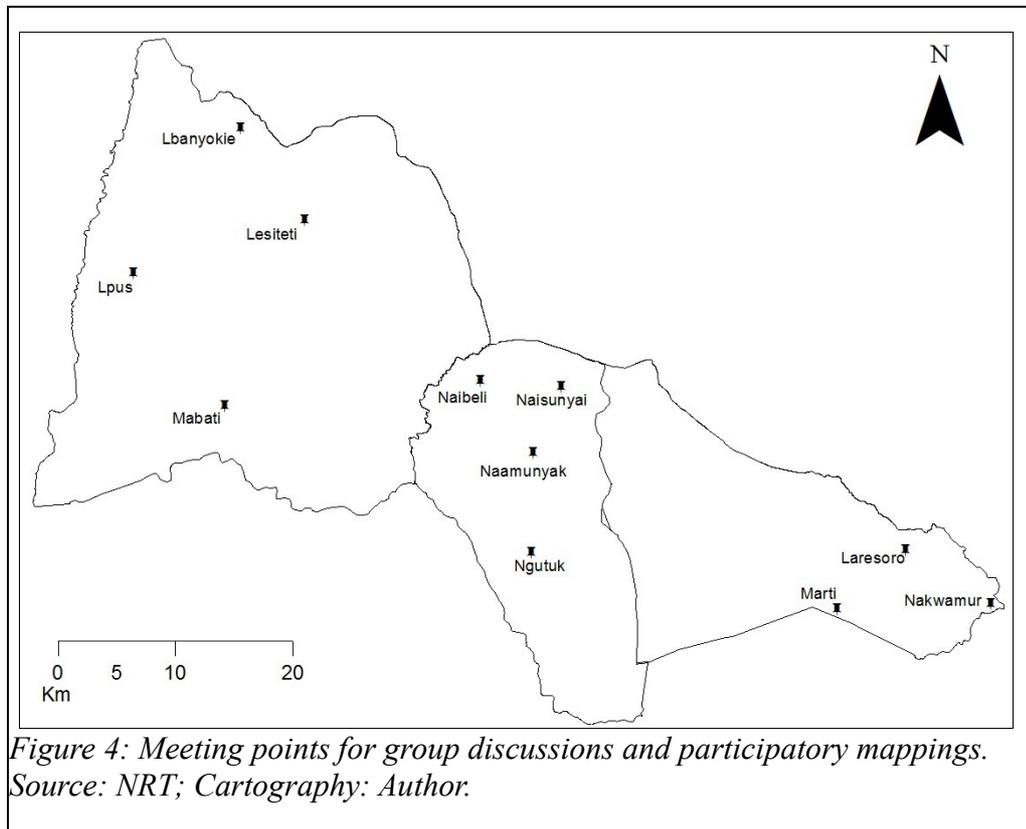
Twenty-three group discussions were conducted between July and August 2014. One to three discussions were held per day in settlements or at convenient meeting points in close proximity to Grevy's zebras' hot spots (settlements shown in figure 4).

Focusing on hot spots allowed for insights into key resource availabilities as recommended by Butt and Turner (2012). Participants were chosen by conservancy staff members according to their settlements and willingness to participate. Usually one person was chosen and informed to find additional

participants. Groups consisted of three to six participants of either women, warriors (young men) or elders (men). Each group session was preceded by a short explanation of the purpose of the research and an introduction of the interviewers. The discussions usually lasted one hour. The questions were posed in English and translated into Samburu. The answers were then translated back into English. Topics concerned the interviewees' personal data such as age, level of education and source of livelihood as well as questions concerning livestock ownership, dry and wet season grazing areas, features of different pasture and knowledge about Grevy's zebras and their conservation. For guideline questions for the group discussions see Annex 2.

Figure 5: Participatory mapping with women from Laresoro, Kalama (August, 2014).
Source: Author's collection.

Subsequent to the group discussion participatory mappings were undertaken, following the tips and guidelines by IFAD (2009 & 2010), Forrester and Cinderby (2014) and others. Outline maps of the conservancies were provided. The participants then marked out restricted zones, areas of livestock species specific grazing, as well as important land marks and other features (according to Letoiye, 2014). One map for each wet and dry seasons was created.

3.4.1 Group Discussion Analysis

Answers were grouped and cross-validated by triangulation. The group discussion members' descriptions of good pasture were compared to literature on preferred *E. grevyi* habitat (Sundaresan *et al.*, 2007). Verbal description of seasonal grazing movement was compared to what the groups had mapped. Differences within the areas and conservancies amongst the different groups were sought out. Discussion topics relevant to *E. grevyi* conservation were grouped into conservation activities, problems the species faces and reasons for side-by-side grazing with livestock. Overall discussions, between six and twelve sub-items were identified for each topic. How many of these items were mentioned by men, women and warriors was counted and compared with a Chi-square test for goodness of fit. The normalised means were used as the expected values. To determine differences in perceptions the frequencies with which fifteen benefits were mentioned either by men or women were counted. Warriors were left out in this analysis because of their small sample size. A non-parametric Man Whitney U test was performed for this data set to detect gender differences.

3.4.2 Participatory Mapping Analysis

The participatory maps were digitised using ArcMap 10.2.2. Photographs of the maps were projected and geo-referenced according to conservancy outlines. Restricted areas were transformed into polygons, as were zones of high zebra

occurrence. Other zebra hot spots were marked as points and important livestock boundaries were digitized as lines. Maps of the different groups were analysed separately to detect gender specific variation. This was done because Letoiye (2014) found evident differences in women's and men's knowledge of grazing areas.

Accuracy was validated by overlaying the meeting points marked on the map with the actual GPS coordinate of each point. Zones restricted to livestock grazing were overlaid with the seasonal Grevy's zebras' hot spots to assess their degree of overlap. Areas marked as Grevy's zebra hot spots by participants were overlaid with hot spots determined by collar data. The degree of similarity between participants' and collar hot spots were ranked as perfect, very good, good and off (3, 2, 1 and 0 points accordingly). The resulting scores for men and women were compared using a Man Whitney U test; again the warriors were omitted from this analysis due to the small sample size.

4. Results of GPS Tracking and Participatory Community Data

4.1 Grevy's Zebra Hot Spots

Of all data points used to compute the Kernel Density hot spots (excluding the 2014 Naibelibeli records), 59.5% fell into the dry season. In the six years in which Grevy's zebras were tracked in the study area, 75% of the months were dry season months. Therefore, Grevy's zebra spend relatively more time in Kalama, Meibae and the WGC during the wet than during the dry season.
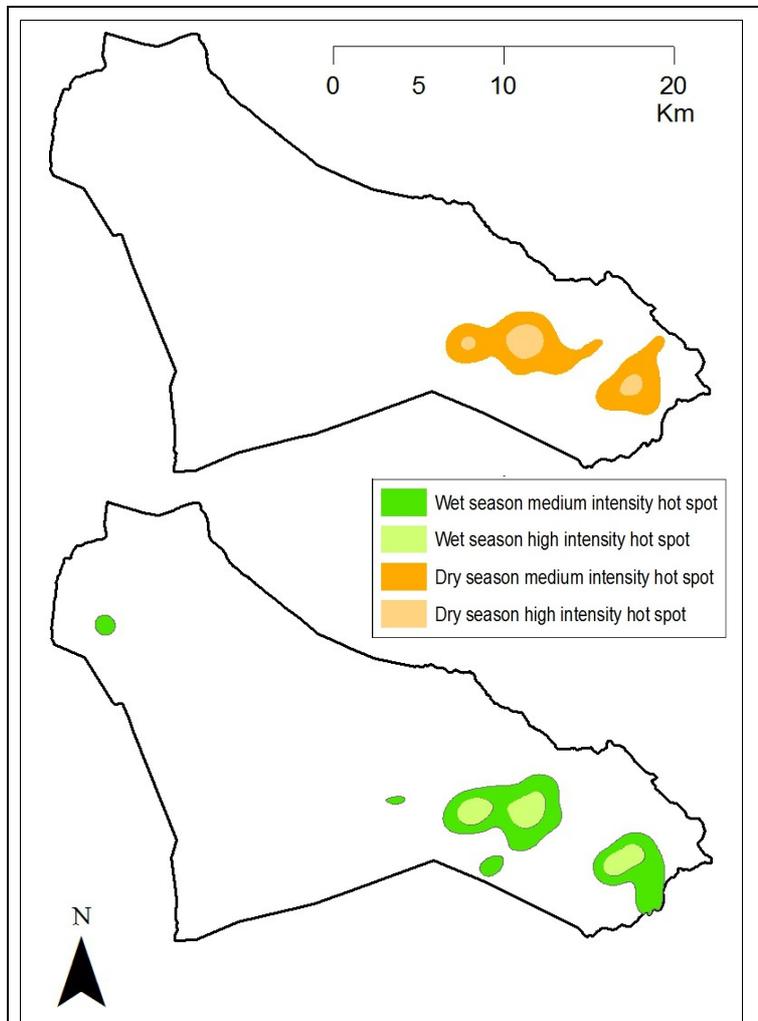
Figure 6: Kalama Grevy's zebra hot spots in the dry season (above) and the wet season (below); with medium intensity polygons representing 11-50 and high intensity polygons 51-100% occurence.

Figure 7: West Gate Grevy's zebra hot spots in the dry season (left) and the wet season (right).
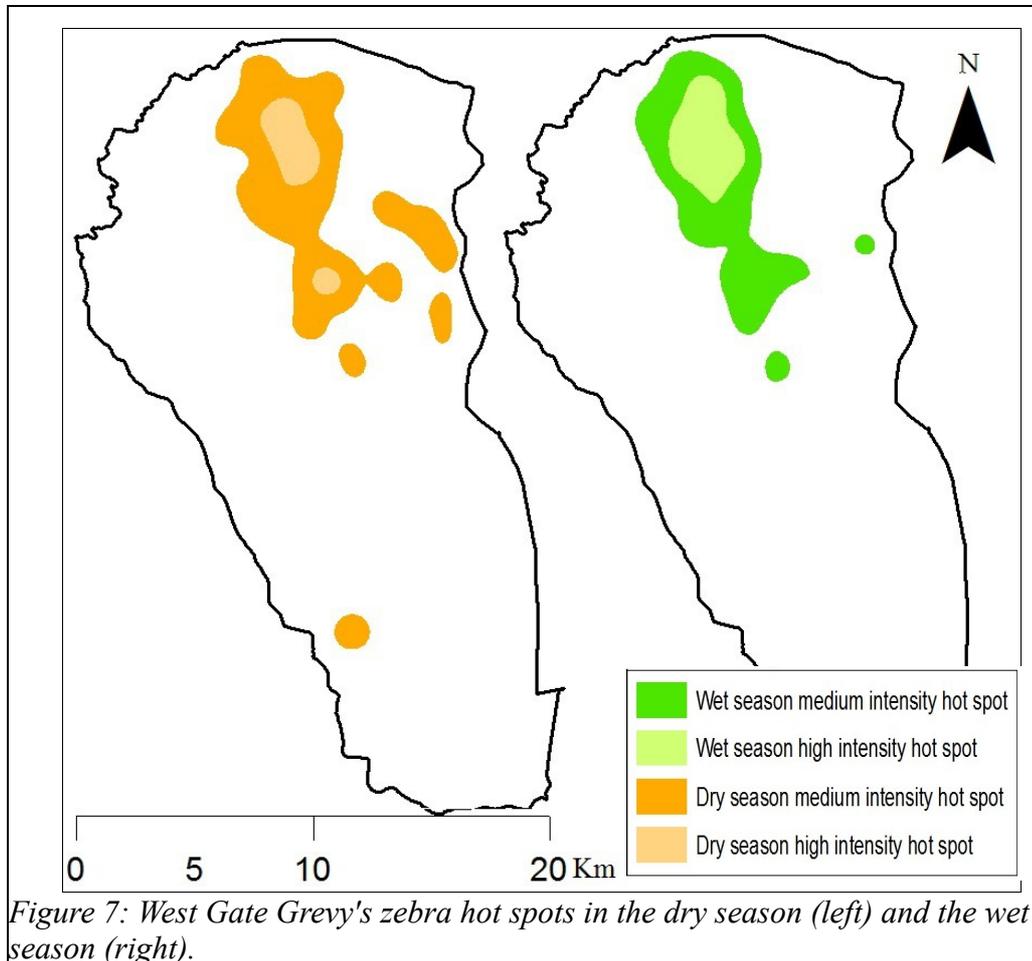
According to the parameters set for computing the Kernel Density hot spots (13.3 km search radius), the areas used by the Grevy's zebras less than 11% of the time, covered almost the entire study area. Therefore, in figures 6, 7 and 8 white zones also represented areas traversed by *E. grevyi* but are disregarded as this study focused on areas of high intensity use.

The hot spots in all three conservancies did not differ greatly in size between seasons. Neither were all hot spots larger nor smaller in size across conservancies in the dry or wet season. In Kalama (figure 6) the total area as well as the zones

of different use intensity (10-50% and 51-100% intensity) were smaller in the dry than in the wet seasons. As seen in figure 8, in Meibae the opposite held true. In Kalama the size difference

accounted for below 6% and in Meibae for below 3% of the total hot spot sizes. In the WGC (figure 7) the total hot spot area was 11.2% bigger in the wet than in the dry season but the area of high intensity use was 23% larger in the dry season.

The hot spots were more scattered and jagged in shape in the dry season in WGC and Meibae, making them more irregular in appearance. The high intensity zones were also more compacted into fewer single areas in the wet than in the dry seasons. These tendencies did not apply for Kalama.

There was extensive overlap between the wet and dry season hot spots in all three conservancies. The average degree of overlap between seasons differed from almost 32% to almost 50% in the three studied conservancies. The areas of 51-100% use intensity in the wet and dry seasons overlapped in Kalama by 54.8% in Meibae by 20.2% and in the WGC by 40.5%. The 4.99 km² overlap of the high intensely used area in Kalama accounted for 57% of the wet and 93.4% of the dry season core area. In Meibae the overlap of core areas covered 4.87 km²; 40.1% of the wet and 29% of the dry seasons' central zones of utilisation. In the WGC these areas overlapped by 5.41 km²; 46.8% of the wet and 74.8% of the dry season core zones respectively (all values listed in table 1). The size of overlap for the areas of 11-50% use intensity between seasons varied between 50% and 75% overlap degrees for the three conservancies in the different seasons, all values are listed in

table 2. Considering the high degree of overlap between seasons in all three conservancies which pointed to close spatial proximity between seasonal hot spots, hypothesis 1.1 (significant spatial differences between seasons) was rejected.

Figure 8: Meibae Grevy's zebra hot spots in the dry season (left) and the wet season (right) with the darker polygons representing 11-50 and lighter polygons 51-100% use intensity.
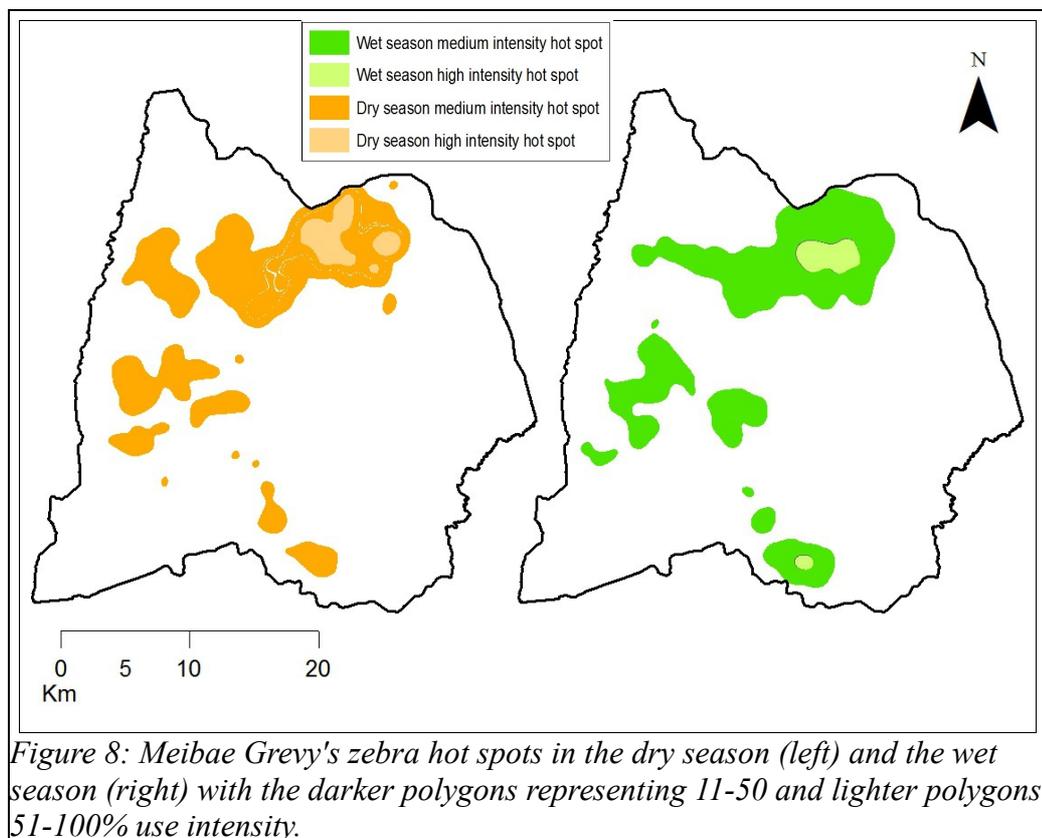
Table 1: Area and overlap size of 51-100% use intensity zones in the three conservancies (2006-2013).

Conservancy	Season	Size of seasonal core area [km²]	Area size of wet and dry season overlap [km²]	Percentage of overlap for seasonal core area [%]
Kalama	wet	8.76	4.99	57
	dry	5.34		93.4
Meibae	wet	12.14	4.87	40.1
	dry	16.81		29
West Gate	wet	11.55	5.41	46.8
	dry	7.23		74.8

Table 2: Area and overlap size of 11-50% use intensity zones in the three conservancies (2006-2013).

Conservancy	Season	Size of seasonal core areas [km²]	Area size of wet and dry season overlap [km²]	Percentage of overlap for seasonal core area [%]
Kalama	wet	27	16.6	61.5
	dry	26.38		62.9
Meibae	wet	152.55	93.97	61.6
	dry	157.53		59.7
West Gate	wet	29.99	22.61	75.4
	dry	44.82		50.4

Records from seven dry and seven wet seasons in the years studied in the Meibae conservancy were taken to estimate appropriateness of data merging. Meibae was chosen out of the three areas because it is the largest of the three conservancies. Out of the 14 seasonal 51-100% use intensity KDs, nine seasons (four dry, five wet seasons) did not completely overlap with the merged over all seasonal 11-100% KDs. However these areas not overlapping with the merged KDs only accounted for 4.2% in size of all the 51-100% hot spot areas. The second dry season of 2007 had the greatest discrepancy with 3.48 km² out of 37.09 km² not overlapping with the merged KD, as can be seen on the map on the left in figure 9 in the South Eastern side of Meibae.

Figure 9: Overlap of individual seasonal KDs (seven wet and seven dry seasons) with merged KD (all wet and all dry seasons) in Meibae conservancy; left: dry season; right: wet season from all zebras tracked.
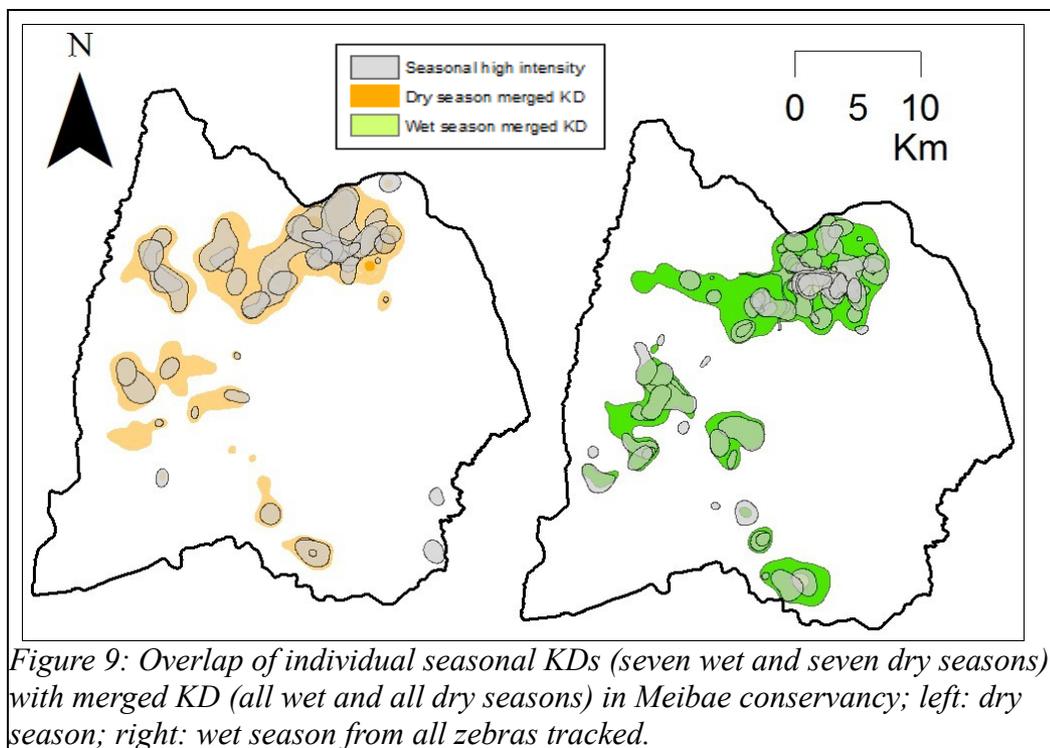
This season had very few data points and high spatial discrepancy to the other zones. A higher degree of coverage can be seen for the wet season on the right in figure 9. Only the areas of highest use intensity for the separate seasons were overlaid with the 11-100% utilisation of the merged data sets for Meibae. Nevertheless, hypothesis 1.2 (inter-annual overlap of hot spots) was accepted on the basis of the very low spatial extent of non-overlap. The relationship of non-overlapping seasons and the thereby affected percentage of area is also shown in figure 11.
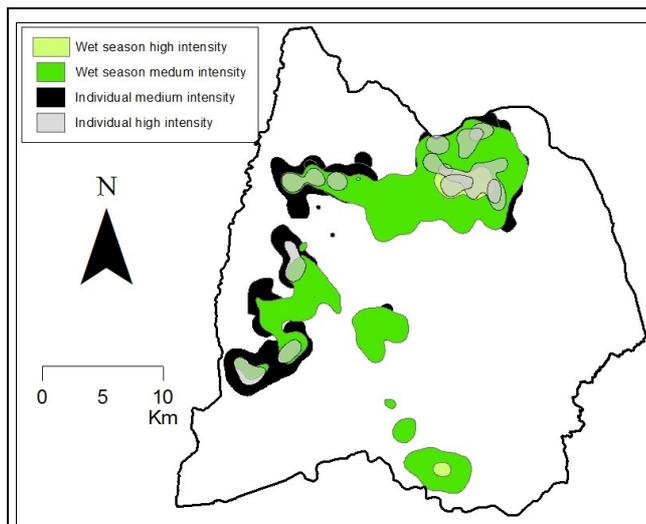
Figure 10: Meibae, four wet seasons for animal 1059 overlapping with KD for merged data of seven wet seasons and 13 animals (merged KD in shades of green; animal 1059 area of 11-50% use intensity in black and 51-100% use intensity in grey).

Individual KDs, computed from records of 15 individual animals tracked in 27 seasons between 2006 and 2012 were compared to the merged KDs in the Meibae conservancy. Out of the 27 KDs 13 high intensity zones (51-100% use) were not entirely covered by the merged seasonal KD (11-100% use). For example, as can be seen in figure 10 for the zebra with the tracking number 1059, areas of medium use intensity (11-50%, shown in black) were not entirely covered by the merged KD. However the zones with high use intensity (51-100% shown in grey)

overlapped with the merged KD to a very high degree. In total out of the more than 388 km² that all individual hot spots added up to, the non-overlap only affected 16.1 km² (4.2%). The animal with the tracking number 1059 had a non-overlap area size discrepancy of almost 7% due to few points being in a very remote area in comparison with the vast majority of this animal's records. In one dry season animal 125 had a main utilisation zone of 3.48 km² which did not overlap with the merged KD at all. These were the same data points which also caused the largest spatial discrepancy in the seasonal comparisons mentioned in the paragraph above. These particular data points were very few in number in comparison to all other individuals tracked. The relationship of number of KDs by individual zebras not overlapping with the merged data set is represented in figure 11. However, as the percentage of area affected by this was negligible (figure 11, bottom chart) hypothesis 1.3 (individuals being represented by merged areas) was nevertheless accepted. It seemed appropriate because the merged KDs represented all other individuals well.

Number of seasonal records not-/overlapping with merged data

5

9

- Number of seasonal records not overlapping
- Number of seasonal records overlapping

Number of individual records not-/overlapping with merged data

13

14

- Number of individual records not overlapping
- Number of individual records overlapping

Size of areas not overlapping with merged data

4%

96%

- Total area size of all records [km]
- Total area size of non-overlapping records [km]

Figure 11: Pie charts depicting how many KDs of seasons and individual zebra records did not overlap with the merged KD (top and centre); bottom chart depicting what percentage of area did not overlap (same for both seasons and individual zebras).

4.2 Additional Landscape Features

The Grevy's zebra hot spots were put into context with the surrounding environment by overlaying them with available maps from past research in the area. Wheeler (2013) identified 723 settlements in the study area (figure 12), of which most lay within Meibae due to its sheer size. Very few settlements are found in Kalama and they mostly lie in the South-East of the conservancy, in the same area as the Grevy's zebra hot spots. No settlements lay within the 51-100% core areas but nine were found in the 11-50% home range in the wet and six in the dry season.

In Meibae 54 and 62 settlements lay within the wet and dry season hot spots respectively. Three settlements lay within the 51-100% core area in the wet but none in the dry season. In the WGC the hot spots bordered with the area of highest settlements density to the North. Eighteen settlements were found in the 11-50% hot spot zone in the wet and 12 in the dry season. The core areas (51-100%) incorporated 2 settlements in the wet and 3 in the dry season.
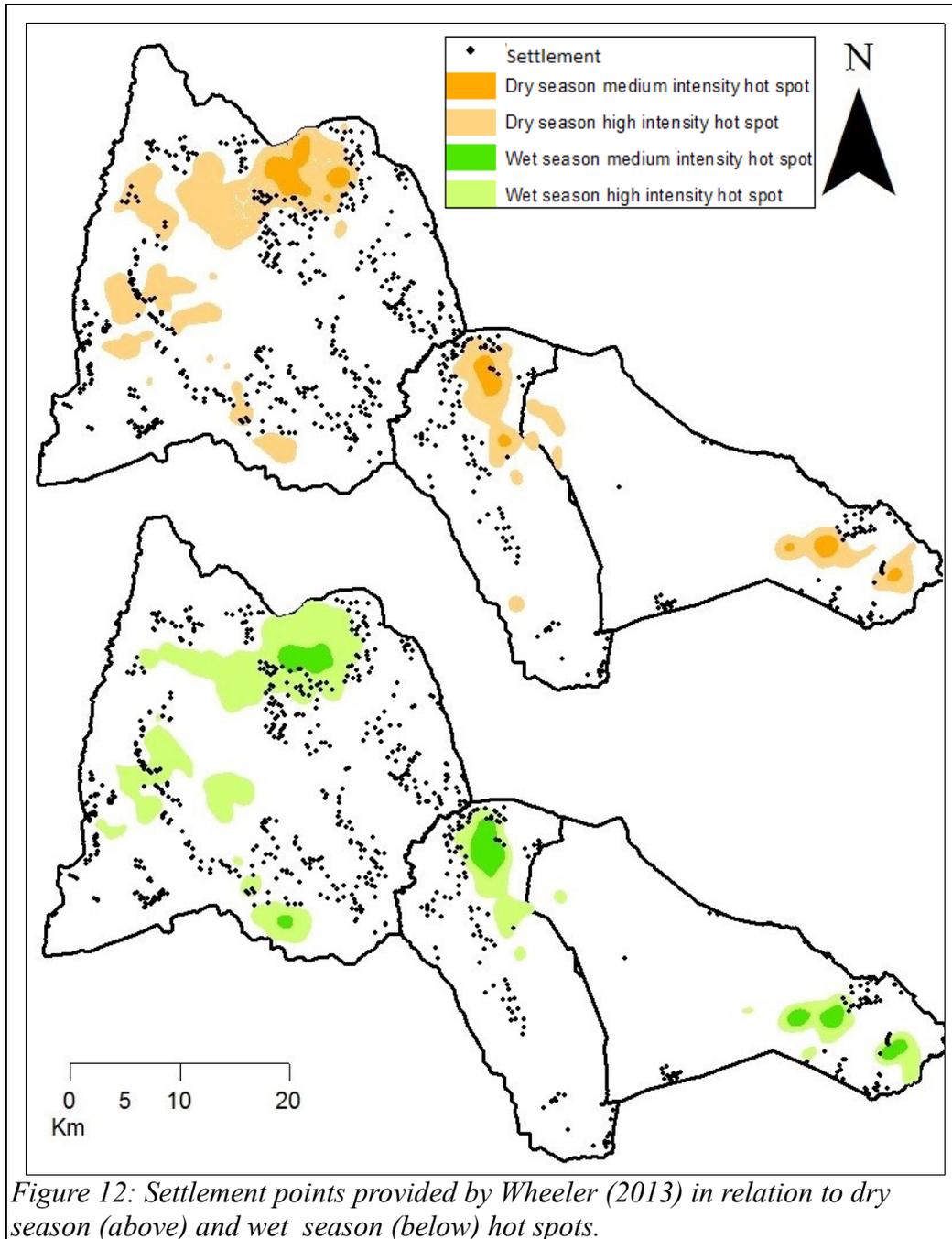
Figure 12: Settlement points provided by Wheeler (2013) in relation to dry season (above) and wet season (below) hot spots.

Figure 13: Permanent water points provided by Wheeler (2013) in relation to dry season (above) and wet season (below) hot spots.
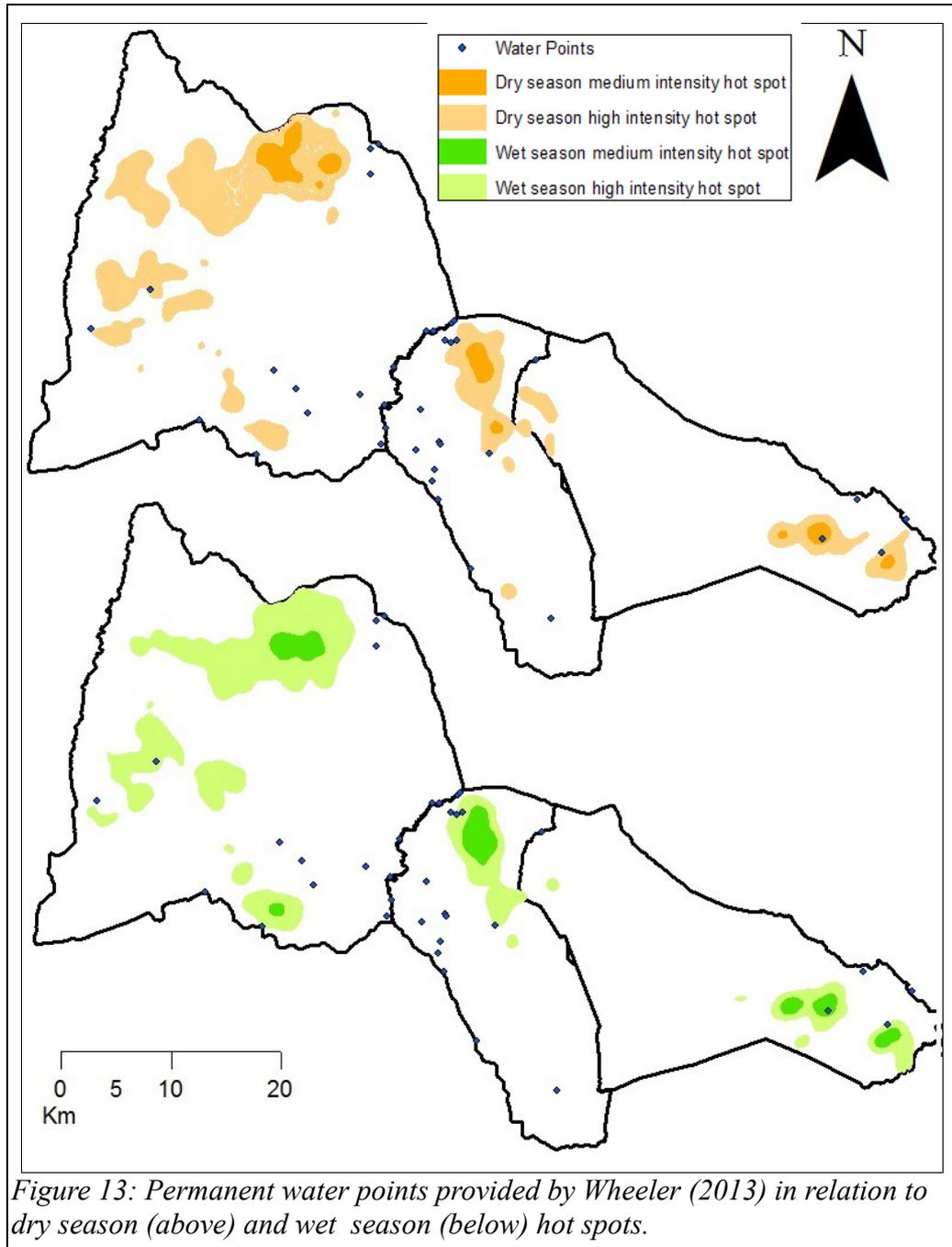
Of the 45 permanent water points identified by Wheeler (2013) in the study area

(figure 13), only four were found within the wider 11-50% *E. grevyi* areas and

two in the 51-100% core zones, these were within the Kalama hot spots. The

water points within hot spots were the same in both seasons apart from one in the

WGC, where a water point on the Southern end of the hot spots was utilised more

in the dry season than one in the North-West.
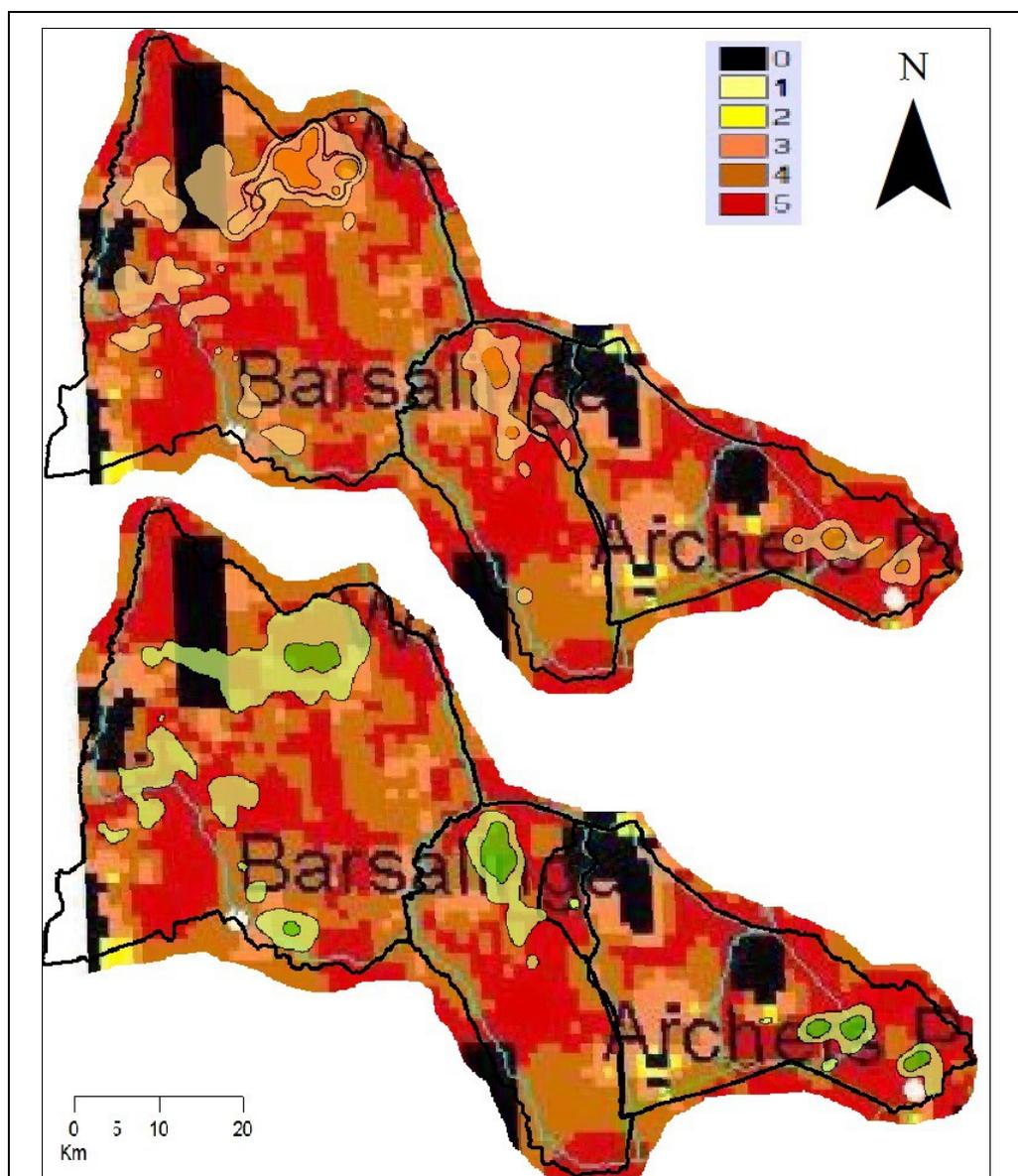
Figure 14: E. grevyi habitat suitability map according to Hostens (2009); 0 representing unsuitable and 5 most suitable habitat. With dry season hot spots above and wet season hot spots below.

Hostens (2009) vegetation classification according to an Africover map placed most of the study area within the two categories of sparse-open shrub land and within shrub and herbaceous cover. Of these two, most hot spots fell into the shrub and herbaceous class in all three conservancies and seasons. Hot spots had a slightly higher percentage area in the sparse-open shrub class in the dry than in the wet season. Only in Kalama did the 51-100% core areas cover a more considerable amount of sparse-open shrub land. Hostens (2009) also made a vegetation classification using MODIS satellite images, both maps can be found in Annex 3. According to the MODIS classification, the hot spots lay within the zones herbaceous, low and woodland (below 70% tree cover) vegetation. The hot spots mostly fell into a combination of these classes in both seasons with the 51-100% core areas mostly covering herbaceous sections.

Hostens' suitability map (2009) for Grevy's zebra habitat (figure 14) included the aspects *E. grevyi* occurrence, settlements, water, vegetation and livestock density. She determined areas from 0 (unsuitable) to 5 (very suitable). In the study area all 51-100% core zones fell mostly within areas identified as very suitable by Hostens. In Meibae and the WGC the core areas also covered pixels of lesser suitability (3 and 4). Only a Western part of the 11-50% hot spot in Meibae lay within an area deemed unsuitable according to Hostens.

4.3 Overlap of Tracked Livestock and Grevy's Zebras
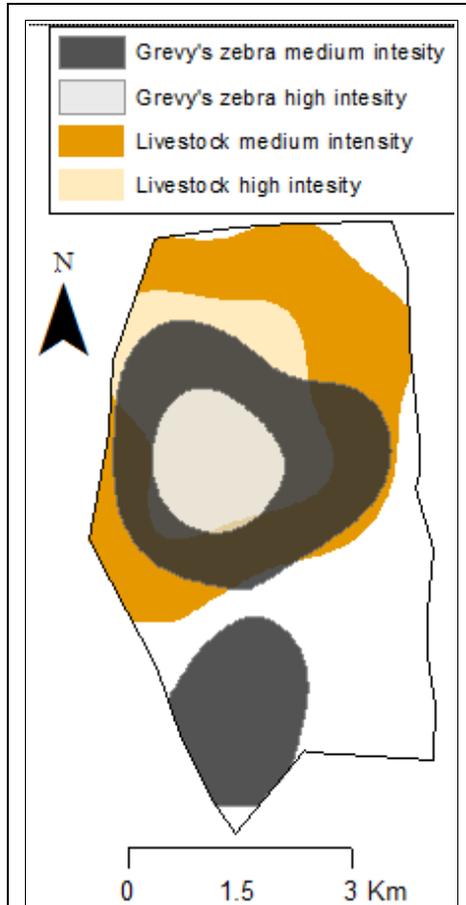
Figure 15: Overlap of Grevy's zebra and livestock grazing zones in Naibelibeli, (medium 11-50 and high 51-100% use intensity).

The dry season tracking of livestock and five recently collared Grevy's zebras in Northern parts of the WGC, made extensive overlap of grazing zones evident (figure 15). The livestock covered an area exceeding 17 km² whilst the zebra roamed over an area of 13 km² in the Naibelibeli grazing block. The zone of highest utilisation intensity for livestock (51-100%) was 7.29 km² in size and the one for *E. grevyi* covered 2.61 km². These two zone of very intense use overlapped by 34.9% covering almost all of the Grevy's zebras' grazing zone. The entire zebras' area of highest utilisation and 7.04 km² of less intensely used zones lay within livestock grazing areas. The remaining 3.53 km² of 11-50% use intensity outside livestock grazing areas accounted for 26.8% of the zebras' zone of use and lies in the far South-Western side of Naibelibeli.

4.4 Group Discussions

Participating group members revealed high agreement about topics discussed. Details would vary but in general opposing answers in response to the same question were seldom given by the different groups. Some important topics were only mentioned rarely such as encroachment into restricted areas and parks and night-time drinking by Grevy's zebra, as well as Grevy's spending nights close to people's homesteads. Answers that were discussed more extensively were grouped for analysis purposes into the topics of the following paragraphs. Most groups were able to answer all the questions. In general far-reaching knowledge on livestock as well as Grevy's zebras was found. Therefore hypothesis 3.1 (awareness within the communities of topics discussed in the following) was accepted.

In all but one discussion (women from Lbanyokie, Meibae) participants stated that livestock and *E. grevyi* graze side by side. The group of women said: "They [the Grevy's zebra,] are close together with the livestock but do not graze together". Women and warriors from Laresoro in Kalama were of the opinion that the zebras graze with the livestock only when the herder is not within close proximity. Additionally, women from Lesiteti in Meibae mentioned that the presence of dogs deters the Grevy's zebras. Many participants stated that side by side grazing occurs more often in the wet than in the dry season. Even though four groups explicitly stated that Grevy's zebras and livestock feed in the same way and have the same resource requirements, competition was not mentioned at

all. The usual answer was that nothing happens when Grevy's zebras and livestock graze side by side. Rarely were any negative interactions mentioned (see 4.4.3 Perceptions) but in eleven discussions the Grevy's zebra was described as being "friendly", "social with" and "used to" livestock. Nine groups mentioned similar attributes in relation to Grevy's zebra and humans. It was also described as "not harmful" in general several times. The participants mentioned that some community members used to chase Grevy's zebras when they were young but that this kind of behaviour has stopped. Participants often said that nowadays children are told not to disturb the zebras.

4.4.1 Threats

The most commonly mentioned threat to Grevy's zebra was diseases (named 17 times in 23 discussions). A second threat the pastoralist were very aware of was starvation due to lack of pasture. The third and fourth most commonly named threats to Grevy's zebra were either lack of access or distance to water.

4.4.2 Conservation

Many group discussion members thought that they did not know anything about Grevy's zebra conservation but were then able to name examples if asked differently. Not disturbing or interfering with *E. grevyi* was perceived as the most important conservation activity or at least it was the aspect most people were

aware of. Apart from the warriors in the WGC, men, women and warriors from all other conservancies mentioned the scout programmes and their contribution to Grevy's zebra conservation. Some more aspects often mentioned included vaccination campaigns, education and the sharing of conservation knowledge and Grevy's zebras' security from predation, which they receive through being in close proximity to either livestock, humans or both. This aspect was mentioned in eight discussions.

4.4.3 Perceptions

The general attitude towards Grevy's zebra conservation was positive throughout the different groups and conservancies. In 22 of the 23 discussions the conservation of Grevy's zebras was seen as important, mostly for economical and sometimes for intrinsic reasons. Only women from Namunyak in Kalama did not answer this particular question, as they were unaware of Grevy's zebra conservation but even they described Grevy's zebras as a friendly and non-harmful species. Over-all answers given, the pastoralists named 14 different specific intangible and economic benefits they receive through Grevy's zebras and their conservation. In contrast to this only three negative aspects came up, which were the transmission of diseases between donkeys and zebras, occasional or accidental killings of livestock by *E. grevyi* and incidents of livestock, especially donkeys going feral and joining zebra herds. However, in respect to livestock killings by Grevy's zebra, these were mentioned by only three groups,

whereas larger livestock species killing smaller was mentioned eight times.

The benefits participants were most aware of, were the employment opportunities Grevy's zebra conservation had created in their areas. The same was true for bursaries distributed to pupils through the GZT and conservancy management. And the attraction of tourism and visitors through Grevy's zebras. This was closely followed by the common statement of the plain fact that the species is friendly and non-harmful to them or their property. Intangible benefits were expressed by statements such as: "Grevy's zebra conservation is important because they belong to us. We like them because they are mostly found here and nowhere else which is a reason to conserve them" (Women from Lbanyokie, Meibae). Women more often mentioned intrinsic benefits than men.

The non-parametric Man Whitney U test revealed no differences in frequencies with which benefits were mentioned by elders and women (U>23 with N=11; N=9).

4.4.4 Description of Grazing Areas

Many similarities became apparent in how participants described grazing areas for livestock and *E. grevyi*. Descriptions for livestock grazing areas were more elaborate and detailed than for Grevy's zebra. Often similar or same terms were used to express which features are sought out both by wildlife and livestock herders alike. Many groups differentiated between which grazing areas are preferred in the wet and which in the dry season, with some groups even stating

that opposite features were favoured between seasons. Groups differed in their description of whether Grevy's zebras climb the mountains or not. The most relevant features of grazing areas named for both livestock and *E. grevyi* were plains or open areas (mentioned 57% of the time for livestock and 65% for Grevy's) and proximity to water sources or the annual river (mentioned in 21 out of 23 group discussions for livestock and in 13 or 57% of the discussions for Grevy's). The third most important aspect for livestock were mountains, especially as a dry season retreat. For Grevy's zebra the use of bushy areas in the dry season and preferences for hills and plateaus in general were mentioned several times by different groups. The use of bushy areas in the dry and avoidance thereof in the wet season was also mentioned in relation to livestock herding.

4.4.5 Plants

Group discussions members named a total of thirty different plants, when they were asked about what perennial grasses are good for livestock and which plants in general are preferred by *E. grevyi*. However as the scientific and the Samburu plant classifications differ, some of the plants named are known as up to four different species according to Linne's nomenclature.

The two perennials named for livestock consumption most commonly (in 83% and 70% of discussion respectively) were "Lanana" and "Lkawa". "Lanana" is known to be *Brachiaria leersioides, Eragrostis superba, Cynodon dactylon* and *Cypholepis yemenica* (GZT, 2008; Herlocker, 1992). "Lkawa" can either be

Chrysopogon plumulosus or *Bothriochloa insculpta* (Herlocker, 1992).

The one plant named in every single discussion, with high importance for Grevy's was the forb *Indigofera spinosa* ("Lkitagesi" in Samburu). The second most commonly named important plant for *E. grevyi* was *Boscia coriacea* ("Serichoi", 30%), an evergreen shrub.

Only in 13% of the meetings were the same specific plants mentioned for both livestock and Grevy's zebra, however the importance of grass in general for *E. grevyi* was noted in 43% of all discussions.

4.5 Participatory Mappings
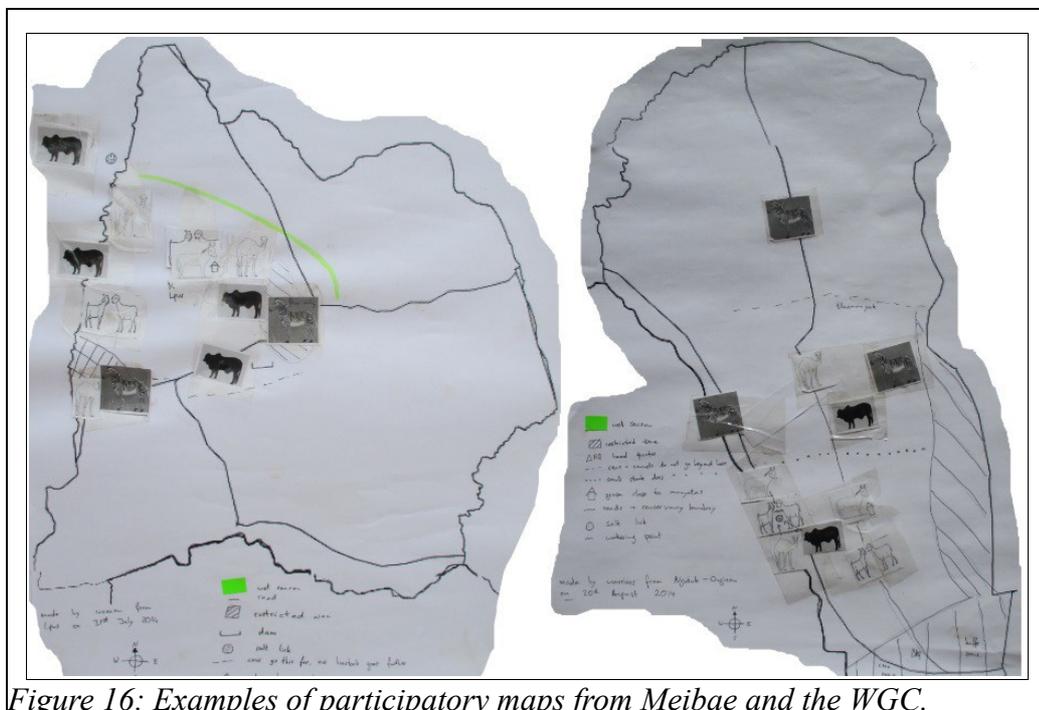
Figure 16: Examples of participatory maps from Meibae and the WGC.

From the 23 groups which were each asked to compile one wet and one dry season grazing map, 40 maps could be used for analysis. Four had to be disregarded due to a blunder in map orientation and two wet season maps could not be generated as the participants had migrated from a different area. The mappings had a high degree of spatial inaccuracy, even though conservancy staff members were present to help with orientation. In eight out of the 40 maps the marked meeting point was more than five kilometres off from its GPS fix. In five maps the point was accurate but the average inaccuracy for the meeting points lay at almost three kilometres. How inaccurate other mapped features were could not be established. Therefore livestock grazing orbits could not be directly overlapped with *E. grevyi* hot spots but the information was considered indicative rather than absolute (for examples of participatory maps see figures 15 and 16).
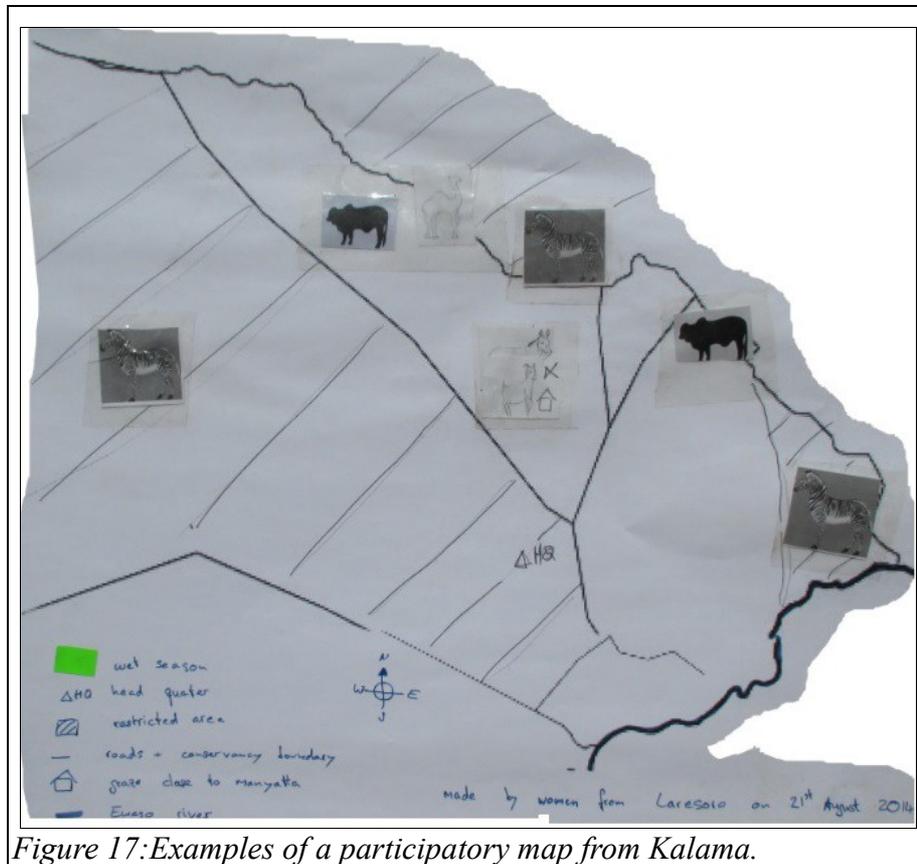
Figure 17:Examples of a participatory map from Kalama.

Only in four out of the 23 group meetings did answers concerning livestock movement given in the discussion differ from what was later marked on the participatory maps. Variation was found in orientations of where livestock moves. In one case (elders from Sukuroi in the WGC), the plains were mentioned as an important wet season grazing area but were then not indicated as such on the map. Five times the descriptions of where *E. grevyi* is found most and the marking of these areas on the maps showed high discrepancies. Several times claims were made that no Grevy's are found in the particular conservancies in the dry season, however, when asked to, participants did point out zebra specific zones on the dry season maps. Differences between maps made by elders, women

and warriors usually concerned placements and the size of restricted areas. However, there was no clear tendency of any one group towards restricting larger or smaller areas. Nevertheless, in general the maps validated and added on to information given in the discussions.

There was some disagreement over whether *E. grevyi* does or does not climb plateaus and mountains. In Lesiteti participants were of the opinion that this does not occur but it was indicated by several groups in two different areas of the WGC.

4.5.1 Livestock Grazing Zones

In the Lbanyokie area of Meibae and in Naisunyai and Sukuroi (West and East of the Naibelibeli dam) in the WGC, livestock grazing zones were larger in the wet than in the dry season. The opposite was true for Kalama's Laresoro area and Lpus in Meibae. The other areas did not show one such clear tendency but often a shift from grazing on one side of the conservancies in the wet to the other side in the dry season, associated with restrictions of areas in the wet for the dry season.

Most participants omitted cattle from the dry season maps as these migrate to "fora" (dry season grazing destinations) far away from the conservancies, usually leaving none or very few cows behind. When present, cattle and camels were often indicated as roaming the furthest distance from the homesteads in both seasons with donkeys and small stock staying closer by. Donkeys were often not given specific grazing zones as many communities do not herd them and they can

roam freely wherever they like.

Livestock grazing zones which overlapped with Grevy's zebra grazing zones, identified by the participants included Barsilinga, the Nkaroni plains (not for camels), the water point South of it and the plateaus West of Lesiteti (not for donkeys) in Meibae. Around Lpus, plateaus both in the West and East were identified as areas of overlap for camels, small stock, donkeys and Grevy's zebra in the dry season. According to the mappings all livestock and *E. grevyi* aggregated around two dams South of Lpus in the wet season. Other areas of overlap occurred South of Mabati in the wet season and around the head quarters in the dry season (excluding cattle).

In the WGC overlap zones mapped, were the Eastern plateaus in the wet season, the area around Naamunyak and the seasonal river towards Lengusaka in both seasons. Other areas strongly indicated as important to both livestock and Grevy's zebras were the Naibelibeli plains, especially in the wet season, the Naibelibeli dam and areas surrounding these two sites. (Figure 24 shows a map including all place names mentioned.)

4.5.2 Restricted Areas

On Kalama there was high agreement of restricted areas between groups. Clearly all groups knew that the wildlife conservancy area in the centre of the conservancy (on left side in both outlines in figure 18 as only half of Kalama is shown) was restricted to livestock in the wet as well as the dry season. In the

digitised map versions the areas did not overlap due to the spatial inaccuracy mentioned before. There was also slight disagreement in how far West of the road the restricted area began. Only one group of women from Laresoro restricted an area in the far East of the conservancy. Encroachment into these areas was mapped by groups from Laresoro. People from Marti mapped night time encroachment but described it as a rare event.

On Meibae (figure 19) there were no grazing restrictions in the dry season, apart from the area around the head quarters in the South, which was only mentioned by the elders from Mabati. There was high agreement over restrictions in the wet season especially concerning the Barsilinga area in the central Western part of the conservancy and around the plateaus further North. And similarly for the area surrounding the head quarters and the South-Western most part of the conservancy, as mentioned and indicated by the Mabati community in the Southern part of Meibae. However, where the locations of the restricted areas were placed on the maps varied tremendously, especially concerning Barsilinga which was marked as restricted in the wet season by all groups but one (women from Lesiteti) but with high spatial inconsistency.

In the WGC the general tendency over restrictions in both seasons matched across all nine groups on 18 maps. In the dry season only the Southern most part of the conservancy towards the SNR was indicated as restricted (figure 20). This area remained restricted in the wet season. Additionally, various parts along the Eastern most side were indicated as restricted depending on where the

communities were from. Different communities restricted different parts around their home areas. In Ngutuk-Ongiron it occurred that the women did not indicate restricted areas as extensively as elders and warriors but they also did not place any livestock in these particular areas. The highest agreement for communities of the Northern parts was over restriction of the plains in the wet season. Only in Sukuroi was the restricted side of the plains indicated by women reversed to the side indicated by men and groups from other areas. Encroachment into restricted zones was reported by community members in Ngutuk-Ongrion.

All restricted areas were overlaid with each other by season to determine the maximum and minimum extent of agreement by participants over where they are. The minimum extent thus indicated the highest level of agreement among groups. This was done in order to compensate for the spatial inaccuracy. Keeping this in mind, these restricted zones are indicative of areas in which Grevy's zebras would aggregate to avoid livestock.
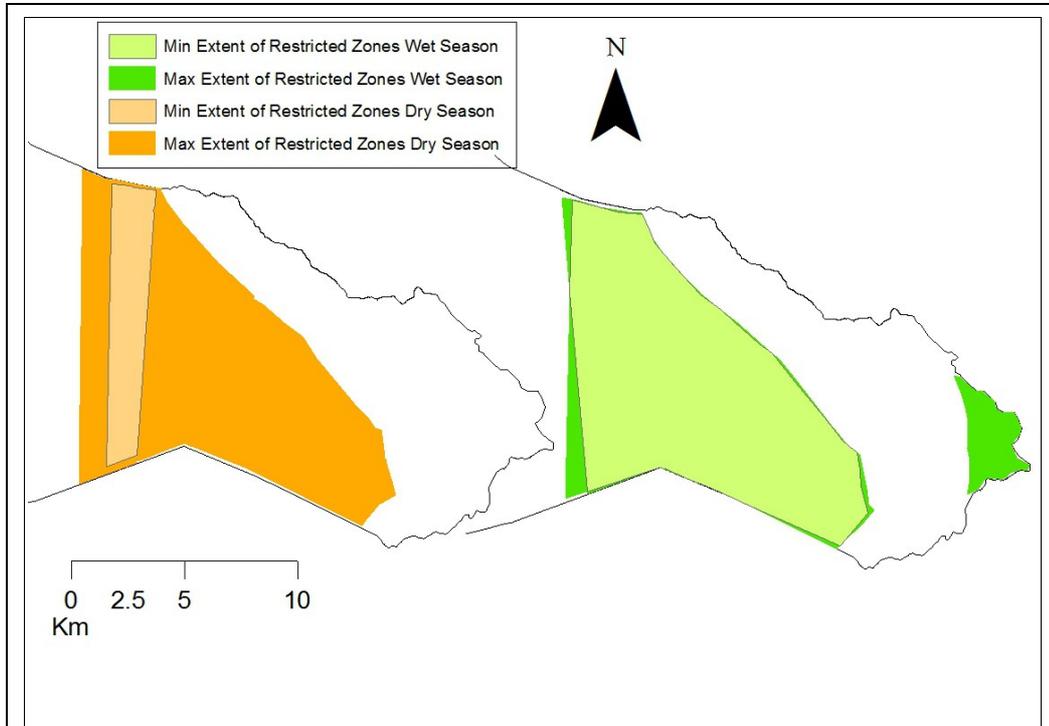
Figure 18: Zones restricted to livestock grazing in the dry (left) and wet (right) season in the East of Kalama; (maximum and minimum extents of restricted zones).
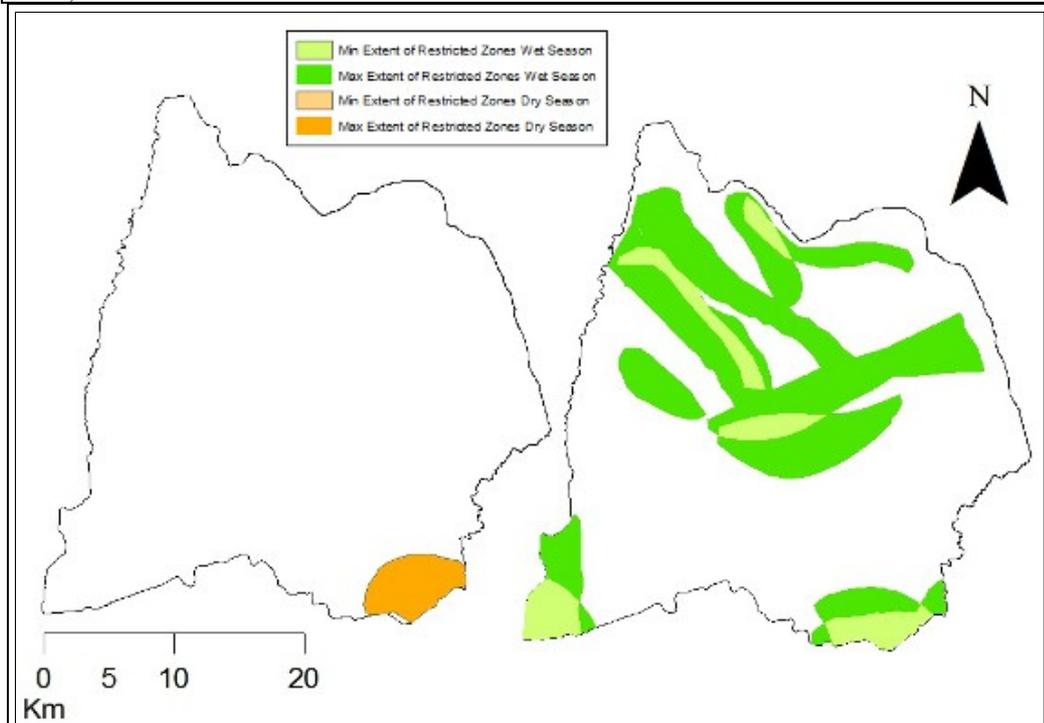
Figure 19: Zones restricted to livestock grazing in the dry (left) and wet (right) season in Meibae.
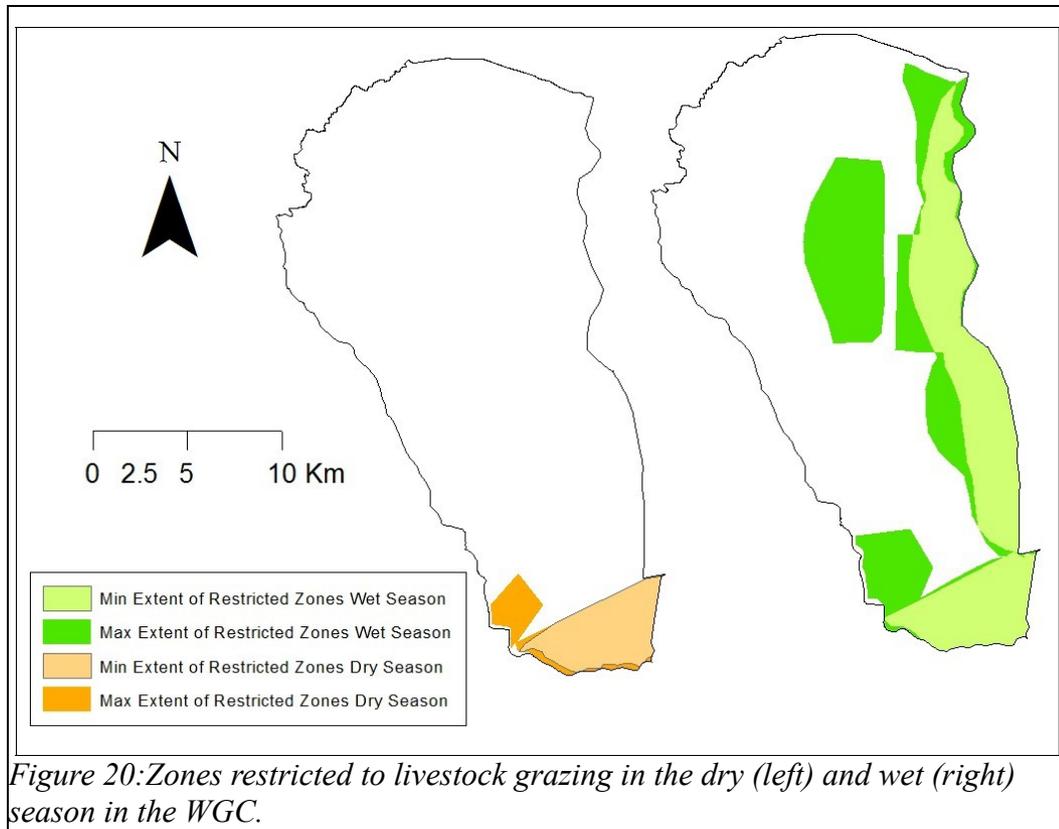
Figure 20:Zones restricted to livestock grazing in the dry (left) and wet (right) season in the WGC.

Figures 21 to 23 are indicators to show that these areas overlaid with Grevy's zebra hot spots, overlapped in Kalama and in the wet seasons in Meibae and the WGC but barley for the minimum extent of the restricted zones. The highest of all possible overlaps over all seasons and area extents was found for the zebras' core area (51-100% use) in Kalama in the wet season and it only accounted for a very small part of the entire hot spot. The majority of home ranges in Meibae and the WGC did not lie within livestock restriction zones. Therefore, and in combination with the tracking data acquired in Naibelibeli (73.2% grazing area overlap between livestock and E. grevyi), hypothesis 2.1 (zebra preference for livestock free grazing zones) was rejected.
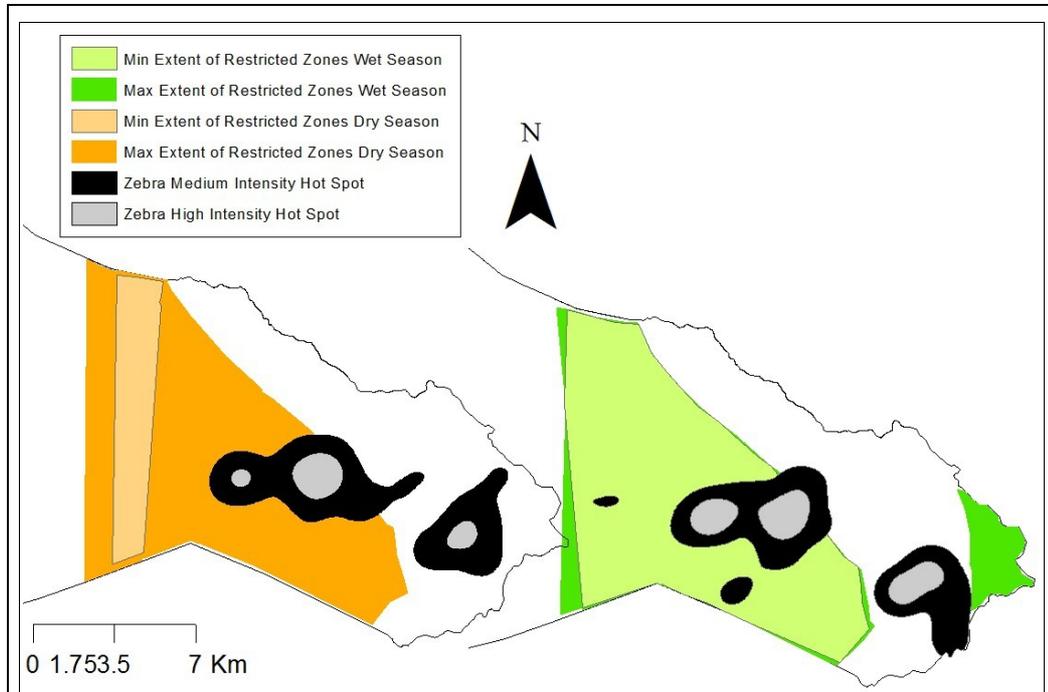
Figure 21: Overlap of livestock restricted zones with Grevy's zebra hot spots in the dry (left) and wet (right) season in the East of Kalama.
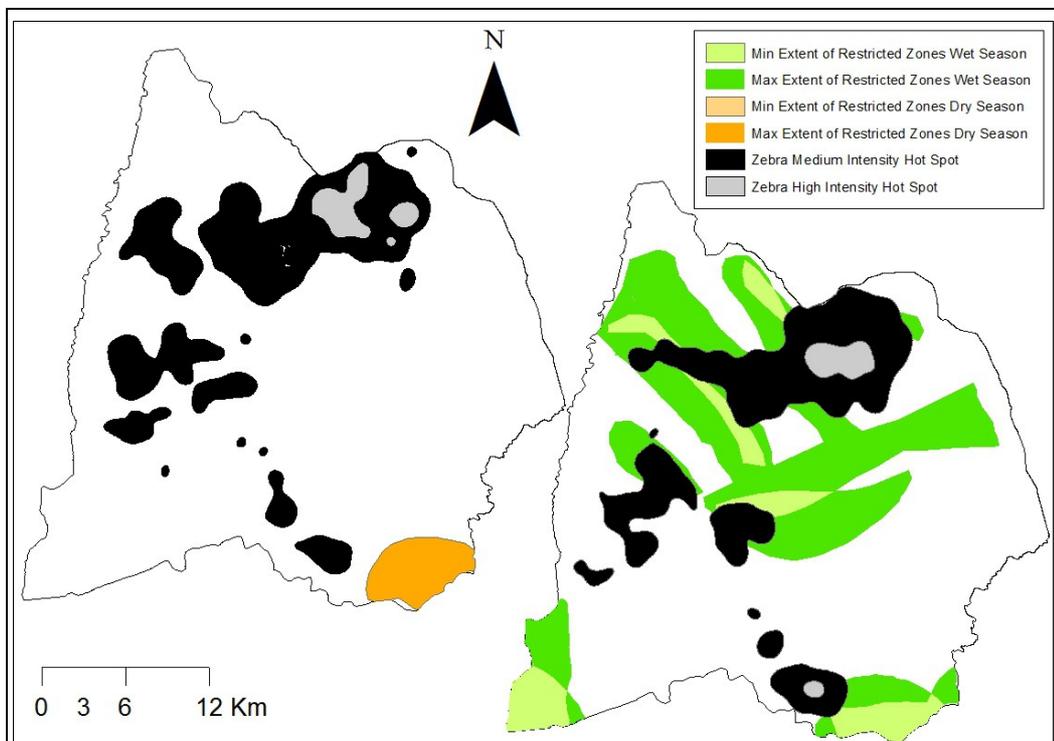
Figure 22: Overlap of livestock restricted zones with Grevy's zebra hot spots in the dry (left) and wet (right) season in Meibae.

Figure 23:Overlap of livestock restricted zones with Grevy's zebra hot spots in the dry (left) and wet (right) season in the WGC.
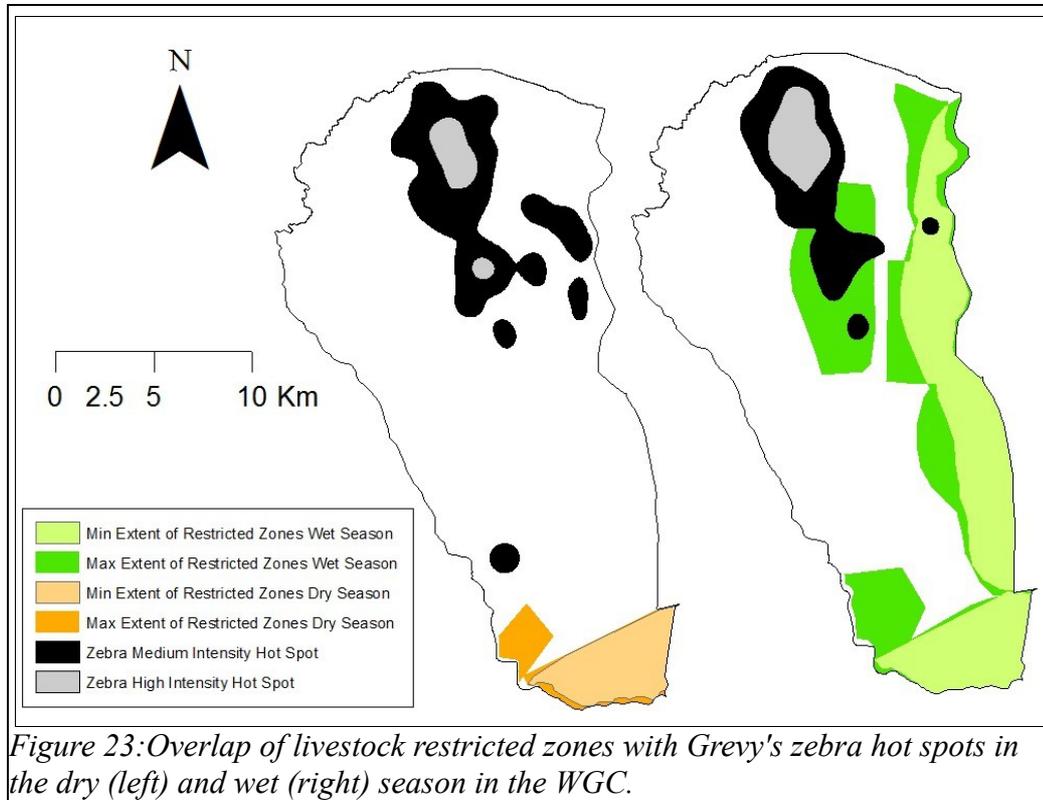
4.5.3 Perceived Hot Spots

According to collar data the settlements of Lesiteti in Meibae and Naamunyak and Sukuroi in the WGC lay within Grevy's zebra hot spots in the wet seasons. For Naamunyak this was also true in the dry season. Additionally, the homesteads of Laresoro in Kalama and Lpus in Meibae lay very close to the hot spots.

Disregarding orientation and scale issues of the participatory maps, the community members mostly placed Grevy's zebra hot spots within close proximity to the areas identified through the collar data KDs. In many cases the areas did not overlap on the digitised maps but the participants meant and

outlined the right location e.g. the Naibelibeli plains in the WGC. Testing the scores for all women versus all elders with the Man Whitney U test at a significance level of 0.05, revealed no difference in how well either groups placed the hot spot areas in relation to the collar data (U>17 with N1=10; N2=8).

Some differences were found for areas of high utilisation between collar and participatory mapping data; for Kalama's dry season the Ewaso river in the South East was identified by participants several times as a Grevy's zebra hot spot. On Meibae areas mapped by community members which did not reflect collar data also included the plateaus on the Western boarder and along the Ewaso river in the South West. Participants from the WGC placed additional zebra hot spots further South (around the head quarters in the core area) and on the Western side. Seasonal rivers were also often marked.
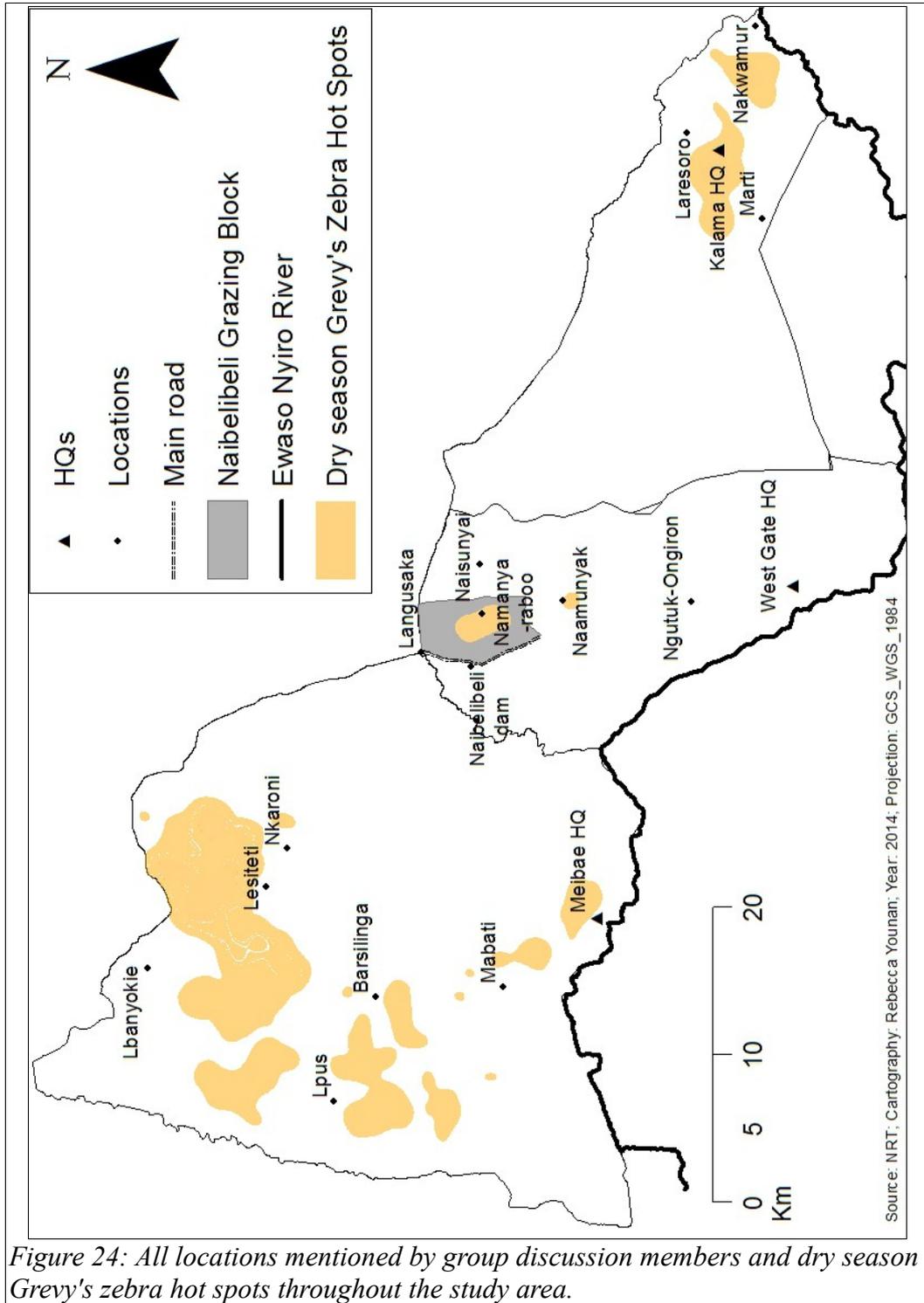
Figure 24: All locations mentioned by group discussion members and dry season Grevy's zebra hot spots throughout the study area.

4.6 Gender Differences

The Chi-Square Goodness of Fit Test for aspects mentioned by either elders, women or warriors showed no significant differences in knowledge on Grevy's zebras, their conservation and interactions with livestock (P=0.96, df=4). Hypothesis 3.2 (gender differences in knowledge and perceptions) was rejected on the basis of general comparisons of maps and answers given. Also no significant differences were found between elders and women neither in relation to knowledge nor in respect to perceptions.

5. Discussion

5.1 Grevy's Zebra Hot Spots

It was surprising that in all three conservancies hot spots for the dry and wet seasons lay in the same areas. It outlines those areas in which inter-anual key resources on which *E. grevyi* depend, are found; and especially that there seems to be no shift in the locations of key resources between seasons. But results were counter intuitive considering that individual Grevy's zebras are known to roam over areas of 10 000 km² (Williams, 2013). Considering Grevy's zebras' movements in the entire study area (including areas used less than 10% of times recorded), the collared animals spread out over almost all of the more than 1900 km². Only in the most South-Western part of Meibae and the North-West of Kalama no zebras were recorded. But records showed that the same individuals could be found long distances away from the study area. Despite far dispersal and movement across the landscapes, the tracked Grevy's zebras seemed to always return to the particular hot spots within Kalama, Meibae and the WGC. A fact requiring additional consideration is that resource availability is reduced in the dry season. Therefore an expansion of utilised zones would be expected, but according to Williams (2013) Grevy's zebras aggregate in the dry season. The hot spot sizes did not increase or decrease significantly according to season. This was in agreement with what Letoiye (2014) observed in Meibae. However, in Meibae and the WGC the data showed a scattering of hot spot areas.

Merging a large data set to compute these hot spots proved to be an appropriate method for the purpose of this study. The highest intensity zones for almost all individuals and years were represented by the merged hot spot. Accordingly, it must be kept in mind that the merged KDs 11-50% use intensity areas, represent individual 51-100% zones. Therefore, the merged hot spots must be considered as highly important in their entity. Another aspect to consider is that the three conservancies were analysed differently and the hot spots identified for each -even though representative of Grevy's zebra presence- may not have been weighted equally. For example the below 11% use intensity area in Meibae could have comprised a higher number of records than the above 11% area in Kalama. The hot spots would have therefore only been relative in relation to the use intensity of each conservancy but not between conservancies. However, a KD computed over the entire three conservancies showed that the high intensity zones still stayed the same despite original record densities. They only changed in shape and especially in size, mostly becoming smaller.

The individual zebras whose hot spots areas were not represented by the merged hot spots had fewer data records than most individuals tracked and with a great spatial discrepancy to the majority of records. Despite the appropriateness of the method for this particular study and despite the merged KDs being representative of individual records to a high degree, merging all data creates a bias against zones with few data points. In Meibae, the area not represented for animal 1059 would have been included into the merged data set if areas of less than 3% use

had been distinguished. This was not the aim of this study. So, it must be kept in mind that hot spots identified through data merging may omit a certain level of detail. Despite this, for the identification of inter-annual areas of high use intensity, the merged KDs delivered valid results.

5.2 Landscape Features

The data used from former Master research had its own limitations (for more details see Hostens, 2009 and Wheeler, 2013). Some of the settlements indicated by Wheeler were abandoned the same year, her water points did not include seasonal water availability. Hostens described vegetation classification in the ASALs as problematic with the Africover map having very limited detailed information due to its large scale. Her suitability map includes some aspects which may now be considered as out-dated , for example livestock density estimations from 1990. It did also not include zebra occurrences from 2011 to 2013, which might have highlighted additional or different areas of utilisation. Nevertheless, it was informative to place the hot spots within a contextual environment.

Settlement data indicated that Grevy's zebras do not categorically avoid humans. Hot spots lying adjacent to a high density of settlements in the WGC can possibly be explained by these settlements having been set up in close proximity to areas of good pasture, which are also sought out by the *E. grevyi*. The strong tendency

towards more settlements lying within *E. grevyi* hot spots in the wet than in the dry season, also indicates that the focus species does not strictly avoid livestock, as livestock graze closer to the homesteads in the wet than in the dry season.

It was remarkable that the water points were mostly not found within the Grevy's zebra hot spots. However, they often lay close to them. One explanation could be that Grevy's zebra spend relatively less time drinking than grazing and moving. Or possibly it is representative of their hardiness towards dry conditions and lower dependency on water than other mammals. An additional factor may be that *E. grevyi* in the area depend more on seasonal than permanent water sources, possibly even because the latter are mostly utilised by livestock.

The hot spots on the vegetation maps pointed towards the importance of herbaceous and shrubby habitat in accordance to literature on Grevy's zebras' preferences (e.g. Sundaresan *et al.*, 2007). High intensity utilisation zones in Meibae and Kalama also falling into woodland according to the MODIS map was not expected from some literature on Grevy's zebra habitat but in agreement with reports by GZT scouts (Low *et al.*, 2013).

Differences between Hostens' suitability map (2009) and the hot spots identified in this study may have arisen from zebra tracking recorded since 2010.

 5.3 Livestock Tracking

The tracking of camels and small stock from Naibelibeli in the West Gate conservancy could not be continued after May 2014, as the drought forced the people to migrate away from their home areas. Due to the tracking devices' very insufficient battery life it was impossible to track the animals further migratory movement, as the area they went to was not accessible by car and the batteries needed to be changed on a daily basis.

Additionally, because of the failure of the rains in the study area, tracking data were only collected in the dry period. Livestock was tracked from the middle of the dry period into the drought and results are -if at all- only representative of this particular season. In the dry season of the first half of 2014 no cattle were present in Naibelibeli. Therefore, it was never possible to track cattle. This was unfortunate as the literature often considers cattle as the most important livestock competitors to wildlife due to their large body size and feeding habits.

Records collected up to May 2014 were informative but few in numbers and not representative enough. Nevertheless, it was in accordance with community data in regard to the intense overlap between livestock grazing zones and *E. grevyi* hot spots. This is in accordance with micro-scale on ground observations from community members trained as Grevy's zebra scouts, which reported 40% to 50% of all zebra observations occurred within close proximity to livestock (Low *et al.*, 2009). Many scholars believe that a lack of overlap between wildlife and livestock is proof of displacement or exclusion (Butt & Turner, 2012). The

extensive overlap found in this study would therefore indicate no such forms of competition. What must also be acknowledged when considering the results is that the areas in which the zebra hot spot did not overlap with livestock grazing zones may not actually indicate the absence of livestock but only the fact that the tracked livestock did not venture into these parts of Naibelibeli.

The intensely used area in which livestock and Grevy's zebra overlapped lay in close proximity to the Naibelibeli dam (mapped in Annex 3). On the one hand, this validates what scholars have published on resource sharing between pastoralists and wildlife (e.g. Butt, 2011), especially when resources become scarce as was the case with water availability in the area during the on-going drought. On the other hand, during the duration of tracking the dam had already dried up and water was no longer available. Perhaps patches of vegetation remaining around the dam may have attracted livestock and Grevy's zebra as pasture was getting scarcer. However, this hypothesis could not be validated as no vegetation survey was made at the time of livestock tracking. Contrary to personal communication and observation, the livestock tracking data did not show congregation on the plains East of the main road up to the Namanyaraboo hill, as expected. But the animals did roam on the Northern parts of the plains, as well as the North-Western.

Both the zebras and the livestocks migration away from the study area may be indicative of a form of exploitative competition of grazing resources (Odadi *et al.* 2011). Which according to Butt and Turner (2012) may have led to emigration

away from areas of high competition pressures.

5.4 Group Discussions

During the group sessions it was difficult to get the "moran" (warriors) to participate. This was because of two reasons; firstly, they do not believe that sitting under a tree and holding discussions is their duty, they see this culturally as something elders do. Letoiye (2014) experienced the same constraints during his study in the area. Secondly, due to the long and severe dry season the Samburus had moved their animals into "fora" (traditional dry season grazing reserves) and it is mainly the "moran" that undertake this long and tedious journey. Nevertheless, three groups of warriors agreed to participate, but unfortunately none in the Meibae conservancy.

Also, unavoidably, translating interviews holds the risk of misunderstandings and loss of information. The translator recommended by the conservancy, was not entirely fluent in English. It required post-processing and additional enquiries to ensure that the main messages came across. This included consultations with the translator, assisted by a GZT employee and cross-checking by conducting one group discussion mostly in English, which incidentally all participants knew.

Discussions of herding management with the community members, revealed some forms of encroachment into areas restricted for livestock. Participants reported that encroachment occurs, for example in Marti and Nakwamur in Kalama, both into Kalama's livestock free conservation core area and into the

SNR. This reflects findings reported by Butt (2011). This form of encroachment did not seem very severe, it was described as a rare event and cattle are not usually involved. However, unmonitored encroachment happens because sometimes camels and especially donkeys are not herded and move across the area freely. The most disruptive form of encroachment was the movement of non-conservancy members into the conservancies' territories. This creates conflict as the conservancies already struggle to support their own livestock numbers while setting aside wildlife retreats. These findings were in agreement with accounts by Greiner (2012), as well as the KWS (2007). Additionally, non-conservancy pastoralists are not aware of restrictions and regulations. Therefore, recently a new grazing committee was formed in the study area with its focus on areas beyond the conservancy boundary and aims to incorporate traditional large scale migration movements into grazing plans.

5.4.1 Threats and Conservation

Asked about specific threats, the ones most commonly named by participants were diseases, starvation and either lack of access or distance to water, in descending order. The IUCN (2014), the KWS (2012) and Williams and Low (2004) too, listed water availability and diseases as main threats. A disease in the centre of attention is Anthrax (Manyibe, Low & Chege, 2006) and one group of warriors from Ngutuk-Ongiron also mentioned this specifically ("Lokuchum" in Samburu). Potential resource competition and vulnerability to diseases are

directly linked through factors such as reduced nutrition leading to lower recruitment over time (Butt & Turner, 2012). Claims made by Williams (2002) that pastoralists close off water holes to Grevy's zebras were in contradiction to what was reported by community members in the study area. They were aware of the need for Grevy's zebras' access to water and even if they had concealed such negative practises, it was reported how elders were employed by the GZT to make shallow water holes for them in the dry season in Laresoro. Threats in the literature, not mentioned in the group discussions included habitat degradation due to over-grazing, competition for resources and low juvenile survival. No specific questions were asked concerning land degradation but even though discussions focused a lot on grazing management and even inquired on vegetation changes over time, no mention of land degradation was made by anyone. Either it is not perceived as such or community members do not directly connect environmental degradation to Grevy's zebra survival. However, the participants mentions of starvation as a threat to *E. grevyi* survival and lack of pasture as a common problem is connected to vegetation scarcity and in turn land degradation. They did not relate land degradation to over-grazing, again either due to lack of awareness of the connection or because it was not explicitly enquired about.

Happold (1995) in a study conducted in Tanzania found that: "Many local people understand and appreciate the value of wildlife and conservation issues" (p.408). The appreciation holds true for this study, however interesting observations were

made concerning community members' ideas of what Grevy's zebra conservation meant. To translate the word "conservation" into the Maa language, the interpreter chose a term that can also be understood to mean "protection". Participants stated that "Grevy's zebras are like our livestock but they do not come home with us" or "nowadays Grevy's zebras have herders". Their ideas of conservation referred to protecting particular wildlife in a way one would tend to domesticated animals. Conservation was understood mainly as active interventions directly between humans and the Grevy's zebras. Even though some were mentioned in discussions, there was little awareness on conservation activities such as awareness raising, education, monitoring and general rangeland improvement. Providing water, fodder and medication to the Grevy's zebras were conservation activities primarily perceived as such by community members.

5.4.2 Interactions with Humans and Livestock

The mentions of *E. grevyi* coming to drink water at night were in accordance with findings by Wheeler (2013) and Williams (2013), but it was not mentioned by many groups. Prins (2000) and Letoiye (2014) who reported sharp declines and negative correlations between Grevy's zebra and human presence were not in agreement with statements made by the pastoralists interviewed. In some interviews they said that Grevy's zebras would visit their homesteads especially at night and would actively seek out the safety provided by human presence. Wheeler (2013) found Grevy's zebras in the area to travel within 3 km of

homesteads every day. Low *et al.* (2008) were not able to determine whether Grevy's zebras avoid or seek out settlement areas but participants were of the opinion that they do associate with them for protection. Most groups remarked the same for side-by-side grazing, naming security through livestock presence as a main attractant for Grevy's zebras. The community members were of the opinion that Grevy's zebras felt safe from potential predation by making livestock their "grazing partners", the same was reported by GZT scouts (Low, Rubenstein, Lalampaa, Letura & Lentiyoo, 2013). Interference, a form of competition referring to aggressive behaviours or avoidance (Butt & Turner, 2012) was not evident from the pastoralists' accounts.

Furthermore, common livestock and Grevy's zebra shared grazing ground was discussed. Concerning competition in the sense of resource exploitation; some scientists would view this as proof of co-existence (Wheeler, 2013). Competition was defined according to Prins (2000) as follows: species or populations must share limited resources and one or both species are negatively affected by the resource exploitation or interferences associated with it. External factors influencing competition are, for example, the amount of rain in a wet season which may determine not only the quantity but even the quality of available pasture in the following dry season (e.g. Fritz *et al.*, 1996). Especially in dry areas of Sub-Saharan Africa, these factors may be more severe to populations than direct competition (Butt & Turner, 2012).

Questions surrounding competition and threats to Grevy's zebra are not as straight

forward as the KWS (2012) claimed when making domestic livestock a leading contributor to the decline of the Grevy's zebra population. Livestock migrates far away from the study area. Group discussion members were also mostly in agreement over *E. grevyi* migrating away from their conservancies. This implied that the study area is not a prime location in which competition occurs. The high mobility of both wild ungulates and livestock must be considered, as preambles to competition are common grazing areas or zones of movement (Butt & Turner, 2012). Ritchie (2002) argued that highly mobile species, should especially be able to co-exist because of their ability to partition resources through movement. Young *et al*. (2005) found correlations between grass cover and plot use by zebras, concluding that this is representative of their ability to track resource abundance. The mitigation of dry season competition is especially the case for cattle which are the first to migrate to "fora". However, it must not be ignored that Voeten and Prins (1999) in their study found zebras and cattle to overlap and compete in the early wet season. But Eltringham (1990) noted that *E. burchelli,* which feeds just like the Grevy's zebra, feeds on different grass compared to cattle, concerning species and growth stage and is therefore "unlikely to compete with livestock to any extent" (p. 5).

The only area in which participants mentioned that *E. grevyi* was more likely to be present in the dry than in the wet season was in Lpus (Meibae). Lpus was described as an important Grevy's zebra dry season retreat within the study area by its inhabitants, even though this was barely reflected by collar data.

All the same, temporally displaced competition, referring to long-term vegetation responses to wet season grazing pressures (Happold, 1995) could not be accounted for by this study. Butt and Turner (2012) pointed out that vegetative response is stronger to grazing during the rainy season, while forage limitations occur during the dry season. Whilst this study did not aim to clarify discrepancies surrounding the issue of competition between *E. grevyi* and livestock, it identified the specific areas in which this is likely to occur and be of importance. Thus clarifying which areas to focus on primarily in future.

5.4.3 Perceptions and Benefits

In contrast to Sundaresan *et al.*'s survey (2012) in which less than 40% of participants realised benefits from Grevy's zebra, in this study over 95% of the discussion members were able to name some benefits they receive through Grevy's zebra conservation. In Sundaresan *et al.*'s studied community conservancies in Laikipia the Grevy's zebra was not a focal species.

Remarkably, when asked for benefits received, the participants in Samburu would point out advantages for the community as a whole rather than on an individual or direct level. For example, student bursaries were often emphasised as a very important advantage even if it was not the participants own children receiving the bursaries. The same held true for employment. Even though the conservancies only employ 35 (Kalama and WGC each) and 24 (Meibae) staff members (NRT, 2014) and the GZT employs eleven people over the whole study area (GZT,

2014), employment was seen as a major benefit. This was possibly the case because of culturally strong social cohesion and interdependence of community members, as well as the lack of any other employment opportunities especially in the remote places of the study area. In Happold's study in Tanzania (1995) locals involved with a protected area did not see employment opportunities as such a major advantage, nevertheless they were also in favour of it.

A difference in perceptions by numbers of livestock owned, as described by Sundaresan *et al.* (2012), could not be assessed as group discussion members owned different amounts of livestock but answered the questions as a group.

Concerning Sundaresan *et al.*'s findings on the overemphasis on tourist benefits by people less exposed to tourism; participants from Meibae, where there is no tourism, mentioned it more often than people from Kalama, where there is tourism, but not more often than community members from the WGC, in which there is also some tourism or awareness thereof especially through the proximity to the SNR and the community owned lodge. This particular aspect could thus not be confirmed but would have required a more specific focus. Bruyere *et al.* (2008) also studied perceptions concerning communities' involvement in tourism in Southern Samburu. All their participants identified economic benefits received from tourism but no employment opportunities thereof. They were also not aware of the connection between tourism and conservation. Awareness for this relationship was more widespread in this study.

Some information gathered in this study pointed to what Sundaresan *et al.* (2012)

found: if community members do not receive efficient benefits through wildlife conservation, their support for it may dwindle. One group of men stated: "We only receive very few benefits from Grevy's zebra but we still don't want anything to disturb their lives". Which also reflected Bruyere *et al.*'s statement (2008) that only minimal benefits are received at the communities' level.

Seeing as many participants indicated a change in attitude by stating they used to chase *E. grevyi* but now teach their children not to, a huge conservation success has already been accomplished. This was also indicative of persecution and harassment of *E. grevyi* by herders (KWS, 2007) no longer being an issue in the community conservancies. It seemed some of the principals called for by Akama (2000) and the KWS (2007) such as inclusion and participation of community members in the community conservancies and Grevy's zebra conservation activities, are being applied and have helped to ensure goodwill and improve attitudes among the pastoralists. Even the groups with the least information on why Grevy's zebra conservation is important and those receiving no direct benefits, knew that it was important not to disturb them. A statement made by the KWS (2007), claiming people with little awareness nor benefits perceive *E. grevyi* as a competitor to their livestock is no longer applicable in the conservancies studied. Not a single discussion participant mentioned competition. Letoiye found many participants to state that Grevy's zebra compete with livestock over resources (2014). His questionnaire was structured in a way that directly asked about competition. In the discussions conducted for this study,

participants were only asked about possible effects of side-by-side grazing, as well as reasons and consequences. How questions are being posed has a direct effect on the pattern of answers to expect. In order not to pre-empt answers, questions in this study were posed in such a way as not to direct the discussion partner towards any particular positive or negative response. Avoiding biased question posing as much as possible, a general tendency towards positive supporting feelings from community members towards Grevy's zebra conservation became apparent. Results in this study do not point to community members seeing Grevy's zebra as a competitor. As Letoiye worked with larger mixed groups of women and men, perhaps some answers given only reflected the opinion of a few individuals. More importantly, even though Letoiye's interviewees expressed their concern about livestock and Grevy's zebra competition, 14 out of 15 groups ranked the severity of the conflict as low to medium. Perhaps this explains why participants did not mention it in these group discussions, as it is not of primary importance to them.

The few negative aspects mentioned in contrast to benefits and positive aspects may have been influenced by not inquiring about them explicitly.

5.4.4 Grazing Areas

The participants mention of open spaces with green grasses as good grazing zones for both Grevy's zebras and livestock is similar to Churcher's description of Grevy's zebra habitat of plains and flats with short vegetation. They did however

not mention rocky terrain, listed by Churcher (1993). The emphasis the pastoralists put on proximity to water (again for both zebra and livestock) reflects attributes for *E. grevyi* habitat put forward by Williams (2002). In contrast to Sundaresan *et al.* (2007) participants claimed that Grevy's zebra could also be found in bushy area, especially in the dry season, whereas Sundaresan *et al.* found most reproductive classes to avoid dense bush. Occurrence in bushy habitat was in accordance to data collected by GZT scouts (Low *et al.*, 2013). The community members implied that Grevy's zebras moved into bushy area in times of resource scarcity which validated Letoiye's observations (2014) but unlike this author the pastoralists did not consider it as displacement of the zebras by livestock.

Their descriptions of Grevy's zebra habitat was detailed, concerning landscape features, characteristics of pasture and preferred fodder plants. Some discrepancies with the literature remain. The similarities between their descriptions for Grevy's zebra and for livestock grazing zones, again point to an extensive spatial overlap in resource utilisation. Concerning specific plants, it was noted how participants were aware of overlap between livestock and Grevy's zebra's fodder plants, making statements such as "they feed just like donkeys". Peculiarly, again not a single mention was made in relation to competition. The pastoralists in Southern Samburu do not seem to perceive the interactions of their livestock with Grevy's zebras as competitive. This stands in stark contrast to many scholar opinions. It may only reflect a difference in how interactions are

classified but it may also point to a basic difference in attitudes of people from outside introducing conservation dogma into the semi-arid rangelands and people who have resided within them for centuries.

Considering the vast abundance of literature on cattle and wildlife competition, it must also be noted that in the study area other livestock species are far more important in interacting with Grevy's zebra than cattle. Food requirements for cattle are very different from those for *E. grevyi*. Considering that all participants pointed out the importance of *Indigofera spinosa* for Grevy's zebra, they may compete with camel, who also utilise this plant (Kuria, Wanyoike, Gachuiri & Wahome, 2005). This may be the case especially in the Grevy's Northern range beyond the study area in which it is very arid and grasses are not abundant and where camel densities have increased in recent times (Corman *et al.*, 2014).

None of the plant species of specific importance to either livestock, Grevy's zebra or both reflected those species listed by Churcher (1993). In his work *Pennesetum schimperi, Chrysopogon ancheri, Cenchrus ciliaris,* and *Enteropogon macro-stachys* were found in Grevy's zebra dung on Lewa. This is attributed to the different environments between the study sites and points to according differences in diets. Community members' accounts of where to find specific grasses confirmed that settlement abandonment can bring ecological benefits, as for example *Cynodon* grasses were said to be found there. Participants often described the ground as barren and the remaining grasses and forbs as dried up and non-nutritious in the dry season. Considering the Grevy's

zebra's ability to process coarse plant material, this may give it an advantage over livestock species as it may still be able to process this low-quality fodder (Williams, 2013). However, due to the high density of especially goats in some of the study area, participants described that all remaining plants were likely to be picked from the ground in the early dry season with no pasture whatsoever remaining to reach the state in which livestock no longer feeds on it.

5.5 Participatory Mapping

Problems during participatory mapping sessions included that the participants did not always comprehend locations of places on maps, similar to limitations encountered by Treves *et al.* (2006). Time was taken to help them orientate. This exercise was supported by one of the conservancies' staff members, however even they sometimes failed to correctly place features or landmarks on the maps. Therefore, the maps had a much lower spatial accuracy than desired. Maps representing the landscape's topography or perhaps even using satellite images might have produced more satisfactory results.

In the WGC it was very surprising that the elders from Sukuroi did not mark the plains as the most important wet season grazing zone for all animals. All other groups in the North of the WGC indicated the plains. However the elders did mention them in the discussion and most likely only forgot to map them, too.

During the mapping of species' specific grazing zones, dispersal of wildlife

outside protected areas (Rannestad, 2006) was evident for Grevy's zebras in the community conservancies. Livestock grazing closer to settlements in the wet than in the dry season as described by Butt (2010) was also found to be true. Observations made by Low *et al.* (2009), in which Grevy's zebras were found in close proximity with small stock and camels but almost never with donkeys was not consistent with the information given by participants through the mappings and discussions. In the maps overlap with mostly small stock, camels and donkeys was communicated. In the discussions, if specifying at all, donkeys were mentioned as the livestock species mostly grazing with *E. grevyi*. Perhaps reports differed because Low *et al.* (2009) only recorded proximities of 100m whereas participants may have focused on general grazing zones. Also, donkeys are significantly less abundant in numbers than especially small stock, making their presence in an area less likely.

Mapping those areas restricted to livestock grazing, exposed several aspects; for one restricting areas is handled differently in the different conservancies. Especially on Meibae there does not seem to be one clear concept.

Additionally, both conservancy management and community elders would restrict areas. Elders form part of the conservancies' grazing committees but practises seem to vary on a small scale, with some settlement areas following rules different to their neighbouring communities. This begs the question how restricted zones are communicated. Inter-map comparisons showed that the general direction in which not to herd was known but the zones indicated by

different groups varied in location and size.

Community members were very much in favour of grazing restrictions, they described it as "having a place for future use in the dry season" and some explained that these areas allowed them to migrate later in the dry season or sometimes even stay sedentary if rains came early. The communities' support for grazing restrictions has the potential to also benefit *E. grevyi*.

Restricted areas incorporate some good pasture and high biomass as they must be able to sustain high livestock numbers in the dry season. If Grevy's zebras were avoiding livestock, they would be most likely to concentrate in areas restricted to livestock grazing. For example in Barsilinga in Meibae, there is an area which is not utilised by many community members in the wet season and it is close to watering points.

Letoiye (2014) found Grevy's zebra to occur more in areas in which livestock only grazes in the dry season. He compared occurrence of Grevy's zebras in dry season areas in relation to availability of dry and wet season grazing zones. These results differed from this particular study because Letoiye used grazing blocks as defined by the conservancy's grazing management plan while this study relied on how community members demarcated grazing areas. However, the restricted area identified for Meibae was a bushy area which is a habitat type less preferred by Grevy's zebras according to Sundaresan *et al.* (2007). In West Gate according to restrictions, the expectation would be to find the Grevy's on the Eastern border in the dry season to avoid livestock. Even though water accessibility along the

border is problematic, *E. grevyi* could be expected to be found here because if not with foals, they should be able to travel the distance to water. Water points are roughly within the distance of 10 km, which Grevy's zebras in the area were found to roam on a daily average by Hostens (2009). In addition non-lactating females do not drink daily (Williams, 2002). But again it is a more bushy area than for example the plains.

Notably, community members and people monitoring *E. grevyi* on the ground placed more emphasis on Grevy's zebra distribution along the Eastern border of the WGC, than became apparent through the collar data. This is an important movement corridor through Loijuk between Kalama and the WGC, used by many zebras in the dry season. The area is not represented as a hot spot through collar data. The reason for this being, that the animals move through it but do not stay in this area for prolonged periods of time (Low, *personal communication*, 2014). The combination of the two different approaches of participatory maps and collar data (figures 21-23) indicated that Grevy's zebra are not increasingly found in dry season restriction zones, thus strongly suggesting that they do not categorically avoid livestock encounters. Or alternatively, prompting questions on whether the vegetation cover in the restricted zones is suitable for *E. grevyi*'s needs. Assuming that restricted areas mainly incorporate unfavourable habitat types, Grevy's zebra would be trading-off livestock avoidance against habitat preference.

Comparing Grevy's zebra hot spots identified by participatory and by collar data, showed a high level of correlation as to where the zebras are found. However,

participants also mapped some areas different from the computed hot spots. As the pastoralists move across the landscape with their livestock and for other chores on a daily basis, their knowledge of where *E. grevyi* is mostly found should not be disregarded. Again the maps spatial inaccuracies made analysis more complicated. Perhaps the differences occurred from participants referring to territorial males which are not represented by the collar data. In one discussion this was definitely the case, as participants stated "in the dry season we see a single Grevy's zebra between here and the river", apparently describing a sedentary male defending a specific territory close to water, exactly like it is described in the literature (Kingdon, 1979; Williams 2013).

5.6 Gender Differences

Concerning gender roles and grazing management, some questions arise; elders, who are the male household heads act as traditional authorities making decisions for the communities in the community conservancy (Butt, 2011; Letoiye, 2014). They have been included in the communities' grazing committees. However, Letoiye (2014) himself already stated that lifestyle changes have led to loss of power over the community members by elders. This was already observed by Herlocker in 1999. In the light of this, it is questioned whether grazing management is as effective as it could be. The small differences observed between women, elders and warriors discussing and mapping grazing zones,

revealed that not everyone may be aware of grazing plans. It would occur that in the same area one group would state they had a communal grazing plan while another would say that no such thing existed. There seems to be an issue in communicating grazing strategies effectively. Also, out of 132 mentions whether children, boys, girls, adults, women, men, warriors or everyone herds the livestock; 57% of the answers referred to children, boys or girls and only 39% to adults, women, men or warriors. Elders alone were only named in 10% of answers to who herds livestock, less than women (11%) and warriors (14%). Perhaps working with elders exclusively to make grazing management decisions is an out-dated approach. Alternatively, it needs to be ensured that decisions reached with the elders are communicated effectively to the herders themselves, which are mostly the children. How grazing management is connected to Grevy's zebra conservation should have been made clear; it starts with behaviours shaped by attitudes and awareness such as not harassing *E. grevyi* and ends with abiding to grazing restrictions to provide livestock-free retreats for Grevy's zebras. Even though it seems Grevy's zebra do not exclusively prefer livestock-free zones, it is still beneficial to both wildlife and livestock when the pastoralists set aside pasture for dry season use.

In addition to gender differences, Letoiye (2014) found women to make more accurate maps than men due to their manifold activities across the landscape; no such tendency could be confirmed by this study. There were no significant difference in neither knowledge on Grevy's zebra conservation, nor mapping

accuracy between women and men. A difference in perception by gender as identified by Sundaresan *et al.* (2012) could also not be confirmed in this study, as neither men nor women mentioned significantly more benefits.

5.7 Methods Used

Finally, considering the information gathered through GPS collar data in comparison to the participatory community data, makes the strengths and limitations in both methods apparent.

Both approaches indicated overlap of grazing zones and dry season migration for both zebras and livestock, especially away from the Naibelibeli plains. The collar data also showed that around some settlements -although few- Grevy's zebra occurrence is high, thus possibly validating what participants stated about *E. grevyi* seeking out settlements at night. Areas of high intensity use for zebras could also be compared between the collar data and the participatory data (see 5.5).

Tracking livestock in Naibelibeli was a first attempt at mirroring the Grevy's zebra movement monitoring by parallel tracking of domestic animals, in order to be able to make accurate comparisons. Had it been possible to continue livestock tracking, the data set could have allowed for a temporal in addition to spatially highly accurate analysis. This could have shown on a daily, as well as monthly basis how Grevy's zebra move in relation to livestock movement. However, the method was vulnerable to the unexpected drought and logistical constraints. It

was also problematic from the technical side as the choice of tracking devices used was not ideal. At the same time the Tracksticks were expensive and when they were lost, there was no way of retrieving them.

When the focus shifted and participatory involvement was included into the study, it was also possible to expand the study area extensively (from Naibelibeli within the WGC to all three conservancy areas). Group discussions and participatory mappings required more time spent in the field but less financial input than for the livestock tracking. Spatial accuracy of participatory data was not sufficient but this could be improved by using more appropriate map templates. This made comparison of collar and mapping data problematic, which should therefore only be considered as indicators but not absolute results. However, in contrast to the collars, group discussions produced more than only spatial information. The interactions with community members allowed for the collection of relevant qualitative information. Additionally, approaching and involving community members in research can be a tool for awareness raising or to strengthen their ownership feelings toward their environment and traditional knowledge and prompt dialogue surrounding Grevy's zebra conservation.

6. Conclusions and Recommendations

Future small scale conservation planning, as well as research on *E. grevyi* which target highest animal concentrations in Southern Samburu, should focus on the inter-annual hot spots identified by this study.

The livestock tracking approach undertaken in Naibelibeli would have delivered promising results, had it not been for the drought. The approach could be repeated with a flexible time line and starting in a wet season to ensure the availability of livestock to track and coverage of both seasons. Further Kernel Density hot spot identifications should make use of the emerging hot spots tool in the ArcMap version 10.3. It enables to identify areas of high use intensity and additionally determines whether the utilisation in- or decreases over time. It does not just evaluate in which area a large number of collar data were recorded but also if these occurrences are consistent over time. For the results gathered in this study, it could be of interest to identify what makes the zone of highest overlap between livestock and *E. grevyi* so appealing, how this area differs from the surroundings and if its location changes over time. At the same time investigating what distinguishes the areas in which Grevy's zebras were not once recorded within six years could shed light on aspects threatening their habitat.

Future researchers interested in Grevy's zebra's relationship to human settlements may consider applying camera traps to validate if they seek out settlements for security at night or not. The settlements targeted should be Laresoro in Kalama, Lesiteti and Lpus in Meibae and Naamunyak and Sukuroi (near the Naibelibeli

dam) in the WGC. Considering water sources it may be of interest to determine if livestock uses permanent water sources relatively more than seasonal sources and how this affects *E. grevyi*.

A lack of understanding and the wish to learn more about Grevy's zebra conservation by community members became apparent during the group discussions. It is therefore recommended that awareness raising programmes should make conservation approaches and activities clearer. Programmes aiming at rangeland restoration and halting land degradation are high on the conservancies' agendas. The community members seemed not to realise the connection between land degradation and wildlife protection. This should also be communicated more. Additionally, education efforts should be expanded beyond schools. Adults, too, have an interest in further understanding conservation issues. And especially the non-schooling children should be targeted, as they are the ones mostly interacting with *E. grevyi* in the grazing zones.

When educating people on conservation and for direct interventions such as administering medicine to Grevy's zebras or providing them with hay in harsh droughts, care must be taken. It is important not to create resentment as some of the community members already voiced displeasure concerning their marginalisation. It was stated by one group of interviewees that government officials intervene when elephants are killed but that no support is given when livestock is killed by wildlife. A balance must be found by conservationists between support provided to the pastoralists communities and activities aimed at

ensuring Grevy's zebra survival.

Many aspects showed that pastoralists have extensive knowledge of *E. grevyi* in their environment and the issues they face. That the pastoralists themselves do not see livestock keeping as a threat to Grevy's zebra survival does not mean it may not be one, but as there has still not been any conclusive scientific evidence the subject should be approached sensitively. The claims made by some conservationists are not supported by empirical studies and hold the danger of shaping perceptions in ways that lead to flawed and none information based management decisions. Firstly, pastoralists are already marginalised communities facing problems such as unemployment, poverty and lack of support from the government. Still, they support conservation and appreciate the few benefits received through it. Secondly, if instead of involving the pastoralists in conservation activities, blaming their main livelihood source as a major threat to Grevy's zebra survival may be counter productive. Using approaches that work against instead of with the pastoralist people, may result in the loss of their support for the cause, which would be catastrophic. Luckily this has been recognised and is already being practised in the study area. Because as Happold (1995) put it: "Wildlife should be regarded as part of the rural economy and therefore wildlife management and utilization should be integrated with other forms of rural development". Certain aspects of Grevy's zebra and livestock co-existence appear to be less problematic than previously thought. Results of this study point towards achievements and further possibilities for reconciliation.

Grazing committees are good solutions to include communities in finding a balance between livestock keeping and wildlife conservation. Perhaps the focus should shift away from elders, who still hold the roles of decision makers even though their power is no longer absolute. Women are more involved in the grazing activities and warriors are more knowledgeable of the wider areas. Elders spend a lot of their time at the homesteads and delegate. Although grazing regulations are in place, they are often not abided to or some community members are not aware of them. With respect to cultural ways, more inclusion of younger generations and women into planning may be productive.

Concluding the use of the two methods, GPS tracking and community participatory data, they allowed for cross-checking and validating the outcomes of one another. They were in agreement about Grevy's zebra and livestock overlap, migration movement and zones of highest use intensity. The combination of two methods resulted in levels of detail neither could have achieved by itself. Future studies contemplating the use of either or both methods should choose in accordance to their research focus, time and budget.

Research and management questions concerning human, livestock and Grevy's zebras' interactions that are yet to be answered are; whether *E. grevyi* truly seeks out livestock and humans as protection; if zones restricted to livestock grazing in the wet season provide suitable habitat for Grevy's zebra and how best to enhance conservation activities and community involvement alike, to benefit both the Grevy's zebras and the pastoralists.

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Annex 1: Number of records per season, year and individual animal.

Area: Kalama	Zebra ID:	116	117	118	119	120	122	125	163	1059	1061	1062	1063	1092	1093	1094	1095	1188
Year	Duration in Month:	3	2	5	5	5	3	15	5	3	2	2	7	20	5	3	1	7
2006	2nd	264	95	207	382	482	87	179										
	2nd				135	149	467	1834										
2007	1st							2069										
	1st							198										
	2nd							2710	2468									
	2nd							120	780									
2010	2nd											117						
2011	1st										174		771	105	794	622	59	
	1st												414	127	596	91		
	2nd									179				346				
2012	1st												88	1890				
	1st													729				
	2nd													399				
	2nd													772				

CXLVII

2013	1st															108
2013	1st															720
	2nd															1180
Area: Meibae	Zebra ID:	119	120	125	126	127	128	1058	1059	1060	1061	1062	1063	1092	1093	1094
Year	Duration in Month:	7	14	3	2	7	5		21	25	10	6	10	5	16	3
2006	2nd	282	455		327	268	320									
2007	1st	2105	2097		457	2288	2347									
	1st	582	668			719	449									
	2nd	1132	3517	188		1057										
	2nd		412													
2010	2nd							613								
2011	1st								3593	3537	2715	1882				
	1st								568	1383	450	390	1360	573	1081	1599
	2nd								580	667			712	715	699	
	2nd								1310	468			413	122	488	
2012	1st								2797	2737						
	1st								1362	1436					394	
	2nd								2567	2592					2927	
	2nd								474	812					1342	

Area: West Gate	Zebra ID:	117	118	119	120	125	1059	1060	1061	1062	1063	1092	1093	1094
Year	Duration in Month:	4	4	5	7	4	5	9	3	2	14	5	10	2
2006	2nd	782	232	365	828									
	2nd		364		977									
2007	1st		776											
	1st					447								
	2nd					254								
2010	2nd									91				
2011	1st						60	144	2006		109			425
	1st						1003	45			292	737	323	43
	2nd							963			1012		922	
2012	1st										2703		2465	
	1st							107			992	243	997	
	2nd							151					128	

Points per animal per conservancy per year and season. Blue rows indicating first and second wet seasons as opposed to dry seasons in each year. "Duration in Month" indicating in how many consecutive month animal collars were transmitting. With animals or seasons with fewer than 30 per conservancy omitted and last points of an ending year added to next year if season was on-going.

Annex 2: Group discussion guide line questions.

	Name	Age	House Hold Size	Education	Additional Info

|	cattle					camels				Small stock					donkeys		
	0	<20	<50	<100	>100	0	<20	<50	<100	0	<20	<50	<100	>100	0	<20	<50

1. Do you keep all your livestock in one area?

2. How and why do livestock numbers fluctuate?

3. Who herds cattle?

4. Who herds small stock?

5. Who herds camels?

6. Do you split the herds?

   6.1.   How?

   6.2.   Why?

   6.3.   Seasonal differences?

7. Where is livestock herded in the dry season?

   7.1.   Which species?

8. Where is livestock herded in the wet season?

   8.1.   Which species?

9. Which three perennial grasses are very good for livestock?

   9.1.   Where are these grasses found?

   9.2.   Has the amount (abundance) and the areas where you find them (distribution) changed?

10. Please describe good grazing areas.

   10.1.   What does landscape look like where grazing is good?

   10.2.   Does it differ for different animals?

   10.3.   What else makes an area good for grazing?

10.4.　　　How far from water can you go?

10.5.　　　Which of these is the most important factor for grazing?

11. What is the pasture like in the dry season?

11.1.　　　Is there a point at which livestock can not eat it the grass any more? What does it look like?

11.2.　　　How does this differ for different livestock species?

12. What would you prefer: a lot of low quality pasture or a small amount of very good quality pasture?

13. Are there areas you avoid?

13.1.　　　If yes- why?

13.2.　　　Does it differ within seasons?

14. Do you follow a communal grazing plan?

14.1.　　　If yes- how does it affect you? If no- why not?

15. When and where do you see GZ?

15.1.　　　Does it differ within seasons?

15.2.　　　How many GZ do you estimate to live in this community conservancy?

15.3.　　　Which differences between GZ and plains zebras do you know?

15.4.　　　How do you think GZ choose grazing areas?

15.5.　　　Can you name three plants that GZ like to eat?

15.6.　　　How do they behave when you see them?

16. Do GZ graze next to livestock?

16.1.　　　Does it differ within seasons?

16.2.   Why do you think they graze together?

16.3.   What happens when they graze together?

16.4.   What is the most important aspect?

17. What do you know about GZ conservation?

17.1.   What problems do GZ face?

17.2.   What is the most important problem?

17.3.   What actions are being taken to conserve GZ?

17.4.   Do you think this is important? Why/ In what way?

17.5.   How do you benefit from GZ?

Annex 3: Reclassified Africover and MODIS vegetation map with Grevy's zebra hot spots.
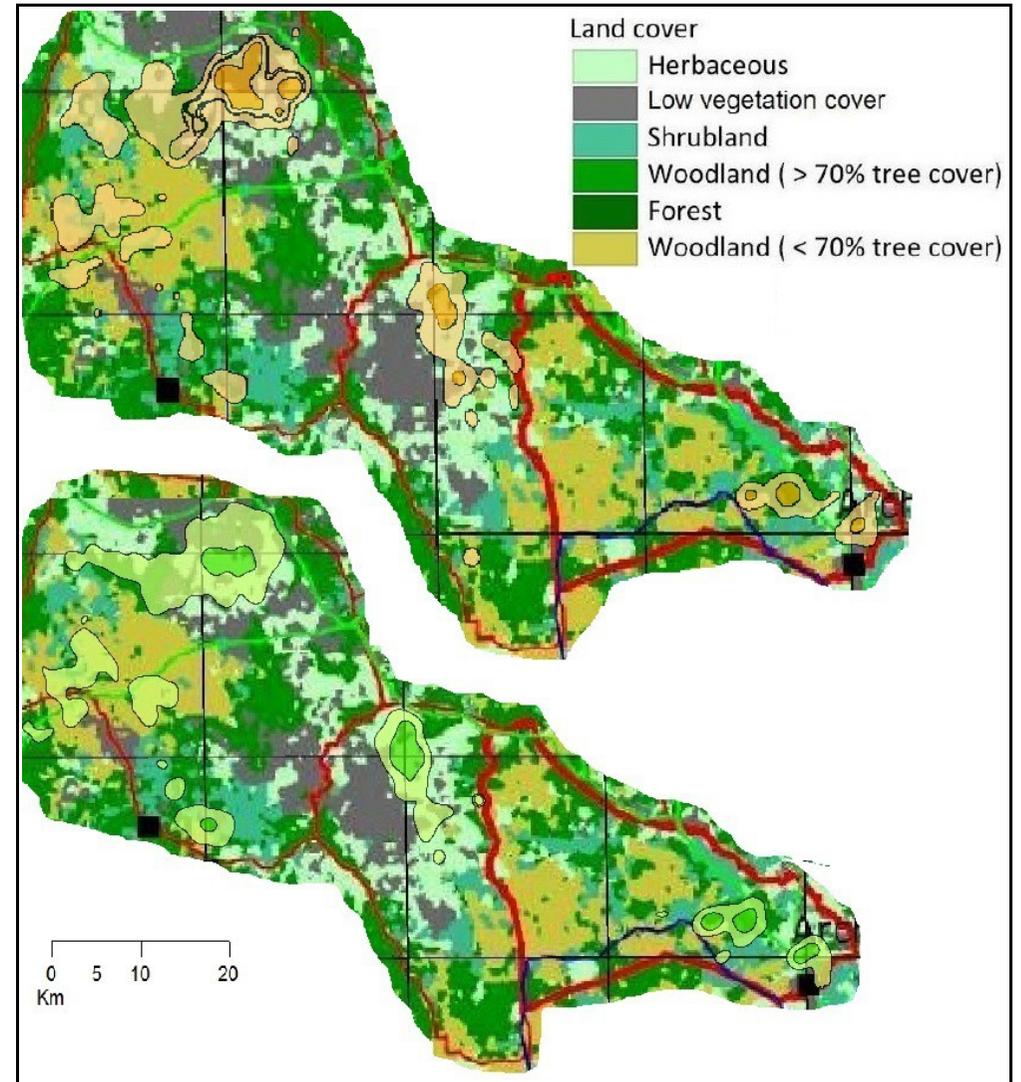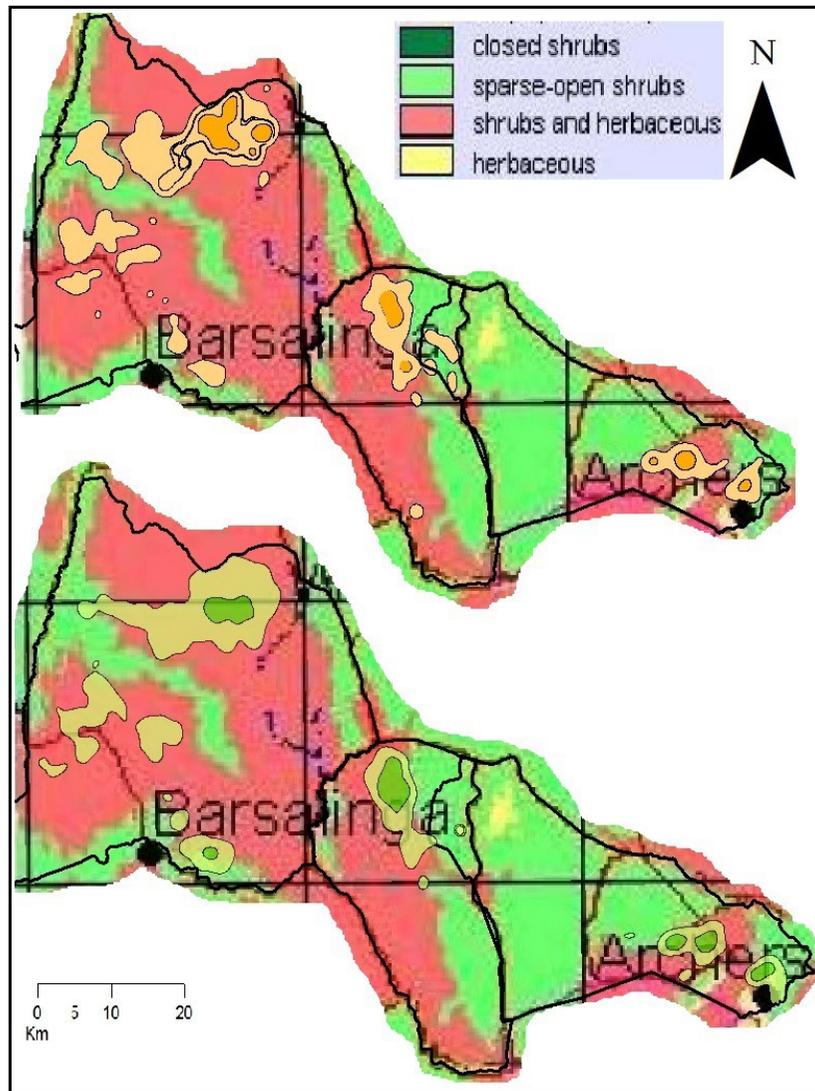
Vegetation maps (Africover on left; MODIS on right) from Hosten's Master thesis (2009) overlapped with Grevy's zebra hot spots (dry season above).